Tampere University

JUHA-MATTI HUHTA

Situational Awareness in Operational Police Encounters

How is it formed, what factors influence it and how it can be trained

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ACADEMIC DISSERTATION
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ABSTRACT

The formation of situational awareness can be seen as the most critical and important skill in the police profession, as all other activities of the police, such as decision-making, tactics, and the use of force, are or should be based on situational awareness. This dissertation defines the situational awareness required in the operational work situations of police, what it consists of and is formed by, what factors affect it, and how its teaching can be developed.

The dissertation consists of four sub-studies, each of which examined the situational awareness of the police through a variety of research questions and settings. Some of the sub-studies examined what was previously known about situational awareness specific to the police, what should be investigated, and the link between the learning of police situational awareness and other motor skills. The dissertation also studied behaviour and activity related to situational awareness in simulated training tasks and examined the relationship between newly defined behavioural dimensions and individual personality traits. The second empirical study design in this dissertation examined gaze behaviour and used qualitative methods to conceptualize police-specific situational awareness.

The results of the dissertation address global challenges of police education relating to the training and practices of police situational awareness, which has so far not been defined or operationalized and is a major limitation for teaching and training. This research shows that elements related to police situational awareness can be identified, defined, and taught. The dissertation revealed and defined six behavioural dimensions that affect situational awareness and/or police activity either positively or negatively, as well as the relationship between these dimensions and personality traits. The dissertation identified the ways in which officers try to collect information in various encounters. Finally, the dissertation identified and defined seven specific themes that when taken into account can form the specific situational awareness of the police.

Keywords: Situational awareness, police, behaviour, personality, gaze behaviour, training and education, police tactics, decision-making

TIIVISTEMÄ

Taitoa ja kykyä muodostaa tilannetietoisuus voidaan pitää kaikkein tärkeimpänä ja kriittisempiä taitona poliisin ammatissa, sillä kaikki poliisitoiminta kuten päätösten tekeminen, taktiikan valinta ja voimakeinojen käyttämisen arviointi ja keinot perustuvat tai niiden tulisi perustua tilannetietoisuuteen. Tässä väitöskirjassa määritellään poliisin operatiivisessa toiminnassa vaadittava tilannetietoisuus; miten tilannetietoisuus muodostuu, mitä se sisältää ja mitkä tekijät vaikuttavat siihen sekä miten poliisitoimintaan liittyvää tilannetietoisuuden opetusta voidaan kehittää.

Tämä väitöskirja sisältää neljä osatutkimusta, joissa jokaisessa poliisityöhön liittyvää tilannetietoisuutta pyritään selvittämään erilaisilla tutkimuskysymyksillä ja menetelmillä. Ensimmäisessä teoreettisessa tutkimuksessa keskitytään selvittämään sitä, mitä poliisin operatiiviseen toimintaan liittyvästä tilannetietoisuudesta on aikaisemmin tiedetty ja sitä mitä pitäisi edelleen tutkia, sekä selvitetään motoristen taitojen oppimisen ja tilannetietoisuuden oppimisen välistä yhteyttä. Toisessa osatutkimuksessa tutkitaan tilannetietoisuuteen liittyvää toimintaa ja käyttäytymistä empiirisen tutkimusasetelman avulla sekä selvitetään tutkimuksessa määriteltyjen käyttäytymisen ulottuvuuksien ja yksilöllisen persoonallisuuden piirteiden välistä yhteyttä. Väitöskirjan toisessa empiirisessä tutkimusasetelmassa selvitetään katseen käyttäytymistä sekä käsitteellistetään nimenomaan poliisitoimintaan liittyvä tilannetietoisuus käyttämällä kvalitatiivisia menetelmiä.

Väitöskirjan tulokset käsittelevät poliisin tilannetietoisuuden kouluttamiseen ja käytäntöihin liittyviä poliisin koulutuksen maailmanlaajuisia haasteita; poliisityöhön liittyvää tilannetietoisuutta ei ole koskaan aikaisemmin määritelty tai operationalisoitu, ja se on ollut merkittävä rajoitus tilannetietoisuuden ja operatiivisen poliisitoiminnan opetukselle ja koulutukselle sekä niiden kehittämiselle. Tämä väitöstutkimus osoittaa, että poliisin tilannetietoisuuteen liittyvät elementit voidaan tunnistaa, määritellä ja niitä on mahdollista opettaa. Väitöskirja paljastaa ja määrittelee kuusi käyttäytymisen ulottuvuutta, jotka vaikuttavat tilannetietoisuuteen ja/tai poliisin toimintaan joko positiivisesti tai negatiivisesti sekä näiden ulottuvuuksien ja persoonallisuuden piirteiden välisiä yhteyksiä. Väitöskirjassa selvitetään millä tavoin kokeneet poliisit pyrkivät keräämään tietoa erilaisissa kohtaamisissa. Lopuksi väitöskirjassa tunnistetaan ja

määritellään kokeneiden poliisien, eksperttien käyttämät seitsemän erityistä teemaa/elementtiä, joiden avulla voidaan muodostaa operatiivisen poliisitoiminnan edellyttämä tilannetietoisuus.

Asiasanat: tilannetietoisuus, poliisi, käyttäytyminen, persoonallisuus, katseenkäyttäytyminen, koulutus ja kasvatus, poliisitaktiikka, päätöksenteko

CONTENTS

1 Introduction 11

2 Theoretical framework 13

2.1 Situational awareness 14

2.2 Decision-making 15

2.3 Personality 16

2.4 Expertise 17

2.4.1 Expert tacit knowledge 17

2.5 Summary of theoretical framework 18

3 Objective and researh questions 20

4 The implementation of the study and methodology 22

4.1 Study participants, procedures and data 22

4.2 Ontology, epistemology and methods 24

4.3 Research ethics, integrity, validity, and reliability 27

5 Main results of substudies 29

5.1 Sub-study 1 29

5.2 Sub-study 2 30

5.3 Sub-study 3 32

5.4 Sub-study 4 32

6 Discussion 35

6.1 Theoretical discussion 35

6.2 Sub-study 1 36

6.3 Sub-study 2 37

6.4 Sub-study 3 40

6.5 Sub-study 4 42

6.5.1 The influence of stress on situational awareness training and practice 45

6.6 Practical implications 47

6.6.1 Theoretical application to police education 47

6.6.2 Practical application to police education: training examples 48

6.7 Limitations and future prospects 52

7 Conclusion 55

Reference 56

List of Figures

Figure 1. Model of situational awareness in police encounters 44

1 INTRODUCTION

Police work is a demanding occupation, and officers' role in maintaining safety is critically important to society. Police work consists of daily activities such as normal interactions with people like helping and guiding, and also highly critical incidents including life-and-death situations where officers have to make fast decisions about tactics and, if needed, decisions and actions about the use of force (UOF) (e.g. Saus et al., 2006; Vickers & Lewinski, 2012; Laguna et al., 2015; Andersen & Gustafsberg, 2016). In these situations, the police have to base their activities in laws and regulations, tactical methods, and in the ever-changing information collected from the environment (Sub-study 1: Di Nota and Huhta, 2019; Sub-study 4: Huhta et al., 2023).

Concern for the safety of police and the public is ongoing and growing among both of these stakeholders (Andersen & Gustafsberg, 2016). Police knowledge and skills have a direct link to how the police can work securely for bystanders, themselves, and target persons, how they can cope with and handle their work in general, and how the police can act as a key public authority with confidence (i.e., according to/in the eyes of the public, inspiring confidence). In fact, the need for the development of officers' operational capacity is not confined to individual performance situations, but rather to the broader social framework on police capabilities, quality, and ethics. The impact of individual police encounters, and especially those which have gained significant publicity and fuelled social debate on wide-ranging political movements (e.g., George Floyd case), have always been part of the debate between the authorities and civil society, but it seems to have become even stronger both locally and globally. The capacity of the individual officer will thus return to the question of full social stability and the legitimacy of the authorities, which justifies the presentation of the current dissertation, which is under studied.

At the same time, police agencies, colleges, and academies are doing their best to train and educate officers to be able to do their job and make effective decisions that are needed often under time pressure and uncertainty (e.g., Saus et al., 2006; Vickers & Lewinski, 2012.) However, a challenge in the field of police training and

education is the diversity of operational activities and the consequent indeterminateness, which has led to the fact that it has not been possible to clearly describe the training needed by the police.

2 THEORETICAL FRAMEWORK

The challenge with police training has always been the diverse nature of police work: it incorporates numerous physical skills and psychological competencies, making quantifying and operationalizing "police performance" very difficult. Police training is always accompanied by police tactics and techniques which are usually not open in the literature or to the public, in which case the systematic examination of operational police activities is not possible. Literature and current practice have not been able to determine the elements of police performance and therefore cannot distinguish between the successes, failures, and developments within the performance. This naturally makes it difficult, if not impossible, to develop training and education.

Developmental issues related to police training are often local but also reflected globally. The length, content, and quality of police training depend on the legal and cultural backgrounds of different countries and systems. At the same time, the framework conditions and characteristics of the individual's physical and mental abilities are universal. It is therefore necessary to deepen research on the subject of police training and education to provide tools for the development of educational systems in different countries and to support a common dialogue.

There are currently no industry-wide policing standards for the content or duration of basic or extended training between agencies or countries. In addition to this, there have not been industry-wide standards for defining and operationalizing police tactics and UOF, including the complex perceptual, cognitive, and motor skills involved (Henson et al., 2010; Sub-study 1: Di Nota & Huhta, 2019). As presented in this dissertation, situational awareness is the most important skill for police, and has not been defined or conceptualized ever before in police-specific contexts.

2.1 Situational awareness

Situational awareness (SA) (sometimes also referred to as 'situation awareness') is essential for understanding any current situation. SA can be defined in several ways, but it is always linked to an overall understanding of the situation at hand (e.g., Stanton et al.,2001; Shortland et al., 2018). The current dissertation models Endsley's (1995, 1999, 2012) definition of SA, which is divided into three components: perception, comprehension, and projection. The first stage is to make observations using our multiple senses (i.e., vision, smell, hearing, touch, taste, and proprioception). Based on the observations made, we form an understanding of the current situation, which is stage two. The third stage is to anticipate what might happen next based on stage two and linking it to prior experience and/or training. It is important to consider that performance itself can be either good or bad independent of SA. That is, even when SA is optimal an individual may perform poorly or in total opposition to what their SA may dictate. Endsley (1995) states that the opposite is also true, such that optimal performance may be based on incomplete SA. One of the objectives of the current dissertation is to examine why this occurs, and how individual factors like personality influence operational police behaviours (see sub-study 2).

In every occupation, the demands of SA are different, and have been investigated in several industries and sectors (e.g., aviation, medicine, military command, sports; for review see Stanton et al. 2017; Sub-study 1: Di Nota & Huhta, 2019). For first responders such as police, firefighters, and emergency medical care providers who often are in critical situations, the importance of SA even greater as there is often question about health, safety, and even life-and-death for themselves or the public they serve. Although SA is considered a significant occupational factor, especially in the above-mentioned professions, there has been very little empirical research that defines what SA is and what components it is based on. Further, the lack of standardized definition means that there is no standardized or validated method for training, measuring, or evaluating SA in operational police contexts (Di Nota et al., 2021a). This gap in practical and theoretical knowledge forms the basis of the current dissertation. Considered together with public interest in police training and performance, there is an urgent need for new studies to operationally define SA and its components in police-specific contexts. More specifically, SA needs to be conceptualized and

operationalized in a way that it can be understood, discussed, and trained more efficiently.

2.2 Decision-making

Decision-making (DM) as a concept is challenging to define, as DM patterns are internal, invisible processes that vary in different situations. DM has been described using various models as a mechanism to choose our actions from different options that might be influenced by our emotions (see Schmidt & Wrisberg, 2004; Riabacke, 2015). The reason DM can also be challenging to define is because DM can be deliberate or intuitive, unconscious or consciuous, and slow or fast (Kahnemann, 2003). DM is also described in psychology as a cognitive process that involves understanding the potential consequences of identified and available alternatives (for review see Gallivan et al., 2018). This definition is quite close with Klein's Recognition-Primed Decision Model (RPDM) (Klein, 1989, 1993) whereby DM is characterized as a fusion of two mental processes: SA and mental simulation. According to Klein's model (1993), police officers can detect "patterns" in their environment (i.e., as a tool to inform SA) and choose the most suitable course of action based on experience and/or training to make accurate and expedient decisions.

Accordingly, DM is understandably an important part of an individual officer's performance and should be taught. Based on my experience as an operator and instructor, I would venture to argue that simply teaching different DM models is not, as such, a very effective way to learn to perform more efficiently. First, we must have an understanding of the situation at the moment. That is, the individual must first understand what is going on right now and how the situation might continue. For this reason, the current dissertation will regard DM as a subordinate skill to SA. We must first have an understanding of what decisions or options are available to us, which are dictated by the knowledge and information that makes up SA. The purpose of this dissertation is to identify this knowledge and information through empirical study to advance police education in SA, tactics, and DM.

2.3 Personality

Personality and personality traits have been a matter of interest for psychologists and also of the general public for decades. Studies have shown that personality traits can change, even significantly, over the course of our lives (see Helson et al., 2002). Personality features have been defined in many ways (e.g., Big Five Factor Model, Minnesota Multiphasic Personality Inventory, NEO Personality Inventory, Personality Research Form) and can be considered as individual attributes that consistently distinguish people from one another in their thinking, emotions, and behaviours (Ones et al., 2005).

It is natural that police organisations are also interested in the personality characteristics of applicants, especially at recruitment stages (e.g., basic or specialized training), as tests are partly used to predict the performance of future employees (Twersky-Glasner, 2005; Henson et al., 2010; Ghazinour et al., 2019). Personality and policing have been studied in the past but studies have focused on, for example, the relationship between personality traits to the quality and quantity of work, cooperation skills, and abuses of police personnel which have led to suspensions or other sanctions (Aamodt, 2004; Richardson et al., 2007; Sanders, 2008). In addition, previous studies have examined the impact of personality characteristics and professional experience on police shooting under pressure (Landman et al., 2016). The results of that study showed that personality traits predicted performance significantly less than experience. Yet, the links or connections between personality and actual police behaviours (i.e., operational activity) have not been systematically studied in the past.

In my experience as a police instructor for 19 years, I have often observed certain behavioural tendencies that were perhaps less informed by SA and more so by the individual's personality traits. Therefore, an additional objective of the current dissertation is to study whether personality has a relationship to gathering information for informing SA and/or whether personality traits might override SA to influence our actions (i.e., behave in a way that is inconsistent with SA). Through this investigation, the current dissertation: a) defines universal observable behavioural dimensions in critical police-specific contexts, b) examines the relationship between personality and these behavioural dimensions, and c) informs training and education that considers how inherent personality traits might influence learning and behaviour.

2.4 Expertise

Expertise has been extensively studied and has several different definitions. One way to determine expertise is to describe it as the ability to perfectly perceive the overall picture in different situations and to act automatically, unconsciously, and flexibly in a way that is suitable (Ropo, 1991). In the development of expertise there are equally several different perspectives. The development of expertise has been described as a progressive linear process in which skills develop relative to the time spent training and gaining experience. However, this view has been met with criticism and a number of researchers suggest that the development of expertise is more related to individual-level competencies than to time spent directly on training. This view is justified by the fact that there are also young experts who do well among us (Doane et al., 1990; Vicente and Wang, 1998; Ericsson, 2004). Ericsson (1993, 1996) is a well-known researcher in the field of expertise, and according to him, the duration of training and deliberate practice has positive effects on performance. However, training and practice must focus on the right things, including situationally tailored skills and requirements.

Growth from novice to expert requires training that supports the organization of new information into existing data structures. Information is typically provided by dividing a larger dataset (e.g., searching a room) into smaller, discrete, and more specific parts or chunks (e.g., listen for cues, breach the door, clear the hallway) (Rauste-von Wright and Wright, 1994; Di Nota, 2017). Of course, in police encounters there are an infinite number of possible chunks and outcomes. The objective of this dissertation is to identify, define, and pragmatically operationalize the universal chunks or factors related to police SA in order to make future training and education more effective and support the development of expertise.

2.4.1 Expert tacit knowledge

The nature of tacit knowledge is well illustrated by the definition of Michael Polanyi (1891 - 1976): “We can know more than we can tell” (Polanyi, 1966, p. 4). Tacit knowledge includes experience and information that is inherently known and

wordless, and therefore cannot be conceptualized. Tacit knowledge develops through practical experience and may not necessarily be recognized as learning, as change in one's own behaviour is often unnoticeable and the individual's development of their own knowledge and skills is hidden in his or her experience (Keskinen 1995; Tuomisto 1998; Järvinen, Koivisto & Poikela 2000). Tacit knowledge can be understood as a counterpoint to identifiable and visible data, as it is not easy to identify or transfer to another person. This is due to the abstract form and context of tacit knowledge and its self-evident nature. Knowledge is gained through experience and has been ingrained in such a way that it does not need to be thought of consciously. The difficulty of expressing tacit knowledge is also due to language limitations, including a lack of appropriate vocabulary (Haldin-Herrqård & Salo, 2008, p. 290). For this reason, the current dissertation is focused on conceptualizing and operationalizing SA from the perspective of expert police practitioners in order to make their tacit knowledge visible.

2.5 Summary of theoretical framework

Since the specific situational awareness of the police in operational situations has not been studied in the past or defined in any way, this doctoral thesis had to rely on combining my observations, practical experiences as an officer and instructor, and strong educational background in order to enable the clarification of police-specific SA. Finding out and understanding the SA of the police must be seen as a priority as all other police activities are based on this central skill. The theoretical sub-headings described in this section (Decision-making, Personality, Expertise, Expert tacit knowledge) formed the theoretical framework for this doctoral thesis. All decision-making on how the police act, what the police communicate, what commands they give, and what different means of force the police can consider in a situation must be based on the situation and the officer’s understanding of it. As understood in the existing literature, experts are known to make the right decisions even in difficult situations, so the methods and means used by experts had to be investigated. In addition to this, my combined experience as a frontline officer and as an instructor of use of force and police tactics for well over 20 years have shown me that, in training and in real police situations, the activity of an individual police officer sometimes appears to be

completely random. Of course, stress has a major impact on performance and I will address stress later as part of the discussion. However, I have wondered why individual officer's performances sometimes do not seem to be based on the situation at hand. What factors other than knowledge, skills, and experience can affect the performance and functioning of the police? For this reason, the possible connections between personality and police activity were also taken into account in this dissertation. Taken together, the basic assumption of the current dissertation is that if we do not know what forms police situation awareness, it will be very difficult for us to practice and teach any other related skills such as decision-making, de-escalation, or police tactics in such a systematic way that the trained skills can be transferred with certainty to real situations.

3 OBJECTIVE AND RESEARH QUESTIONS

Like I have presented in the previous chapter research literature indicates that police situational awareness (SA) training, education, and practice have shown that SA is not clearly defined, it is not collectively understood, and there are currently no written guidelines to teach it. This study was particularly designed to fill the gaps in the previous literature to understand what SA in police fieldwork situations means, what it consists of, and what kind of understanding and competence is required for police officers to accurately interpret the situation and make effective decisions based on it. The aim was also to increase understanding of how SA evolves, and how it can be developed, during basic police training as part of developing expertise to inform how police SA can be taught.

The dissertation consists of four sub-studies. The aim of each sub-study was to address the current knowledge gap that still exists in research data and practice relating to police work and training in relation to SA. Together these sub-studies identify the content and specifics of SA related to police work and activities to improve the means by which police SA training can be developed.

The following research questions were set to achieve the objectives of each sub-study:

Research Question 1. What is known about police training in relation to Situational Awareness?

Objective: Clarify existing knowledge of the factors related to police training of situational awareness, decision-making, and complex motor skills.

(Results are reported in sub-study 1; *Complex Motor Learning and Police Training: Applied, Cognitive, and Clinical Perspectives)*

Research Question 2. What observable dimensions of behavior can be defined in relation to situational awareness, and how are personality traits related to these behavioral dimensions?

Objective I: Identify and define observable behavioural dimensions during a simulated operational police task.

Objective II: Explore the possible connection between behavioural dimensions and personality traits.

(Results are reported in sub-study 2; *Universal Police Behaviours during Critical Incidents and Their Connection to Personality: A Preliminary Study)*

Research Question 3. How is critical information sought during police encounters and what factors form police-specific situational awareness?

Objective I: Determine the gaze and fixation behaviors of police officers at the expert level (i.e., experienced, specialized officers and instructors) to identify how they seek critical information to achieve the first stage of situational awareness (i.e., observations and perceptions).

(Results are reported in sub-study 3; *Experience-Dependent Effects to Situational Awareness in Police Officers: An Eye Tracking Study)*

Objective II: Identify and define those critical factors by which situational awareness is formed within the context of police work.

(Results are reported in sub-study 4; *Deriving Expert Knowledge of Situational Awareness in Policing: a Mixed-Methods Study)*

Objective III: Observe how the objective (i.e., visuomotor behaviour) and subjective (i.e., qualitative responses) indicators of situational awareness might differ between expert and novice officers.

Objective IV: Investigate what capabilities current police training at the Police University College of Finland provides for the development of SA by comparing early and intermediate novice police trainees.

(Results are reported in sub-study 3; *Experience-Dependent Effects to Situational Awareness in Police Officers: An Eye Tracking Study* and in sub-study 4; *Deriving Expert Knowledge of Situational Awareness in Policing: a Mixed-Methods Study)*

4 THE IMPLEMENTATION OF THE STUDY AND METHODOLOGY

4.1 Study participants, procedures and data

This dissertation consists of four sub-studies, one of which was a comprehensive literature review (sub-study 1) and three sub-studies that used an experimental design. Sub-study 2 consisted of 45 volunteer participants that were Police University College of Finland students that were finishing their studies prior to their field practice. In the study, participants took two different psychological personality tests to measure personality traits. The participants then completed four simulated operational police tasks. Simulated situations were carried out in the Police University College's training town. In each simulation, each participant acted alone and performance was externally evaluated by two experienced police officers and professional trainers. Performance was evaluated based on six observable behavioural dimensions that were defined in relation to situational awareness (SA). The evaluation was carried out by marking the cross-sectional line in the assessment tool for each dimension, which started with 0 and ended with 10. (Example: Is the testee able to observe the direction of potential threat in his/her action in space A? 0 = no control of the environs 10 = temporally and spatially comprehensive control of the environs). The evaluation was designed in advance to be appropriate for each situation and to be assessed in terms of the behavioural dimensions presented in the sub-study. Personality traits and performance data were compared.

Data from sub-studies 3 and 4 were collected from the same study sample that involved 34 participants, 11 of whom were experienced police officers. In addition to their operational police experience, these experts had a background in special groups (e.g., tactical response, K9 = a dog patrol) and six were further subdivided into an expert 2 group as they were experienced and qualified instructors in the use of force and tactics. The remaining 23 participants were students at the Police University College of Finland and were divided into two groups according to their level of study.

In the study design, each participant was presented with 13 static photographs on the screen of the computer that showed typical police work situations that ranged from non-threatening to highly threatening. At the same time, participants' eye movements were recorded using eye-tracking equipment (Tobii T60, software version of Tobii Pro Lab 1.64). Each image, or simulated situation, was visible for 15 seconds, after which a black background appeared on the screen and two questions were asked to the participants. The questions were told to the participants beforehand and the questions were the same and asked in the same order each time:

1. "Tell us about the situation: What there is, what can happen next, and how can the situation develop?"

2. "How do you act: Tell us about your decisions and actions. Also tell us about possible alternative ways to act and justify your actions."

After answering the questions for picture eight, participants were asked one additional question: "Where did you try to look first in the previous eight situations? Name two things." Participants were asked this question only once at this stage, as the first eight images did not have any objects in the target person's hands. The images were purposefully designed and presented this way so that participants would not be primed to expect an object in the target person's hands every time, which would have likely influenced their visuomotor behaviors.

Sub-study 3 evaluated the objective gaze and fixation patterns in the first five seconds of each situation. Gaze and fixation behaviors were operationalized in two different ways: 1) visit duration, which measured the time spent (in seconds) fixating various regions of interest including the target person, their face, hands, or body, and the surrounding environment; 2) fixation order, meaning the chronological order of where participants stopped to fix their gaze within each scene. Participants' answers to all questions were recorded, transcribed, and analyzed thematically in sub-study 4 to determine the different elements that comprise situational awareness in police-specific contexts.

4.2 Ontology, epistemology and methods

Ontology is generally considered to be the basis for describing the reality in which the phenomenon is understood to be present. Each era and philosophical trends have influenced the significance of ontology, which has progressed cumulatively in history by bringing forward the ideas of earlier thinkers (Tuominen & Wihersaari, 2006; Haaparanta & Niiniluoto, 2016). In this dissertation, ontologically, a decision must be made: What is the essence of the phenomenon being investigated (i.e., situational awareness)? How does it manifest itself? How is that phenomenon understood from a police point of view, and specifically in operational encounters?

The ontological basis of this dissertation is pragmatism. The founders of pragmatism are Charles Peirce and William James, as well as those who advanced the Pragmatic Movement, such as John Dewey, George Herbet, and Josiah Royc. However, the ideas of the above-mentioned individuals were not consistent, but each had a slightly different angle of approach. Peirce (1877/2001) believed in the existence of real "things" that are independent of people's perceptions, so his philosophy was based on realism. James and Dewey, on the other hand, emphasized that information is constructed and built up with study (Pihlström, 2008; Martela, 2019). As stated, pragmatism is diverse from the point of view of ontology and contains differing interpretations of reality. In this dissertation, I commit myself to ontological realism as I believe that some kind of reality exist independent from individuals thought or conceptualization. (Holma, 2004). Pragmatism states that research can help to achieve the best possible knowledge and understanding, but not the ultimate truth, because, as in science in general, later newer arguments can change previous perceptions (see Saurama, 2016). The aim of pragmatism is to find and identify theories that can support people to work better in practice. That is, research begins and ends in practical experience, revealing the nature of reality. Therefore, pragmatism can be simplistically described as a practice-theory-practice model (Puolimatka, 1995; Martela, 2019). Also essential in the pragmatic approach is a practical need behind the research issues. As I have identified a need for advancing the definition and education of police-specific situational awareness, this dissertation follows a pragmatic framework to create a new theory through practical applied research so that this theory can return to action as improved practice.

Investigations rooted in pragmatism value methodological diversity, such that each study should choose the appropriate research setting and methods for examining the practical phenomena. However, in addition to experimental research settings,

pragmatic research may also be theoretical and can also be applied in the analysis of qualitative data (see Patton, 2002; Kilpinen, 2008; Määttänen, 2009; Siljander, 2014). This dissertation has reviewed previous theoretical research on the phenomenon (i.e., the SA of police in encounters) in sub-study 1. In addition, two empirical research studies were carried out, resulting in three mixed-methods analyses that used theoretical, qualitative, and quantitative approaches (sub-studies 2, 3 and 4). To return the practice-informed theory back to practice, the results of this pragmatic research have led to two preliminary training events that evaluated the usefulness of the research results to the theoretical teaching of SA (see Chapter 4). This dissertation is naturally placed in the field of pragmatism, as research is not only exploitable but also progressive in its field, where understanding of police SA, operational activities, and the development of education are of practical value (see Puolimatka 1995, pp. 47-48; Siljander 2014, pp. 182).

The epistemological (i.e., knowledge-based) basis for the phenomenon being studied is to answer the questions from where and how individuals gather information, and how valid the information is. In other words, epistemology is a fundamental aspect of philosophy, as it is rooted in knowledge. Available information becomes knowledge when it fulfils the following three conditions: 1) the person presented with the matter must believe it themselves; 2) this belief must be objectively true, and; 3) the belief must be justified. The chosen methodological approach will focus the study to the phenomenon under investigation (Anttila, 1996). In this dissertation, epistemologically speaking, situational awareness is understood as a phenomenon based on external reality (i.e., physical environment, walls, tools, etc.), but at the same time is also based on the 'hidden' inner thinking processes, structures, and habits of the individual. The technical knowledge interest in this dissertation seeks information to understand and explain the phenomenon by monitoring relevant behaviours in natural simulated environments. The knowledge interest can therefore be shared with those who work in policing to answer: How do officers interpret a situation? What are they thinking? What factors (i.e., general and individual characteristics of the situation, trained or untrained behaviours) guide interpretation and resulting decision-making? To examine these internal and external processes, it makes sense to examine the subject of study (SA) using a mixed-methods methodological approach.

There is no one specific methodology for human or educational research. However, knowledge is acquired by the same methods as other disciplines. Schwandt (2007) defines methodology as the theory of the progress of research. Methodology can also be understood from its Greek origin as "path" and "collected together" (Varto, 2011). Human beings are the subject of research in human science as a broad field of study. Educational reality or practice is, in turn, the subject of general research in educational sciences. The characteristic of human sciences (i.e., the study of human and human activity) is not only interesting and challenging, but also vulnerable because it may even be impossible to find, explain, and justify a solid or permanent pattern or theory describing a phenomenon (Metsämuuronen, 2006, pp. 18-19).

The methodology of this dissertation clearly does not follow any particular or prescribed approach. Rather, my research methods and materials are located in a mixed-methods field of research and consist of theoretical, quantitative, and qualitative perspectives (Creswell, 2014; Tashakkori & Teddlie, 2010). This dissertation contains four articles: One article is a comprehensive theoretical review of existing knowledge (sub-study 1). The relationship between personality, SA, and behaviour was examined in an experimental setting where the variables were divided into independent and dependent variables as is typical for experimental research (sub-study 2, see Nummenmaa, Konttinen, Kuusinen, Leskinen, 1997). In a second experimental study, empirical data were collected from the same sample and divided into two different research designs based on quantitative (sub-study 3) and qualitative (sub-study 4) methodologies.

Qualitative research on the acquisition of material favours methods of data collection in which the viewpoints of the subjects can be seen. Popular methods include active observation, theme interview, group interview, and discursive analyses of various documents and texts. According to Hirsjärvi (2008), the sample sizes of qualitative studies are in most cases significantly smaller than in a quantitative study. The analysis of qualitative material often begins with transcription in written form. For the use of recorded or oral qualitative material, it is often most appropriate to transcribe it word to word. The reader of the qualitative study never sees, and cannot see, the entirety of the research material. Accordingly, transcription is done either on the whole material or pieces of it. There is no direct guideline on the method or accuracy (i.e., verbatim or re-interpreted by the transcriber) of the transcription and therefore the manner and form of analysis determines the method of transcription. In sub-study 4,

transcription was intentionally conducted from word to word so that no information would be unintentionally lost. In this way, the extracted parts (such as those in Table 2 in sub-study 4) facilitate the reader's own assessment of the findings and interpretations. In addition, presenting the research material in this manner increases the transparency of the analysis and improves the validity of the study (Hirsjärvi, 2008; Nikander, 2010).

4.3 Research ethics, integrity, validity, and reliability

The studies in this dissertation are in accordance with the guidelines of the The Finnish National Board on Research Integrity (Tenk) and were approved by the research ethics board of the Police University College of Finland. I have been honest and meticulous in all my activities, which is demonstrated through transparent reporting practices in each sub-study that have been published in open access journals. All participants in the studies have been volunteers and were informed at all stages of the study about the possibility of withdrawing from the study at any time with no consequence. All research data were pseydonymised (i.e., assigned a de-identified participant number) so that no one individual is identifiable, and no one's name is visible in any data files. In the analysis stages, all data were examined and analyzed very carefully by myself and at least one other collaborator, and the statistical analyses applied were appropriate to the nature of the data (i.e., data that violated assumptions of normal distributions were analyzed with non-parametric statistics). Statistical analysis was carried out using carefully selected analysis tools including SPSS (Version 25, IBM Corp., Armonk, NY, USA). The experimental arrangements are detailed in each research article so that the studies can be replicated.

In assessing the validity of the studies in this dissertation, it is necessary to assess whether the methods used adequately measure what they are supposed to measure, i.e. how well the methods used correspond to the phenomenon that they are used to study. Accordingly, a multi-methodological approach was strategically used following consideration of the most appropriate methods and means to be used on a case-by-case basis separately for each study (2-4) and I have described in detail in each separate article of my dissertation the methods of

data acquisition and analysis I used. For example, in study 2 personality traits were not intentionally dichotomized, but were reviewed as a continuum, so that the quantitative research approach in the analysis phase of the data (n=45) was clearly more meaningful in terms of the reliability of the results than if the personality traits had been treated in a "yes" - "no" manner. In study four, on the other hand, the decision was made to transcribe data verbatim so that no information would change or be omitted based on the researcher's assumptions. This dissertation shows that it is possible to formalise and synthesize the conclusions of each study, which are based on data obtained by different methods that in turn support validity.

In assessing the reliability of the research, the reproducibility and portability or generalizability of the research results must also be assessed, and are discussed separately in each sub-study and also in section 6.7 (Limitation and future prospects) of this summary. Methods and materials were carefully described to allow for the accurate replication of the study designs, procedures, and outcomes. Reliability was also increased by presenting information in a variety of formats, including written text, line and bar graphics, and reproduced images of human figures so that the reader is able to reach the study conclusions by themselves. Although the participant samples were all Finnish police officers, the fundamental principles and concepts revealed in each study (e.g., time and distance laws) apply to police everywhere.

5 MAIN RESULTS OF SUBSTUDIES

5.1 Sub-study 1

The first sub-study of my doctoral research was a comprehensive theoretical review of how the brain learns and performs complex motor skills, including those involved in police work. The study argues that there are currently no industry-wide standards for defining and training police tactics, situational awareness (SA), or use of force (UOF), including the complex perceptual, cognitive, and motor skills involved. Further, there is no standardized police training on the physiological responses to stress that influence all of these skills and behaviours.

This sub-study synthesizes evidence from a variety of fields, including cognitive neuroscience, clinical research on visuomotor disorders, and applied policing to understand the relationships between stress, training/learning, and complex UOF and SA skills in a police context.

Based on the reviewed literature, this study provides evidence-based recommendations for the content (i.e., essential skills including SA, decision-making, and stress management) and delivery (i.e., duration, timing, delivery, and content of instructor feedback) of police training to promote learning as well as performance outcomes. The study also identifies practical challenges to delivering and evaluating police training, such as limited resources and barriers to conducting research in real-world police agency settings. Most importantly, this study argues that UOF and SA training should be modelled in accordance with how our visuomotor systems break down and process continuous streams of action. In this way, the perceptions, information, and motor skills relevant to SA should be broken down into smaller “chunks” or defined components so that it would be possible to discuss and understand the meanings of these specific components. With systematic and continued training these chunks can, if needed, be regrouped into larger ones, which is less consumed by mental effort (see Ericsson et al., 1993; Zacks & Sargent, 2010).

In order to understand, discuss, and teach the SA of the police as described above, the gap between research knowledge and SA practice needs to be filled. To fill this

gap, the first step is to seek out and find all the knowledge and understanding of SA directly from the police, including what it means and what it involves. This sub-study clarifies what is known and what is not yet known about police training and practice in SA. The following sub-studies will examine officers at all levels (novice, expert, instructor) to conceptualize and operationalize police-specific SA to inform the development of evidence-based SA training and education.

5.2 Sub-study 2

This sub-study defined outwardly observable dimensions of behaviour in operational police situations. Experienced police UOF trainers have observed actions similar to the behavioural dimensions defined in this study for years, but which have never been collectively defined in literature or practice. This may lead to certain types of behaviour being referred to in different terms, leaving a common understanding lacking. A lack of common understanding can, in turn, lead to misunderstandings and make practice less effective. The absence of standard definitions has made it very difficult or impossible to associate behavioural dimensions with SA. At worst, behaviours might be completely misunderstood in which case the risk of errors in police work situations increases.

This study identified six behavioural dimensions: Control of the Environment, Operational Flexibility, Initiative, Critical Decision-Making, Withdrawal, and Target-Oriented Behaviour. Each behavioural dimension was precisely defined, such that a common language for these components now exists (Sub-study 2: Huhta et al., 2021). The behavioural dimensions defined here describe activities that are untrained and inherent but which can now be viewed from the outside. With training, teaching, and experience, these unconscious behaviours can be reinforced if they are adaptive or be updated or replaced if they are maladaptive to informing police SA. Therefore, this study did not attempt to describe the various elements of police SA specifically, nor in any form the tactical or technical methods of the police. Instead, the aim was to create definitions of behaviour to be observed from the outside so that potentially risky behaviours can be identified, debated, and thus accounted for in teaching and education as part of our understanding of SA.

In addition, this sub-study examined whether the behavioral dimensions described above were linked to various individual personality traits. The goal of the sub-study was by no means to define different personality traits as better or worse

suited for policing, but to look for possible connections between personality and behaviour in a more empirical way than has been done in the existing literature. The hypothesis was that personality traits would be connected to behavioural dimensions. If confirmed, these connections would be important information for educators in both teaching and especially for giving feedback, as well as for the police students themselves, whereby receiving feedback and self-reflecting on learning would be more effective (Honkela et al., 2000). Their behaviour would therefore no longer be haphazard and undefined; instead, behaviour and its origin could be identified, and its connection with personality traits could be taken into account.

Personality was divided into four traits in this study: Extraversion, Intuitiveness, Emotionality, and Flexibility. The study did not use a dichotomic division, but the intensities of personality traits existed on a continuum from 0 to 100, where 100 meant a particularly strong expression of that personality trait. To measure personality traits, the same personality tests that were in use by the Police University College of Finland Entrance Exams (i.e., Personal Research Form) during that period were used.

The results of the sub-study showed that behavioral dimensions were not influenced by the participant's age or sex, but were related to personality traits. The ability to maintain good Control of the Environment and Operational Flexibility declined with the increase in personality traits Extraversion and Flexibility. That is, individuals whose personality traits were higher in Extraversion and Flexibility showed lower Control of the Environment and Operational Flexibility than participants with less dominant expression of these two personality traits. Initiative decreased as the personality trait Flexibility increased. Critical Decision-Making, in a situation where the suspect attempted to harm a bystander with an axe, improved with an increase in Extraversion. Unnecessary Withdrawal Behavior increased with high Emotionality and unnecessary Target Oriented Behaviour increased with Extraversion.

The preliminary results of this sub-study were also shared during a theoretical training lesson to the research participants following the study, including what the six behavioural dimensions were and their connections to personality traits. Following this session, the participants indicated: 1) how useful this knowledge was to understanding their own behaviour, and 2) whether this knowledge positively influenced how they will interpret situations in the future, including consideration of tactics and decision-making on a Likert scale (0 = not at all, 5 =

very much). The mean Likert scores were 4.3 and 4.6, suggesting that even the theoretical (but not practical) knowledge of the research findings is acceptable by trainees and improves their overall understanding of police SA.

5.3 Sub-study 3

This study was designed to examine the first phase of Endsley's (1995) well known model of SA (i.e., perception) and test whether there are differences between expert and novice police officers using an objective and implicit physiological measure of SA: gaze and fixation patterns. Participants' eye movements were tracked while viewing 13 static images of staged police encounters. The goal of the study was to reveal expert strategies for building SA in order to teach these patterns of information gathering more efficiently to trainees.

The results showed that both groups, novice and experts, spent more time looking at the target person relative to the environment. However, the time spent by experts fixating on the environment was significantly less than the time spent by novices.

Results for the fixation order showed that all participants first drew their gaze on the target person's face before any other area of interest such as the subject's hands or body. The Novice 1 group (i.e., no tactical or use of force training) considers the target person's hands significantly later compared to the Novice 2 group that had completed all or part of their tactics and use of force training block and the expert group, which included experienced officers from special units and instructors.

5.4 Sub-study 4

The data from this sub-study were collected together with sub-study 3. Recognizing that what you see does not always correspond with what is consciously perceived or remembered, the goal of this sub-study was to reveal expert tacit knowledge about the elements they are evaluating to inform SA. Through a mixed qualitative and quantitative analysis, the lacking definition of

police-specific SA identified in sub-study 1 can be conceptualized more concretely into discrete elements or "chunks" that facilitate teaching and understanding.

Following the presentation of each image, participants were asked two questions:

1. "Tell us about the situation: What there is, what can happen next, and how can the situation develop?"

2. "How do you act: Tell us about your decisions and actions. Also tell us about possible alternative ways to act and justify your actions."

Qualitative analysis of interview material revealed seven specific themes that define SA in operational police contexts. The themes were: Distance/Time Law, Partner/Roles, Profiling the Suspect, Surrounding Environment and Conditions, Tactical Options and Opportunities, Ongoing Assessment of Own Tactical Activities and Outcomes, and Dangerous Objects. All of these themes are defined and conceptualized in this sub-study. Further, experts' responses were significantly more diverse, comprehensive, and analytical than those of the novice groups, highlighting the interconnectedness of the themes.

Quantitative analyses show that experts note the above themes in almost every situation. Statistical analyses showed that there were significant differences in the ability of different groups to identify themes, specifically between both expert groups and the Novice 1 group, and also between the Expert 2 group (i.e., police instructors) and Novice 2 group. At their current training phase, the Novice 1 group was unable to interpret SA using these themes or "chunks", as they were able to recognize only one or a few themes, if any, for each situation.

Not included in the published version of this sub-study, participants were asked one additional question after picture eight only: "Where did you look at first?". Contrary to the eye tracking results in sub-study 3, all participants indicated that they looked to the target person's hands first even though objective data shows that participants first drew their gaze on the target person's face before any other area of interest. Similar to sub-study 2, preliminary findings of the eye tracking data from sub-study 3 and the themes identified by experts in sub-study 4 were presented to the participants who completed both of these procedures in a single combined experimental design. Following the theoretical training session, participants completed a Likert scale (0 = not at all, 5 = very much) in response to three questions: Do you feel that you learned about skills and factors that are related to making perceptions during police tasks? Do you feel that you learned

about skills and factors that are needed to interpret situations in police work, and to interpret how the situation might evolve? Making expert's interpretations visible can, in my opinion, enhance understanding and learning as related to these studies? The mean Likert scores were 4.5, 4.4 and 4.8, once again demonstrating that training theoretical knowledge related to SA is acceptable and promotes understanding.

6 DISCUSSION

6.1 Theoretical discussion

The purpose of this dissertation was to find out what situational awareness (SA) related to, and required for, police encounters means: What should officers precisely observe, take into account, understand, and evaluate so that he or she is able to inform the best possible SA? At the same time, SA should be formed as fast and clearly as possible to inform and make decisions and actions based on that knowledge and information. This dissertation was specifically about SA related to operational police work encounters. Naturally, overall SA evaluation starts immediately when officers first receive a call about some task, or for example, when a police patrol has decided to stop a car driving in front of them. In these cases, officers begin to gather information from the dispatch, citizens, or police computers, including historical information about an address or vehicle. Based on that information, officers are starting to interpret the situation and build SA. In the same way, leaders of multi-patrol situations that require a coordinated response from multiple units and services (i.e., fire, police, paramedic) must be able to form a "big picture" as precise as possible using different sources. Therefore, SA is vitally important to police work at all levels and needs to be investigated empirically and continuously.

This dissertation was about specifically investigating SA as it connects with and builds individual-level behaviour and action in situations where officers encounter target persons or members of the public. To understand this specific SA, it was first required to identify, conceptualize, and define behaviours and habits which are observable in police training and operational contexts, and also figure out their possible connections with inherent personality traits, how an officer interprets the situation, and how these relationships build SA. In addition, this dissertation identifies the habits and means that experts use to interpret the situation so that this tacit knowledge that forms SA would be made visible, understandable, and definable. In turn, the purpose of all the information, observations, and findings of this dissertation is to serve the development of future police training in tactics, use of force (UOF), and furthermore in SA.

6.2 Sub-study 1

In sub-study 1, the basic hypothesis is that the ability to form SA is a skill that can be defined, conceptualized, trained, taught, and evaluated. This sub-study tried to connect all of the existing knowledge about teaching police skills related to tactics, UOF and SA to establish what is known and unknown. Sub-study 1 argues that SA and decision-making are central skills that connect motor, cognitive, and sensory processes. That is, SA is a trainable skill like any other (e.g., complex motor skills). Accordingly, before teaching the skill, it must be defined so that its constituent parts can be demonstrated in an educational setting in an easily understandable form. Skills required in policing like UOF equipment handling are taught like practically all other motor skills – in pieces. Teaching a skill occurs in phases and can be theoretically defined in many ways. One very common way that has been a long custom in education (e.g. Fitts & Posner, 1967) is to divide skill learning into three different phases: 1) cognitive learning phase, in which the skill is conceptualized, understood, and represented as a whole; 2) associative learning phase, which focuses and ties your perceptions to training the skill itself; and 3) automatic phase, in which the skill has become implicit as a whole, freeing your perceptions to be based on observations from the environment.

By understanding how complex motor skills are theoretically and practically learned in the brain, the same processes can be applied to training SA. To do so, we must have enough information about the skill itself (i.e., how it is defined, what it involves) to achieve the first learning phase. The brain's distributed mirror neuron regions are primarily responsible for observation-based learning of countless actions by transforming perceptions and information from an external perspective and mapping them onto one's own body (i.e., first-person perspective), and planning and executing motor movements. Motor skills also engage brain regions responsible for language processing in order to articulate and speak aloud the necessary physical procedures. With repeated training and practice (i.e., associative learning phase), a new motor skill will follow the neuronal activation model that recalibrates and strengthens neural connections to embed the skill into long-term "muscle memory". In the same way, SA in police encounters can be taught by systematically activating neuronal connections to make them stronger and more reliable. In turn, the skill of interpreting the situation and forming SA develops and becomes automatic.

6.3 Sub-study 2

In police operational practice and tactical training there are, and have always been, commonly identified behavioural habits from the perspective of UOF instructors and trainers; for example, some officers or trainees will usually charge toward the target person upon seeing them, known as 'preying'; conversely, an officer may unnecessarily delay even though they should act; another officer in an encounter situation may not able to change the action that he or she has started, even though it is obvious to them that their chosen behaviours will not lead to the desired or intended end result. However, these implicit, primitive, and untrained behavioural habits have never been systematically identified, shared, used, or defined. To date, it has not been possible to systematically intervene on these outwardly observable behaviours in training and through instructor feedback, even though they have been consistently observed across many individuals. Due to a lack of explicit definitions and shared understanding, how these behavioural dimensions work together or in isolation to influence situational outcomes and inform SA in police work are not understood.

This sub-study defined six different behavioural dimensions: Control of the Environment, Operational Flexibility, Initiative, Critical Decision-Making, Target-Oriented Behaviour, and Withdrawal. These behavioural dimensions are actions that are mostly caused by unconscious, untrained functions and are often more powerful or dominant in stressful situations. These dimensions have been defined and written in a way that would be as understandable as possible to police officers and UOF instructors (for exact definitions, see sub-study 2). Good Control of the Environment describes a natural ability to take into account the environment as a whole, in which case one single object, stimulus, condition, or space (e.g., room, side corridor, etc.) does not guide behaviour or attention in a manner that takes away the individual's ability to control other factors that could expose them to danger from another direction. Operational Flexibility describes behaviour that shows the officer is flexible in changing their already-selected function, including tactic or UOF tool, if the first method turns out to be fruitless or completely wrong. Initiative means the ability to take advantage of the situation through one's own activities in order to make it possible later to move towards the intended goal. It should be noted that in police encounters Initiative is often first taken by the opposite party, so an officer's ability to take Initiative is important. Similar to existing applied police research (Nieuwenhuys et al., 2012; Andersen et al., 2016, 2018), Critical Decision-Making in this sub-study refers to the ability to make rapid

and critical decisions on the use or non-use of a firearm. When there is too much Target-Oriented Behaviour, it means directing attention and activities to the target person too quickly, even though it would be more advantageous to take into account the whole situation and move forward in stages. Withdrawal means unnecessary delay in the situation to move towards the target person or completion of the task. Withdrawal behaviour can also manifest itself by performing less important or critical functions in a situation where the focus should only be on the most critical functions or actions.

Depending on the situation, these behavioural dimensions can be realized as excellent functions that improve or facilitate the formation of SA and reasonable actions. An example of this can be considered with the dimension Control of the Environment, whereby an individual's natural way of searching for information, and at the same time maintaining 360-degree control, is to the advantage of achieving optimal SA. Another example of the positive impact of behavioural dimensions is the natural ability to take Initiative and having Operational Flexibility so that as the situation changes, the person has the flexibility to change his or her actions and take the initiative to act appropriately as soon as the situation permits. However, the behavioural dimensions may also make it more difficult to create SA. For example, inherently weak Control of the Environment can be observed when collecting critical information is not consistent, efficient, or complete as seen in cases where areas (e.g., rooms, corners, etc.) are left unexplored.

Behavioural dimensions can also cause actions contrary to the established SA, including irrational, ineffective, and risky activities from the view of bystanders, target persons, officers, or all of the above. Consider an example of a police situation where the information collected clearly shows that a victim is in need of immediate help in the next room. In other words, based on SA, it would be quite clear that the officers should proceed to the next room with determination and speed. However, Withdrawal expressed in a strong form may unnecessarily delay SA-based activities. In this case, behavioural dimensions do not directly effect SA itself, which at this point includes the current understanding (i.e., level 2 of Endsley, 1995) that one should proceed quickly to the next room because if not, someone is going to be in a life-threatening situation (i.e., level 3: prediction from Endsley, 1995). Therefore, the behaviour dimensions may not negatively affect SA formation, but instead the decisions to act accordingly that may result in final outcomes that are contrary to SA. From an educational perspective, these behavioural dimensions might be difficult to observe but their detection would be

particularly important for teaching and learning (see Section 5.2 - Practical Implications).

This study also looked at the possible relationships between the above noted behavioural dimensions and individual personality traits, which were defined as four types: Extraversion, Intuitiveness, Emotionality, and Flexibility. In this sub-study, personality traits were not dichotomized into classes or a 'yes/no' manner but were assessed as a continuum, giving each trait values between 0 and 100. Studies have shown that personality is not a permanent quality but changes over the lifespan (see Helson et al., 2002). In spite of this, it is critical to understand how personality traits may influence an officer's performance of various behavioural dimensions at the time and moment when a skill is being practiced. Understanding how this connection is relevant to the subject to be learned or practiced is important for both the instructor and trainee for giving and receiving feedback.

The study revealed a number of connections between personality traits and the defined behavioural dimensions. The results showed that very strong Extraversion was connected to weakened Control of the Environment and Operational Flexibility. The personality trait Flexibility in its strong form was also negatively linked to the above-mentioned dimensions, and also weakened the ability to take Initiative. In addition to this, powerful Extraversion was also associated with unnecessary Target-Oriented Behaviour. Strong Emotionality, on the other hand, was linked to unnecessary Withdrawal behaviour.

The purpose of this study was not to classify personality traits as "good" or "bad" from a police point it view, but to examine the possible connections between them and relevant behavioural dimensions. For example, Extraversion is understandably an important feature among police; officers are genuinely interested in people and are approachable. Emotionality helps officers to act empathetically in situations where it is beneficial. In this way, it is clear that these specific personality features cannot be considered inappropriate for the police (see Landman et al., 2016). However, there are also operational task situations, as shown in sub-study 2, where certain personality traits can have adverse effects. The consequences of these instances might be a lack of Control of the Environment, exposing the officers to serious risk, or detrimental to the victim in situations where police assistance may be delayed due to unnecessary Withdrawal behaviours. Strong Target-Oriented Behaviour may cause officers to physically take down the first person he or she meets, even though that person has nothing to do with the

situation itself, which would not be good from that person's (or the officer's later) point of view. For these reasons, it is important to identify these connections so that instructors and trainees can have a shared understanding and direct attention towards unbeneficial or risky behaviours in teaching and feedback.

Based on the insights from this sub-study, police behaviour in training (or live operational) situations is understood to not be 'random' but rather is identified and addressed as it relates to the individual's personality. In addition to this, it is now possible to observe that personality features or traits may have direct influence on these defined behavioural dimensions. By helping officers (novice or expert) understand the origins of their own behaviours in a much easier way, these findings also contribute to improved learning through self-reflection (see Honkela et al., 2000). In this way, individual officers are able to recognize his or her own potentially unfavourable habits and behaviour and can thus develop his or her own competence in a more focused and informed way.

As a summary of the above discussion behavioural dimensions in operational police contexts and their origins have been unknown, and therefore it has not been possible to systematically consider these factors in training and giving feedback. Accordingly, a clear understanding of what has happened and why has been lacking at the individual level. On the basis of the information presented in this sub-study, behavioural dimensions can facilitate and improve, or complicate and weaken, the formation of SA and/or the officer's overall performance. The extent to which behavioural dimensions, personality traits, or their established connections influence SA depends on how strongly they are expressed, and upon the officer's own understanding of these factors.

6.4 Sub-study 3

This study revealed the visuomotor patterns used by novice and expert police officers when looking at pictures of various staged encounters. Gaze orientation and searching behaviours on the correct and critical targets are particularly important for police, as situations can genuinely be life-or-death and outcomes can change in milliseconds (Sub-study 1: Di Nota & Huhta, 2019). Man cannot observe and understand all of the surrounding reality at the same time, so the ability to search and discover critical information is an important skill (see Salas et al., 1995; Varila & Rekola, 2003). Gaze behaviour and making observations are the

first stage of SA, meaning early-stage SA according to Endsley's (1995) model, and is the focus of the current sub-study.

Results showed that in the first 5 seconds, participants looked at the target person longer than the surrounding environment, especially the expert officers who tried to collect as much information as possible about the target person and his ability to function. By analyzing the order of gaze fixation, the results show that all participants first fixated on the target person's face. Based on the expert's interview data (see sub-study 4), the fixation should go directly towards the target's hands, but fixating on the face may be such a primitive response that it overrides this explicit knowledge. Fixating on and reading an individual's face (including the direction of their gaze) is also very important for officers, as faces can reveal a target person's mindset or mood. By interpreting facial information, police may also get indications about what a target person might do (Ekman, 1993; Surakka et al., 1998; Hietanen, 1999). For example, when a target person repeatedly draws their gaze to the front door, he may be planning to escape. Similarly, if a target repeatedly gazes at a closet or towards the glove compartment in a car, it may suggest that the target person is nervous about something they are trying to hide from the police (e.g., drugs) or considering something that can be used for harm (e.g., weapon or firearm). In other words, consciously interpreting a target's face can help the third stage of Endley's (1995) SA model that involves predicting what may happen next.

In line with previous studies (Heusler et al., 2020), expert officers fixated on target person's hands faster than novices, even though they unconsciously prioritized faces first. Fast scanning of the hands, including the whole-body area, is a well-known fact and emphasized in police educational training and practice – hands are important. If someone wants to harm an officer, they will use their hands – either empty or holding some object (e.g., knife, firearm). The visuomotor patterns used by experts are particularly important as an enabler of rapid SA. If, for example, an officer fails to see a knife in the target person's hands or on a table next to them, the officer or the bystanders present are exposed to immediate health and life risk if the target person is capable and motivated to harm them. In some situations, if the target person has initiative, the police generally do not have time to respond or act quick enough. This is due to the general laws of physics, where conscious action is always faster than reaction (Blair et al., 2011). Based on the results of this sub-study, it is possible to systematically develop the first phase of SA (Endsley, 1995) and teach more effective strategies for searching and detecting critical

information. As theorized in sub-study 1 (Sub-study 1: Di Nota & Huhta, 2019), the current sub-study identifies adaptive visuomotor patterns that can be taught earlier in an officer's career that will also form a better foundation for SA skills.

6.5 Sub-study 4

This study identifies critical components, themes, or "chunks" relevant to forming police SA in encounter situations. The results were obtained by qualitative analyses of interview data. Expert officers unanimously identified the seven themes in all of the presented encounters and which are defined in the results: Distance/Time Laws, Partner/Roles, Profiling the Suspect, Surrounding Environment and Conditions, Tactical Options and Opportunities, Ongoing Assessment of Own Tactical Activities and Outcomes, and Dangerous Objects. These results can be considered particularly important since the elements of SA formation in police encounter have never been identified or defined before. These themes refer to the most critical elements that officers must detect and interpret to be capable of forming SA.

In brief, Distance/Time Laws means the distance between police and targets and/or between targets and bystanders that officers need to protect, and the time that officers do or do not have. Partner/Roles refers to job roles (i.e., primary role, secondary role), controlling the situation and environment (360-degree) with the help of these roles, which also dictate each officer's Tactical Options. Profiling the Suspect means considering the target person's functional capacity: what they are capable of doing, if he/she is armed, and how fast or strong he/she is. Surrounding Environment and Conditions means the physical reality of the situation (e.g., door, hidden corner, lighting conditions). Tactical Options and Opportunities means police tactical alternatives that take into account the situation as a whole to be either possible or not possible, and upon which the decision to act is mostly based on. Ongoing Assessment of Own Tactical Activities and Outcomes refers to an officer's own action or passivity and their awareness of how these effect a situation (e.g., what may result from targets or bystanders if the officer announces their presence as police; an officer's consideration of the target person's possible reactions to their advancing movements). Dangerous Objects refers to items that are present or possibly present, pose a possible safety risk, and can influence the situation (for exact definitions see sub-study 4).

To date, training in police SA, tactics, and UOF has been limited by poorly defined factors that only describe the phenomena above (and inconsistently so) in a way that is not effective for teaching and learning and which might also be very misleading. A primary challenge has been individual police instructor's subjective experiences that inform quasi-theories that are instructed as 'ultimate truths' without question (see Di Nota et al., 2021b). Instructors may also fail at articulating the specifics of SA, using general, metaphorical, or not concrete language (e.g., "You should feel and taste the situations") or conceptualizing SA using only the term itself (e.g., "Were you situationally aware?"). As a result, SA has remained unfamiliar, unidentifiable, and individualized in a way that even experienced officers have been unable to reflect on their level of SA or develop the skills connected to it, like searching for critical information and interpreting the situation. Through on-the-job training and experience, experienced officers may have built their SA based on the identified themes, but their learning may have been random or inconsistent due to the lack of standard language regarding police-specific SA. The effectiveness of transferring skills learned in such a random and inarticulate manner into real-world situations is also very uncertain (Engström, 2001).

Due to the interconnectedness of the identified themes, this sub-study also emphasizes their combined and integrated instruction. For informing SA, each of the above-mentioned themes need to be identified and considered because changes in one theme's content or interpretation will immediately affect other themes. For example, when profiling a target person's functional capacity as being fast or strong, changes to the Distance/Time Law like relative position will immediately inform the officer's suspect profile. A fast-moving target person will cut the distance between themselves and the officer or a bystander very quickly, which means that even a relatively long distance does not necessarily provide the officers time that would usually be required to reach a safe distance (Nieuwenhuys et al., 2012). Similarly, if the officer does not detect an invisible corner (Surrounding Environment and Conditions) where a target person might be located, the Tactical Option he or she selected may be totally inappropriate for this specific situation and might compromise their operational safety.

As shown in sub-study 4, the current curriculum at the police University College of Finland enhances novice's capabilities for forming SA. This is based on the finding that the Novice 1 group was unable to note almost any of the identified themes while the Novice 2 group was able to identify significantly more themes (which still

varied between zero to seven themes for each image) following their block of tactical and UOF training, which did not systematically teach about SA at the time of the study. To address Objective IV in Research Question 3 of this dissertation, sub-study 4 demonstrates that the current curriculum at the Police University College of Finland positively impacts the development of expertise in SA among novices. The current findings will contribute further to this development by teaching the expert officer's way of forming SA to trainees in early stages of police education. As has already been observed in driving studies (Chapman & Underwood, 1998), novices can be taught to identify critical objects for building SA more quickly. Through increased familiarity, objects can be detected and interpreted faster, which in turn optimizes gaze behaviour and shortens the brain's processing time (Klein, 1993). For this reason, teaching and practicing SA must be precise, systematic, comprehensive, and should be rooted in evidence-based approaches.

Figure 1. Model of situational awareness in police encounters

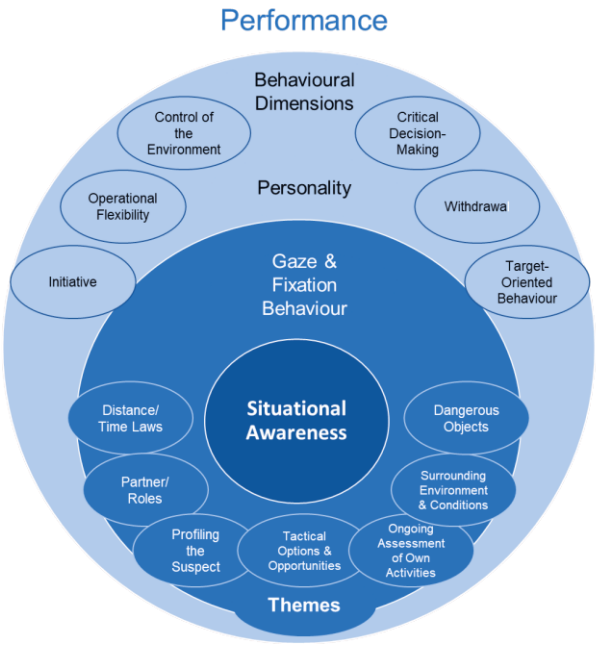

Figure 1, *Model of situational awareness in police encounters* illustrates the defined and conceptualized findings of the dissertation, which have been lacking in applied police research, training, and practice as stated in sub-study 1. The central skill required of all police and the topic of this dissertation is situational awareness (SA), which is placed in the middle of the figure. In police encounters, SA is initially formed by optimal gaze behaviour (sub-study 3) and by evaluating seven themes (sub-study 4), which are described on the second ring. The themes are closely linked and changes or shortcomings in the assessment of a single theme affect the assessment of all other themes and their "correctness". That is, misjudging the Surrounding Environment and Conditions can lead to suboptimal understanding of available Tactical Options and Opportunities and possibly missed Dangerous Objects. The outer circle shows six behavioural dimensions, the intensity of which are connected to inherent personality traits (sub-study 2). Each behavioural dimension may be beneficial or detrimental to the formation of SA, and for performance based on SA. Especially in the case of behavioural dimensions with a strong expression, it may result in performance that is completely against SA, which means that police performance is not good and, at worst, may be entirely random, uninformed, and dangerous. Even if SA would be “perfect”, performance can be incomplete or even totally wrong because personality traits might strengthen (or diminish) behavioural dimensions that directly influence how we choose to act or primitively act without any conscious decision-making. That is, the behavioural dimensions are not something that can be explicitly taught, but instead are meant to provide police instructors with concrete tools to observe and identify these behavioural tendencies to focus and enhance SA training depending on individuals’ personality and learning goals.

6.5.1 The influence of stress on situational awareness training and practice

The presence of stress has an enormous influence on all stages of SA. Previous studies related to police work and stress have shown that when an officer is stressed, their brain and body is not functioning normally or optimally (see Andersen & Gustafsberg, 2016; Anderson et al., 2019; Sub-study 1: Di Nota &

Huhta, 2019; Nieuwenhuys & Oudejans, 2010; 2011). Even the most optimal gaze behaviour does not necessarily provide the accurate interpretation and understanding of critical information, and accordingly does not inform correct SA. People also blink more, experience perceptual distortions, and form observations with delay (i.e., usually after several seconds) in stressful compared to non-stressful situations (Klinger & Brunson, 2009; Andersen & Gustafsberg, 2016). In addition, stress influences the way an individual is able to remember their own performance and actions. From an educational perspective, stress is usually harmful and hinders learning (Lewinski et al., 2016; Sub-study 1: Di Nota & Huhta, 2019; Di Nota et al., 2020).

Stress can also influence the strength of the behavioural dimensions presented in sub-study 2, such that the more stressed an officer is the more their functions are directed by implicit and primitive strategies and traits (Hine et al., 2019; Kahneman, 2003). Under high stress, even being certain about an individual calling for help may not necessarily drive an officer to act with enough determination to save them if Withdrawal behaviour is very strong due to the level of physiological stress and/or dominant personality traits. Even though the participants in sub-study 2 were all novice trainees, these behavioural dimensions should be accounted for and considered even among experienced officers. Based on my 19 years of experience as a police instructor, these behavioural phenomena can be observed regardless of an officer's years of experience or specialized training. In agreement with previous studies related to police behaviours, when stress levels are sufficiently high the person's experience is not relevant to their behaviour (Andersen & Gustafsberg, 2016; Anderson et al., 2019; Di Nota et al., 2021a).

The instruction of stress management skills is, therefore, critical for the acquisition and exploitation of any other policing skills. As stress grows, many of the skills taught are forgotten and/or behaviour and activity being to be guided by the primitive control system. Therefore, SA training must be aimed at developing SA skills to the level of automation (Ericsson, 1998; Ericsson et al., 1993). The negative impact of stress is reduced on automated 'backbone' or 'muscle memory' skills where officers have the opportunity to form realistic SA, even in situations where stress cannot be eliminated or adequately managed (Sub-study 1: Di Nota & Huhta, 2019; Di Nota et al., 2021b).

6.6 Practical implications

6.6.1 Theoretical application to police education

The definition and standardization of the elements that form or effect SA or behaviour enables instructors to systematically teach and train them. The definitions and standards of behavioural dimensions identified in sub-study 2 enables instructors to identify and observe different forms of behaviour. It is no longer necessary to interpret behaviours as random, but they can now be combined and understood in the context of individual personality traits. The instructor is now able to combine weak Control of the Environment, a lack of Flexibility, or a weak ability to take Initiative with the individual's Extraversion and/or Flexibility to better support learning. Now the individual can also be taught to: 1) recognize possible unconscious risky behaviour for him or herself, 2) use more time and consideration to ensure better SA, and 3) base their decisions and actions on SA. In the same way, the findings from sub-studies 3 and 4 can be systematically taught so that trainees understand how the order of gaze behaviour enables them to search for critical information, including the detection and understanding of the seven themes to form more complete SA in operational police encounter situations.

As stated in Chapter 4: Results, responses from study participants indicates that classroom-based training is feasible in the early stages of SA education whereby police situations are simulated with photographs and explained theoretically. In these controlled learning environments, the use of concepts is effective when they can also be presented in written and visual form in addition to spoken language. In this case, different learning styles can be quite easily taken into account in teaching (e.g., visual and auditory learners, see Fleming, 1995). By interpreting displayed images it is possible to teach correct gaze behaviour and motor sequences/ordering, show important areas of interest, and in addition critical information gathering and analysis (e.g., considering how a target person's face, hand, and body features inform their functional capacity and future behaviour). In classroom-based teaching, the means used by experts to form SA (i.e., to teach the seven themes or "chunks" of SA revealed in sub-study 4) can be presented in a multichannel, multimodal fashion. However, in light of neuroscientific studies it should be noted that observation-based training is most effective when the

learner already has a fairly good set of motor skills and experience (Sub-study 1: Di Nota & Huhta, 2019). If this is the case, then observation-based teaching will activate the parts of the brain responsible for live performance (Calvo-Merino et al., 2006; Cross et al., 2009). Thus, observation-based training is most effective among experienced and skilled officers and, in line with the first learning phase of teaching skills at a cognitive level (Fitts & Posner, 1967; Schmidt, 1988), can help beginners learn the basics of new procedural skills before they are physically practiced. As learning and skills progress, training must also be carried out under live conditions (i.e., live simulation-based training) so that there is the greatest possible correlation between training and working life situations (Sub-study 1: Di Nota & Huhta, 2019; Di Nota et al., 2021b).

The aim of all training and development of expertise is to achieve functions that are appropriate, optimal, and as automatic as possible. In accordance with Klein's (1993) theory, experts learn to identify previously experienced and well-known patterns and cues from the target person or environment, which can be used to interpret the situation and predict the future (phase 3 SA, see Endsley, 1995). By using evidence-based educational practices and information, we can plan curriculums and individual training sessions in a way that genuinely achieves learning objectives and develops exactly those skills that officers need in their dangerous and demanding profession.

6.6.2 Practical application to police education: training examples

In police work, there are situations where the officer is required to be able to act quickly (Keampf et al., 1996; Vickers et al., 2012). Therefore, in live training the practice of fast physical arrest is justified. The learning objectives of such a task would include developing interpretation of the situation and decision-making while at the same time practicing taking initiative (i.e., taking action instead of reacting, see Blair et al., 2011). Through these objectives, police are able to achieve fast overtaking before the situation would escalate because of the target person in a way that may harm bystanders. The tactical options for fast physical arrest could include an activity where the officer keeps a far distance, takes time,

prepares him or herself for a use of force tool, and giving the target person orders, for example, to come to the police. When training, instructors should be very precise and sure that the desired option (i.e., fast physical arrest) is achieved based on decision-making that is rooted in SA. It should be noted that this behaviour can also be driven by powerful Target-Oriented Behaviour, which is related to a strongly Extraverted personality type (sub-study 2). Even though the action may have been correct and successful, it was not formed the way it should be (i.e., based on SA-informed decision-making) but instead relied more on primitive responses. On the other hand, reactive actions caused by untrained behavioural dimensions could also be completely wrong. 'Accidentally' right or wrong functions do not promote genuine learning, which means that the training objectives are not achieved, therefore nothing is learned, and skills will not be transferred into the field.

In the above-mentioned training situation, the instructor must determine whether the performance of the trainee was based on SA, including the assessment and evaluation of the seven SA themes (sub-study 4). This includes the instructor's consideration of whether the trainee's actions were based on evaluation of Distance and Profiling the Suspect's ability to act. Thus, instructors should have the knowledge to recognize the manner by which the trainee is able to engage in rapid and secure physical arrest (i.e., informed by SA and not primitive or random behaviour).

In police tactics in general and in accordance with Finnish laws governing the use of force (Police Act 2:17, 22.7.2011/872), the police should avoid situations where the opposing party has the same level of power as the officer. Therefore, the police should not choose milder or equal force options than the nature of the threat caused by the target person as this could lead to the escalation of the situation, risking death to the officer and/or increase the likelihood of using a firearm towards the target person in a case where it could have been avoided by choosing other more appropriate means. In other words, the officer should not choose a telescopic baton in a situation where the target person has a similar or better weapon (i.e., longer and thicker metal tube). Similarly, in the particular exercise mentioned above the officer would not seek fast physical arrest if the target person is considered to be equally or more skilled and strong (unless it is strictly necessary). Therefore, Profiling the Suspect's functional capacity is also very important from a legal point of view.

The instructor must therefore be sure that the target person's face, hands, and waist area had been deliberately scanned and interpreted by the trainee to Profile the Suspect's functional capacity. In addition, the instructor needs to know whether the trainee checked the Surrounding Environment and Conditions in case the target has immediately available Dangerous Objects. That is, the instructor must be aware of whether the trainee consciously fixated their gaze on the right cues to derive critical information. Physical capture would not be wise as a Tactical Option and Opportunity if the target person has a knife in his or her hand or in their immediate vicinity. Of course, the opposite situation may be true whereby the instructor observes that the Dangerous Object is present but not in the immediate vicinity. In this case, the instructor may evaluate that the trainee has sufficient time to execute a physical arrest before the target person can reach the object. Instructors should also be sure that the trainee has fully evaluated the Surrounding Environment and Conditions so that he or she is aware of the possible dark corners that in a worst-case scenario could hide another person or threat (i.e., +1 rule, see Sub-study 2: Huhta et al., 2021).

As a second applied example, there is a different kind of exercise and the trainee's actions are described. In domestic violence training situations, the target person is not compliant with the officer's orders to approach them. After a little while, the target person produces a knife from somewhere, takes it into his hand, and starts to approach the officer. In these circumstances, the trainee is able to flexibly change their tactical options and the content of their orders to command the target person to put the knife away but also make it very clear that if he continues to approach them with the knife, that the officer will use a firearm. In this example, the trainee's actions have so far reflected the behavioural dimensions of Flexibility (i.e., updating orders), Initiative (i.e., content of the revised orders that guide the target person's options for action), and is also in line with basic tactical principles. The trainee was able to inform their SA by using the themes Dangerous Objects, Distance/Time Laws, and Tactical Options and Opportunities.

It is important to note: SA should be formed continuously. Generally speaking, in domestic violence tasks distances are often small. So, officers should be able to continuously identify and evaluate the seven themes. Particularly in these kinds of situations, officers should evaluate whether other features of the Surrounding Environment and Conditions can increase Distance or Time. As the training scenario above continues, there may be an opportunity for the trainee to retreat

even a little bit and, for example, draw a sofa chair in their vicinity between themselves and the target person as an obstacle to slow down their advances. However, the trainee does not have this idea and they do not act accordingly to gain more Distance and Time. Instead, the officer remained passive and held the same position. Why does this happen? It may not be possible for the trainee and instructor to understand what happened, including identifying where and why the trainee's performance started to go wrong, unless there is a commonly shared and understood concept of SA: what it consists of and what may affect it.

The trainee's actions – both optimal and suboptimal – can be understood within the framework offered by the behavioural dimensions (sub-study 2) and SA themes (sub-study 4) defined in the current dissertation. The trainee's initial actions were supported by their capacity for Flexible and Initiative-based behaviour, but they were unable to form SA continuously using all of the identified themes or "chunks". After giving the orders for the target person not to approach them, the trainee stopped forming SA, which led to the situation where the distance between them and the target person was, and remained, too short. In relation to the themes (sub-study 4), the trainee was unable to recognize or evaluate too short of a Distance in relation to their Profile of the Suspect and Dangerous Object. The trainee was also unable to connect the Surrounding Environment and Conditions to their own Tactical Options, and failed to understand how their passivity could influence Ongoing Assessment of their Own Tactical Activities and Outcomes. In this case, it might have led to the situation where the target person was able to charge towards the trainee and harm them. Therefore, it is critical that Ongoing Assessment of Own Tactical Activities and Outcomes also includes consideration of how inactivity might affect the future just as much as active behaviour (level 3 SA, see Endsley, 1995). All officers and especially police instructions should have an understanding of, and capability to, combine the factors addressed in this dissertation, which directly affect SA formation and may also cause behaviour that is against it.

Police instructors should also note that despite optimal SA, performance can be irrational and completely wrong. As Endsley (1995) has stated, performance can be poor even though SA is optimal and vice versa that performance can be good even if SA is incomplete. Accordingly, instructors should be aware that optimal outcomes may have occurred by accident or luck, meaning that during the performance/situation there may have been serious lapses in SA, even if those factors did not lead the situation to easily observable or identifiable danger. If

incomplete or misinformed actions do not cause a negative end result in training or field situations, we should still understand that a negative result could have been possible. Therefore, it is just as important to give detailed feedback on all of the factors that led to a good outcome as it is for negative outcomes. In this way, instructors and trainees can learn, recognize, and understand all aspects of the entire situation and not only the final outcome (Di Nota et al., 2021a; 2021b).

If the instructor and trainee are unable to recognize risky situational factors and all the necessary learning objectives for SA, the activity cannot naturally be developed and individuals may think that the trainee's level of competence is better than it actually is. Perhaps the most damaging consequence of the failure to recognize incomplete SA and performance in training situations is incorrect learning that can, at worst, cause serious and unnecessary life and health risk to bystanders, target persons, and the officer themselves. Connected to the previous training example, if staying still does not lead to identifiable danger in a situation where it would otherwise be absolutely important to gain more Distance or Time by moving or through other manoeuvres (e.g., using the Surrounding Environment and Conditions to drag the sofa between the officer and target person), the officer would not gain an understanding of the meaning of Distance and Time Laws, and may not try to gain these elements when needed in the future. This kind of incomplete training and the experience from it actually weakens the officer's professional competence and work safety. Therefore, in teaching and training we should clearly understand where, how, and why performance was successful or unsuccessful based on SA, what activities should be improved, what factors may have been overlooked, and what may have been misunderstood. In this way, future training can be enhanced by focusing instructor feedback to meaningfully address the trainee's specific developmental needs.

6.7 Limitations and future prospects

In sub-study 2, the connection between personality and behavioural dimensions was only conducted on police trainees, thus results cannot be directly generalized to experienced officers. Previous studies and my own direct observations as a police instructor for nearly 20 years have shown that

experienced officers can behave illogically and against SA in stressful situations (Andersen & Gustafsberg, 2016), which means that some factors other than SA drives their behaviour. Based on this idea, it might be reasonable to assume that behavioural dimensions and their connections to personality traits also affect the actions of experienced officers, which should be the subject of future studies.

In sub-study 3, gaze behaviour only measured the time that participants spent on the target person versus the environment, fixation order, and the study was conducted in a classroom setting with minimal stress. Even more relevant and concrete information about naturalistic gaze behaviour might have been found if the study was conducted in a live training environment with wearable eye tracking glasses (e.g., Nieuwenhuys & Oudejans, 2010, 2011). In addition, as eye tracking technology continues to develop it will be possible to gain more precise information about where officers look and connect this information to real police work situations.

Sub-study 4 found and identified themes that were based on a Finnish policing context and expressed in the Finnish language. It is very possible that when using another language, the content of the themes could be different. The role of language in human thinking, cognition, and reasoning is a well-known fact and as such the importance of language in forming the themes cannot be overlooked. For example, Distance and Time Laws was considered as a single theme as it conveyed highly related information. Humans are fundamentally the same across languages and cultures; we have one brain, a body, two hands, and legs that provide the same manner for collecting information. Physical laws like time and action versus reaction are also universal. However, it is possible that when expressed in a different language this theme could have been considered two separate factors and not one as in this sub-study. If expressed in another richer or more simplified language, the content of these themes could have been divided or combined differently, which would have influenced the number of identified themes to, for example, six or eight and not seven as defined in the current sub-study.

In addition to the limitations provided here, police behaviour and SA formation is likely affected by factors other than the ones identified in this dissertation. One possible factor might be an individual's self-perceived action competence, whereby an individual who perceives themselves to be more or less competent than they actually are may form their SA differently from another officer, even if all other external information and situational factors are the same. Based on the current state of knowledge summarized in sub-study 1, it is important to continue

targeted investigations into police SA and all the factors within it, including those factors that may cause behaviour that is against it. Through continued research and delivery of evidence-based education, we can equalize the professional skill set used by officers around the world and better prepare them to safely carry out their duties that in turn will enhance their ability to protect and serve the public.

7 CONCLUSION

The aim of this dissertation was to fill a gap in research and practice related to police-specific situational awareness (SA). This research reveals novel, genuine, and important knowledge that reconceptualizes SA required in police work encounters so that its teaching and training can be done in a way that is supported by our brain structure (i.e., in understandable discrete “chunks”) as was informed by sub-study 1. This work identifies and defines outwardly observable behavioural dimensions that can support or hinder SA formation and evaluates their connection to individual personality traits (sub-study 2). Clarifying these relationships also provides an understanding of why certain behaviours occur that are totally against SA. This dissertation was also able to produce objective data about gaze and fixation behaviour that represent the early stage of SA (level 1 – perception, Endsley, 1995, sub-study 3). Finally, this dissertation revealed and clearly defined seven themes that are used to create SA in police encounters, and relevant examples in applied police settings were provided. Considered together, these findings are valuable for enhancing evidence-based police training in SA, tactics, and use of force in Finland and around the globe.

REFERENCE

Aamodt, M. G. (2004). Special issue on using MMPI-2 scale configurations in law enforcement selection: Introduction and meta-analysis. Applied HRM Research, 9(2), 41-52.

Andersen, J. P., & Gustafsberg, H. (2016). A training method to improve police use of force decision making: a randomized controlled trial. *Sage Open*, *6*(2), https://doi.org/10.1177/2158244016638708

Anderson, G. S., Di Nota, P. M., Metz, G. A. S., & Andersen, J. P. (2019). The impact of acute stress physiology on skilled motor performance: Implications for policing. Frontiers in psychology, 10, 2501:1–11. https://doi.org/10.3389/fpsyg.2019.02501

Anttila, P. (1996). Tutkimisen taito ja tiedon hankinta [Skills of research and acquisition of knowledge]. *Helsinki: Akatiimi*.

Blair, J.P.; Pollock, J.; Montague, D.; Nichols, T.; Curnutt, J.; Burns, D. (2011). Reasonableness and reaction time. Police Q. 14 (4):323–343. https://doi.org/10.1177/1098611111423737

Chapman, P. R., & Underwood, G. (1998). Visual search of dynamic scenes: Event types and the role of experience in viewing driving situations. Eye guidance in reading and scene perception, 369-393.

Calvo-Merino, B., Grèzes, J., Glaser, D. E., Passingham, R. E., & Haggard, P. (2006). Seeing or doing? Influence of visual and motor familiarity in action observation. Current biology, 16(19), 1905-1910. https://doi.org/10.1016/j.cub.2006.07.065

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). Thousand Oaks, CA: Sage.

Cross, E. S., Kraemer, D. J., Hamilton, A. F. D. C., Kelley, W. M., & Grafton, S. T. (2009). Sensitivity of the action observation network to physical and observational

learning. Cerebral cortex, 19(2), 315-326.enneheus. https://doi.org/10.1093/cercor/bhn083

Di Nota, P. M. (2017). Short-and long-term changes in attention, memory and brain activity following exercise, motor learning, and expertise. Dissertation. Toronto, (ON): York University.

Di Nota, P. M., & Huhta, J. M. (2019). Complex motor learning and police training: applied, cognitive, and clinical perspectives. Frontiers in Psychology, 10, 1797. https://doi.org/10.3389/fpsyg.2019.01797

Di Nota, P.M., Stoliker, B., Vaughan, A., Andersen, J.P., & Anderson, G.S. (2020). Stress and memory: A systematic state-of-the-art review with evidence-gathering recommendations for police. Policing: An International Journal, 44(1), 1-17. https://doi.org/10.1108/PIJPSM-06-2020-0093.

Di Nota, P.M.; Chan, J.F.; Huhta, J.-M.; Andersen, J.P. (2021a) Considering Objective and Subjective Measures for Police Use of Force Evaluation. Int. J. Environ. Res. Public Health 2021, 18, 5351. https://doi. org/10.3390/ijerph18105351

Di Nota, P. M., Andersen, J. P., Huhta, J. M., & Gustafsberg, H. (2021b). Evidence-based instruction of police use of force: Practical methods and pedagogical principles. In In E. P. Arble & B. B. Arnetz (Eds.), Interventions, Training, and Technologies for Improved Police Well-Being and Performance (pp. 72-101). Information Science Reference/IGI Global. https://doi.org/10.4018/978-1-7998-6820-0.ch005

Doane, S. M., Pellegrino, J. W., and Klatzky, R. L. (1990). Expertise in a computer operating system: conceptualization and performance. Hum. Comput. Interact. 5, 267–304. doi: 10.1207/s15327051hci0502&3_5

Gallivan, J. P., Chapman, C. S., Wolpert, D. M., & Flanagan, J. R. (2018). Decision-making in sensorimotor control. Nature Reviews Neuroscience, 19(9), 519-534.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. Human Factors, 37(1), 32–64. https://doi.org/10.1518/001872095779049543

Endsley, M. R. (1999). Situation awareness and human error: Designing to support human performance. In: Proceedings of the High Consequence System Surety Conference, pp. 2–9. Sandia National Laboratory.

Endsley, M. R. (2012). Situation awareness. In G. Salvendy (Ed.), Handbook of human factors and ergonomics (4th ed.). John Wiley & Sons, pp. 553–568.

Engeström, Y. (2001). Kehittävä siirtovaikutus: mitä ja miksi [Developmental transfer effect: what and why]. Teoksessa T. Tuomi-Gröhn & Y. Engeström (toim.) Koulun ja työn rajavyöhykkeellä. Uusia työssä oppimisen mahdollisuuksia. Helsinki: Yliopistopaino, 19-27.

Ericsson, K. A., Chase, W. G., and Faloon, S. (1980). Acquisition of a memory skill. Science 208, 1181–1182. doi: 10.1126/science.7375930

Ericsson, K. A., Krampe, R. T., and Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. Psychol. Rev. 100, 363–406. doi: 10.1037/0033-295X.100.3.363

Ericsson, K. A., and Lehmann, A. C. (1996). Expert and exceptional performance: evidence of maximal adaptation to task constraints. Annu. Rev. Psychol. 47, 273–305. doi: 10.1146/annurev.psych.47.1.273

Ericsson, K. A. (1998). The scientific study of expert levels of performance: general implications for optimal learning and creativity. High Abil. Stud. 9, 75–100. doi: 10.1080/1359813980090106

Ericsson, K. A. (2004). Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. Acad. Med. 79, S70–S81. doi: 10.1097/00001888-200410001-00022

Ekman, P. (1993). Facial expression and emotion. American psychologist, 48(4), 384.

Fitts, P. M. & Posner, M. I. (1967). Human Performance. Belmont, CA: Brooks/ Cole

Fleming, N. D. (1995). I'm different; not dumb. Modes of presentation (VARK) in the tertiary classroom. In Research and development in higher education, Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia (HERDSA), HERDSA (Vol. 18, pp. 308-313).

Gallivan, J. P., Chapman, C. S., Wolpert, D. M., & Flanagan, J. R. (2018). Decision-making in sensorimotor control. Nature Reviews Neuroscience, 19(9), 519-534.

Ghazinour, M., Padyab, M., Lauritz, L. E., & Richter, J. (2019). Personality and mental health changes throughout the course of university police training in Sweden. Nordisk politiforskning, 6(1), 7–23. https://doi.org/10.18261/issn.1894-8693-2019-01-03

Haaparanta, L., & Niiniluoto, I. (2016). Johdatus tieteelliseen ajatteluun [Introduction to scientific thinking]. Helsinki: Gaudeamus.

Haldin-Herrgård, T. M., & Salo, P. (2008). Piilevien voimavarojen ilmaisemisesta hiljaisessa osaamisessa [Expression of hidden resources in quiet knowledge]. Kansavalistusseura.

Helson, R., Jones, C., & Kwan, V. S. (2002). Personality change over 40 years of adulthood: Hierarchical linear modeling analyses of two longitudinal samples. Journal of Personality and Social Psychology, 83(3), 752–766. https://doi.org/10.1037/0022-3514.83.3.752

Henson, B., Reyns, B. W., Klahm, C. F., & Frank, J. (2010). Do good recruits make good cops? Problems predicting and measuring academy and street-level success. Police Quarterly, 13(1), 5–26. https://doi.org/10.1177/1098611109357320

Heusler, B.; Sutter, C. (2018). Gaze Control in Law Enforcement: Comparing a Tactical Police Unit to Patrol Officers. J. Police Crim. Psychol. 1–17. [CrossRef]

Hietanen, J. K. (1999). Does your gaze direction and head orientation shift my visual attention?. Neuroreport, 10(16), 3443-3447.

Hine, K. A., Porter, L. E., Westera, N. J., Alpert, G. P., & Allen, A. (2018). Exploring police use of force decision-making processes and impairments using a naturalistic decision-making approach. Criminal Justice and Behavior, 45(11), 1782–1801. doi:10.1177/0093854818789726

Hine, K. A., Porter, L. E., Westera, N. J., Alpert, G. P., & Allen, A. (2019). What were they thinking? Factors influencing police recruits' decisions about force. Policing and society, 29(6), 673-691. https://doi.org/10.1080/10439463.2018.1432612.

Hirsjärvi, S. & Hurme, H. (2008). Tutkimushaastattelu [Research interview]. . Helsinki: Yliopistopaino.

Holma, K. (2004). Plurealism and education: Israel Scheffler's synthesis and its presumable educational implications. Educational Theory, 54(4), 419-430. https://doi.org/10.1111/j.0013-2004.2004.00028.x

Honkela, T., Leinonen, T., Lonka, K., & Raike, A. (2000). Self-organizing maps and constructive learning. In Proceedings of the International Conference on Educational Uses of Communication and Information Technologies, ICEUT (pp. 339–343).

Huhta, J. M., Nota, P. M. D., Nyman, M., Pietilä, E., & Ropo, E. (2021). Universal police behaviours during critical incidents and their connection to personality: A preliminary study. *Nordic Journal of Studies in Policing*, *8*(1), 1-18. https://doi.org/10.18261/issn.2703-7045-2021-01-04

Huhta, J. M., Di Nota, P. M., Surakka, V., Isokoski, P., & Ropo, E. (2022). Experience-dependent effects to situational awareness in police officers: an eye tracking study. *International journal of environmental research and public health*, *19*(9), 5047. DOI: 10.3390/ijerph19095047

Huhta, JM., Di Nota, P.M., Hietanen, T., & Ropo, E. (2023). Deriving Expert Knowledge of Situational Awareness in Policing: a Mixed-Methods Study. Journal of Police and Criminal Psychology. https://doi.org/10.1007/s11896-023-09574-6

Järvinen, A. & Koivisto, T. & Poikela, E (2002) Oppiminen työssä ja työyhteisössä [Learning at work and work community]. Juva: WS Bookwell

Kahneman, D. (2003). A perspective on judgement and choice: mapping bounded rationality. Am. Psychol. 58, 697–720. doi: 10.1037/0003-066X.58.9.697

Keskinen, E. (1995). Taitojen oppiminen [Learning skills]. In Kuusinen, J (toim.) Kasvatuspsykologia [Education psychology]. Juva:WSOY:n graafiset laitokset, 70 – 94.

Klein, G. A. (1989). Strategies of decision making. Yellow Springs, OH: Klein Associates Inc.

Klein, G. A. (1993). A recognition-primed decision (RPD) model of rapid decision making. Decision making in action: Models and methods, 5(4), 138-147. Ablex Publishing Corporation

Keampf, G.L.; Klein, G.; Thordsen, M.L.; Wolf, S. (1996). Decision making in complex naval command-and-control environments. Hum. Factors 38, 220–231. [CrossRef]

Klinger, D. A., & Brunson, R. K. (2009). Police officers' perceptual distortions during lethal force situations: Informing the reasonableness standard. Criminology & Public Policy, 8(1), 117-140. https://doi.org/10.1111/j.1745-9133.2009.00537.x

Laguna, L., Agliotta, J., & Mannon, S. (2015). Pre-employment screening of police officers: Limitations of the MMP-2 K-scale as a useful predictor of the performance. Journal of Police and Criminal Psychology, 30(1), 1–5. https://doi.org/10.1007/s11896-013-9135-9

Landman, A., Nieuwenhuys, A., & Oudejans, R. R. (2016). The impact of personality traits and professional experience on police officers' shooting performance under pressure. Ergonomics, 59(7), 950–961.

Lewinski, W. J., Dysterheft, J. L., Priem M. M., & Pettitt, R. W. (2016). Police officers' actual vs. recalled path of travel in response to a threatening traffic stop scenario. Police Practice and Research, 17(1), 51–67. https://doi.org/10.1080/15614263.2014.959950

Martela, F. (2019). A pragmatist inquiry into the art of living: Seeking reasonable and life-enhancing values within the fallible human condition. *Publications of the Faculty of Social Sciences*.

Metsämuuronen, J. (2006). Metedologian perusteet ihmistieteissä [The basics of methology in human science]. Teoksessa Metsämuuronen, J (toim.) Laadullisen tutkimuksen käsikirja [Manual of Qualitative Research]. Jyväskylä: Gummerus Kirjapaino Oy, 16-77.

Määttänen, P. (2009) Toiminta ja kokemus: Pragmatistisen terveen järjen filosofia.[Action and experience: The philosophy of Pragmatistic common sense.] Helsinki: Gaudeamus.

Nieuwenhuys, A.; Oudejans, R.R. (2010). Effects of anxiety on handgun shooting behavior of police officers: A pilot study. Anxiety Stress Coping 23, 225–233. [CrossRef]

Nieuwenhuys, A.; Oudejans, R.R. (2011). Training with anxiety: Short-and long-term effects on police officers' shooting behavior under pressure. Cogn. Processing 12, 277–288. [CrossRef]

Nikander, P. (2010). Laadullisten aineistojen litterointi, kääntäminen ja validiteetti [Littering, translation and validity of quality materials]. (pp. 432-445). Vastapaino.

Nummenmaa, T., Konttinen, R., Kuusinen, J., & Leskinen, E. (1997). Tutkimusaineiston analyysi [Analysis of research material]. Porvoo: Wsoy.

Ones, D. S., Viswesvaran, C., & Dilchert, S. (2005). Personality at work: Raising awareness and correcting misconceptions. Human Performance, 18, 389–404. https://doi.org/10.1207/s15327043hup1804_5

Patton, M. Q. (2002). Two decades of developments in qualitative inquiry: A personal, experiential perspective. Qualitative social work, 1(3), 261-283.

Peirce, Charles S. (1877/2001). Kuinka käsityksiä muodostetaan [How to form ideas]. Teoksessa C.S. Peirce (2001) Johdatus tieteen logiikkaan ja muita kirjoituksia [Introduction to scientific logic and other writings]. Suom. Markus Lång. Tampere: Vastapaino, 127−150.

Pihlström, S. (2008). Pragmatismi filosofisena perinteenä [Pragmatism as a philosophical tradition]. Teoksessa Kilpinen, E., Kivinen, O. & Pihlström, S. (toim.) Pragmatismi filosofiassa ja yhteiskuntatieteissä [Pragmatism in Philosophy and Social Sciences]. Helsinki: Gaudeamus, 21−51.

Puolimatka, T. (1995). Kasvatus ja filosofia [Education and philosophy].. Helsinki: Kirjayhtymä.

Rauste-von Wright, M.-L., and Wright, J. (1994). Oppiminen ja koulutus [Learning and education]. Juva: WSOY:n graafisetlaitokset.

Riabacke A. & Riabacke M. (2015). Päätöksenteko [Decision-making]. Talentum. ISBN: 9789521422607

Richardson, D. W., Cave, S. B., & La Grange, L. (2007). Prediction of police officer performance among New Mexico State Police as assessed by the Personality Assessment Inventory. Journal of Police and Criminal Psychology, 22(2), 84–90.

Ropo, E. (1991). Opettajaeksperttiyden kehittyminen–tutkimustuloksia ja näkökulmia [Developing teacher expertise–research results and perspectives]. Aikuiskasvatus 11, 153–163

Salas, E., Bowers, C. A., and Cannon-Bowers, J. A. (1995). Military team research: 10 years of progress. Mil. Psychol. 7, 55–75. doi: 10.1207/s15327876mp0702_2

Sanders, B. A. (2008). Using personality traits to predict police officer performance. Policing: An International Journal of Police Strategies & Management. Vol. 31, 129-147. https://doi.org/10.1108/13639510810852611

Saurama, E. (2016). Sosiaalityön käytäntötutkimus ja pragmatismi [Social work practice research and pragmatism]. In Satka, M., Julkununen, I., Kääriäinen, A.,

Polanyi, M. (1966). The tacit dimension. Doubleday & Company

Saus, E. R., Johnsen, B. H., Eid, J., Riisem, P. K., Andersen, R., & Thayer, J. F. (2006). The effect of brief situational awareness training in a police shooting simulator: An experimental study. *Military psychology*, *18*(sup1), S3-S21.

Schmidt, R. A. (1975). Motor skills. NY: Harper and Row.

Schmidt, R. A. (1988). Motor control and learning. 2nd ed. Champaign, IL: Human Kinetics.

Schimdt R, Wrisberg D, (2004). Motor Learning and Performance, Human Kinetics USA

Schwandt, T. A., Lincoln, Y. S., & Guba, E. G. (2007). Judging interpretations: But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. New directions for evaluation, 2007(114), 11-25.

Shortland N., Alison L., Barrett-Pink C. (2018). Military (in) decision-making process: A psychological framework to examine decision inertia in military operations. Theor Issues Ergon Sci 19(6):752–772. https://doi.org/10.1080/1463922X.2018.1497726

Siljander, P. (2014). Systemaattinen johdatus kasvatustieteeseen, Peruskäsitteet ja pääsuuntaukset [Systematic introduction to education, Basic concepts and main trends]. Tampere: Vastapaino.

Stanton, N. A., Chambers, P. R., & Piggott, J. (2001). Situational awareness and safety. *Safety science*,*39*(3), 189-204.

Stanton, N. A., Salmon, P. M., Walker, G. H., Salas, E., & Hancock, P. A. (2017). State-of-science: situation awareness in individuals, teams and systems. Ergonomics, 60(4), 449-466.

Surakka, V., & Hietanen, J. K. (1998). Facial and emotional reactions to Duchenne and non-Duchenne smiles. International journal of psychophysiology, 29(1), 23-33.

Tashakkori, A., & Teddlie, C. (Eds.). (2010). *Sage handbook of mixed methods in social & behavioral research*. Sage.

Tuominen, M., & Wihersaari, J. (2006). *Ammattikasvatusfilosofia [Professional Education Philosophy]*. Okka, Opetus-, kasvatus-ja koulutusalojen säätiö.

Tuomisto, J. (1998). Arkipäivän oppiminen aikuiskasvatuksen ja elinikäisen oppimisen kontekstissa [Learning everyday in the context of adult education and lifelong learning]. In Sallila, P & Vaherva, T (toim.) Arkipäivän oppiminen [It's day-to-day learning]. Aikuiskasvatuksen 39. vuosikirja [The 39th Yearbook of Adult Education]. Helsinki: BTJ Kirjastopalvelu Oy, 30- 58.

Twersky-Glasner, A. (2005). Police personality: What is it and why are they like that? Journal of Police and Criminal Psychology, 20(1), 56–67. https://doi.org/10.1007/BF02806707

Varila, J., and Rekola, H. (2003). Mitä on työssä oppiminen: teoreettisia ja empiirisiä näkökulmia työssä oppimiseen [What is learning at work: Theoretical and empirical perspectives on learning at work]. Joensuu: Joensuun yliopisto.

Varto, J. (2011). Miksi miettiä metodologioita [Why Meditate on Methodologies]. Teoksessa K. Holma & K. Mälkki (toim.) Tutkimusmatkalla. Metodologia, teoria ja filosofia kasvatustutkimuksessa [In K. Holma & K. Mälkki (eds.) on an expedition. Methodology, theory and philosophy in education research]. Helsinki: Gaudeamus, 13-24.

Vicente, K. J., and Wang, J. H. (1998). An ecological theory of expertise effects in memory recall. Psychol. Rev. 105, 33–57. doi: 10.1037/0033-295X.105.1.33

Vickers, J. N., & Lewinski, W. (2012). Performing under pressure: Gaze control, decision making and shooting performance of elite and rookie police officers. Human Movement Science, 31(1), 101-117. https://doi.org/10.1016/j.humov.2011.04.004.

Zacks, J. M., and Sargent, J. Q. (2010). “Chapter 7–event perception: a theory and its application to clinical neuroscience” in Introduction to functional magnetic resonance imaging. 1st Edn. Vol. 53. ed. B. Ross (Burlington: Elsevier Inc.), 253–299

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The independent empirical study was designed and carried (conceptualization; methodology, quantitative analysis and data curation) by first author Juha-Matti Huhta. Co-authors contributed by providing assistant and comments. The manuscript was written and submitted by the first author Juha-Matti Huhta with co-operation with Paula Di Nota.

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Complex Motor Learning and Police Training: Applied, Cognitive, and Clinical Perspectives

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The practices surrounding police training of complex motor skills, including the use of force, varies greatly around the world, and even over the course of an officer's career. As the nature of policing changes with society and the advancement of science and technology, so should the training practices that officers undertake at both central (i.e., police academy basic recruit training) and local (i.e., individual agency or precinct) levels. The following review is intended to bridge the gap between scientific knowledge and applied practice to inform best practices for training complex motor skills that are unique and critical to law enforcement, including the use of lethal force. We begin by providing a basic understanding of the fundamental cognitive processes underlying motor learning, from novel skill acquisition to complex behaviors including situational awareness, and decision-making that precede and inform action. Motor learning, memory, and perception are then discussed within the context of occupationally relevant stress, with a review of evidence-based training practices that promote officer performance and physiological responses to stress during high-stakes encounters. A lack of applied research identifying the neurophysiological mechanisms underlying motor learning in police is inferred from a review of evidence from various clinical populations suffering from disorders of cognitive and motor systems, including Alzheimer's and Parkinson's disease and stroke. We conclude this review by identifying practical, organizational, and systemic challenges to implementing evidence-based practices in policing and provide recommendations for best practices that will promote training effectiveness and occupational safety of end-users (i.e., police trainers and officers).

Keywords: procedural learning, motor learning, plasticity, training, stress, physiology, occupational health, police

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Law enforcement personnel including police officers rely on several types of information as they go about their duties and daily routines; external cues from the environment, internal physiology, declarative memory of laws and regulations, and implicitly learned tactical skills. Police are also entrusted to resolve potentially dangerous or violent encounters, in some cases necessitating the use of force. As a result, law enforcement personnel are exposed to high levels of occupational stress, which have been shown to pose risks to

physical and mental health (Carleton et al., 2018, 2019; Planche et al., 2019). Policing skills, including physical capabilities and mental resiliency, are modifiable by training and experience and have an influence on police decision-making and performance in the field. To bridge the gap between empirical research and applied practice, we begin this review by describing initial learning processes (i.e., basic skill acquisition) before reviewing motor learning of specialized physical skills relevant to law enforcement. Specifically, we propose that situational awareness and decision-making are essential motor skills for policing that integrate sensory, motor, and cognitive functioning. The neurophysiological processes underlying procedural motor learning will be integrated throughout these discussions. Then, we show how occupationally relevant stress influences police performance, and has been adaptively integrated into state-of-the-art training to promote motor learning outcomes. Next, evidence from various clinical populations will be reviewed to identify cognitive and neurophysiological mechanisms that are important for procedural motor learning among police. Finally, we conclude our review by identifying practical, organizational, and systemic challenges to implementing evidence-based police practices and put forth recommendations to overcoming these challenges that will improve training effectiveness and direct future work.

Before we begin, the authors would like to emphasize that this review is not intended to criticize or condemn any current practices. Rather, the following review is intended to provide an accessible summary of what happens in the brain during complex motor learning (i.e., police training), as well as during real-world police encounters that induce physiological stress responses that directly influence whether training is recalled during in-the-moment decision-making. Our hope is that police trainers and curriculum developers will use this information to inform, update, or improve understanding of current training practices to maximize learning outcomes. As society, technology, and scientific knowledge continue to advance, so should police training practices for the purpose of maintaining public and occupational safety.

APPLIED MOTOR LEARNING IN LAW ENFORCEMENT

The manner by which police officers learn motor skills is no different from other humans simply because of their occupation–they have to progress from initial skill learning to high proficiency using the same neurophysiological processes as experts in other domains. To acquire this expertise, police officers must undergo rigorous training and acquire experience in the field. In addition to learning specific motor skills such as firearm handling and hands-on tactics, police officers must also train visuomotor networks involved in situational awareness. Together with past experiences (in training and on the job) and individual action competencies, an officer's perceptual assessments implicitly inform complex decision-making for choosing the most appropriate motor command during dynamic and unpredictable encounters. Neural mechanisms underlying effective police training methods remain unknown and will be inferred from fundamental science and research on clinical populations that experience breakdowns in the cognitive and neurological mechanisms that facilitate motor learning and memory.

Early Motor Learning: Basic Competency and Novel Skill Acquisition

Skill acquisition and motor learning come with experience, which includes problem-solving through individual trial-and-error or during training with supervisors, teachers, or colleagues. Using firearm skills training as an example, new recruits (presumably without any prior experience with firearms) will carefully observe and model the behaviors of their instructor. A crucial step in the process of motor learning is the ability to define, understand, and remember the ordered sequence of observed movements (**Figure 1**). In order to do so, sensory-motor and memory regions of the brain are recruited to help break down continuous streams of motion (as well as music and language, see Zacks et al., 2009a; Francois and Schön, 2011; Lerner et al., 2011) into component "chunks" (Zacks and Sargent, 2010). Motor chunks begin and end with event borders that are typically marked by distinct kinematic movement parameters, including changes in position or location, speed, and direction of movement and also perceived changes in goals and intentions (Zacks et al., 2009b, 2010; Hemeren and Thill, 2011).

To continue with our previous example, drawing one's firearm requires a set of discrete movements or chunks, including reaching down, releasing the gun from the holster, pulling the gun up from the holster to the chest and pushing it straight with the arms to the firing position, and aiming at a target. Segmenting motor sequences in this way facilitate early motor learning and gaining competence in smaller, more manageable units of information (Ericsson et al., 1980; Gobet and Simon, 1998; Bo and Seidler, 2009). With continued training, motor chunks can be grouped or "concatenated" into longer sequences (Sakai et al., 2003; Bläsing, 2015) that can be performed and recalled with less mental effort. Although it has not been directly investigated in police, one could hypothesize that experienced officers would identify fewer and larger chunks of component actions (e.g., a single motion for "pointing a firearm") based on these previous findings. Future applied research on police segmentation behaviors would clarify the relationship between multisensory perception, motor learning, and memory. All of these cognitive processes are especially relevant for police, whose decision-making (i.e., motor selection) is guided by assessment of the environment, current physiological status (e.g., stressed, fatigued), and prior experience.

Reinforcing Motor Learning in the Brain

Our brains have evolved a highly sophisticated and complex network of brain areas that facilitate imitation-based learning.

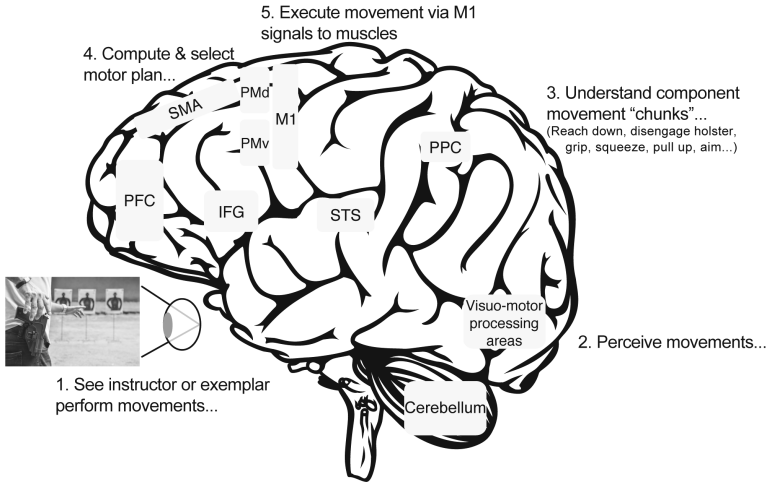

FIGURE 1 | Transforming vision into action. Regions of the mirror neuron network (MNN) are independently responsible for a myriad of functions, including sensory perception, language processing, transforming external information onto internal body-centered reference frames, and planning and executing movements. Through repeated practice, the neuronal pattern of activation (or "motor representation") underlying a novel movement is recalibrated and reinforced or consolidated into long-term memory. IFG, inferior frontal gyrus; M1, primary motor cortex; PFC, prefrontal cortex; PMd, dorsal premotor cortex; PMv, ventral premotor cortex; PPC, posterior parietal cortex; SMA, supplementary motor area; STS, superior temporal sulcus.

Giving credence to the old adage "monkey see, monkey do", researchers unintentionally discovered the "mirror neuron network" (MNN, **Figure 1**) during neurophysiological investigations on reaching behaviors in monkeys (Gallese et al., 1996; Rizzolatti et al., 1996). Based on subsequent research in both animals and humans, the MNN has been shown to facilitate imitation-based learning by way of transforming observed or verbally instructed movements into a physically embodied action (for contemporary critical review, see Kilner and Lemon, 2013). Behavior is typically associated with the ability to execute a given movement but also involves observing and thinking about movement(s) through visualization or planning. That is, an officer's MNN is activated while they are using their firearm, when they observe an instructor use their firearm, as well as when they visualize themselves using their firearm (Grèzes and Decety, 2001).

Based on common activation of the MNN during observation, visualization, and execution of movement, it begs the question: Can motor learning be achieved without physical practice? Several researchers have directly compared training gains across these paradigms for simple movement sequences (e.g., finger tapping). While similar performance gains (Hird et al., 1991), force gains, muscular motor-evoked potentials (Yue and Cole, 1992; Mattar and Gribble, 2005; Porro et al., 2007), and neural activation (Cisek and Kalaska, 2004) were found during observation- and visualization-based training paradigms, these measures and physical competency were less than movement-based training. Therefore, the neurophysiological connections enabling successful motor learning cannot be achieved to the same degree without physical practice[1].

Brain regions comprising the MNN in humans include ventral and dorsal premotor cortices (Binkofski and Buccino, 2006), intraparietal sulcus, superior parietal lobe (Filimon et al., 2007), inferior parietal lobule, inferior frontal gyrus (Broca's area), cingulate gyrus, cerebellum, superior temporal sulcus (Iacoboni et al., 2001), supplementary motor area (SMA), and primary motor cortex (M1). Individually, these nodes are functionally related to sensory, motor, language, attention, and memory processing (**Figure 1**). Together, the MNN transforms and maps externally perceived movement onto internal body-centered reference frames. Premotor cortices and SMA are primarily responsible for computing the desired motor plan, which is set into motion by triggering activation of M1 neurons that directly innervate corresponding muscle groups (for review, see Gallivan and Culham, 2015). There has been some debate regarding the activation of M1 and SMA during observation and visualization when motor output signals are inhibited and no overt movement occurs (Roth et al., 1996; Grèzes and Decety, 2001). Nonetheless, these nodes have shown reliable activation during all three types of movement processing to enable transformation of sensory and cognitive information into motor commands.

[1]Some of the noted benefits of visualization (or mental imagery, motor imagery, or mental simulation) include the rehearsal of visual, motor/kinesthetic, spatial, and symbolic aspects of a given movement in the absence of overt movement (Sherwood and Lee, 2003). Visualization as a proposed component of intuitive decision-making and an effective training tool in the context of policing are discussed below.

A given movement, such as drawing one's firearm, is coded as a very specific pattern of neural activation in the MNN, referred to in the scientific literature as a "motor representation." Once a given movement is performed (e.g., drawing, aiming, and firing a firearm), there is immediate visual feedback regarding whether the outcome was successful or not. These "incoming" visual signals, or *reafferents*, are compared to predictive "outgoing" *efference copy* signals that are generated by the brain during movement preparation (Blakemore et al., 1998; Rizzolatti et al., 1998; DeSouza et al., 2003). When predicted and actual movement is successful, and incoming feedback signals are congruent with the predictive outgoing signals, the motor representation is reinforced. Specifically, neural connections between MNN regions for the successful movement are strengthened, in turn facilitating future successful performance and engraining motor learning (Rizzolatti and Craighero, 2004; Oosterhof et al., 2013). When predicted and actual behavioral outcomes do not match, motor planning signals are recalibrated and updated with subsequent attempts, a process referred to as "motor adaptation" (Cressman and Henriques, 2009; Salomonczyk et al., 2011; Neva and Henriques, 2013).

In order to forge the functional connections between brain regions that code a novel motor representation, researchers have identified a competitive mechanism whereby stronger pre-synaptic inputs weaken the inputs from other neurons to the same post-synaptic cell, resulting in learning-dependent plasticity (Song et al., 2000). Made famous by Hebb (1949), neurons that "fire together, wire together", known as spike-timing-dependent plasticity (STDP). In other words, the repeated and paired activation between neurons is reinforced with experience and training, forging stronger, and more reliable connections.

Just as training is intended to encode correct behaviors, it provides an opportunity to work through errors constructively (section "The Gold Standard for Complex Motor Learning for Police: Scenario-Based Training"). Our brains are equipped with specialized functions to ensure that those errors are not encoded over correct patterns of behavior. The precise timing of coordinated and long-range neural activation among regions of the MNN can induce states of anti-STDP, potentially blocking the encoding of new information that needs to be erased (Koch et al., 2013). For instance, anti-STDP processes could prevent the encoding of an officer's incorrect drawing of their firearm or movement pattern through a training scenario that resulted in them being shot by an armed suspect. Break-downs in learning-dependent STDP mechanisms are observed in clinical populations, including individuals with Alzheimer's disease (AD) and are discussed further in section "Seeing and Hearing is Believing: Superadditive Mechanisms of Multisensory Inputs".

Defining Expertise in Policing

Performance Enhancement

Initial motor learning is characterized by effortful practice and mastery of component actions or "chunks" (e.g., drawing, aiming, and firing) of larger action sequences (e.g., quickly reaching for one's firearm). With continued training comes a reduction and eventual plateau in performance errors, reaction times, and the effort needed to execute now-automatized behaviors. Such performance measures have often been used to define expertise in empirical research studies of various problem-solving tasks. Expert knowledge is organized in large scale, multilevel, and interconnected data structures that integrate sensory, motor, and linguistic functions of component "chunks" of information (Di Nota, 2017). Increasing the number of chunks in novice thinking does not make him an expert but requires a structured organization of knowledge (Rauste-von Wright and Wright, 1994). As a result, experts are characterized to have an excellent ability to perceive the overall picture in different situations, with an unconscious understanding of how to meet the needs of novel situations (Ropo, 1991).

Defining expertise as a progressive linear process that encompasses a finite set of physical skills has been met with criticism. Several researchers argue that the extent or duration of training time is less important to defining expertise than an individual's competence, with less experienced individuals outperforming experts in several domains (Doane et al., 1990; Vicente and Wang, 1998; Ericsson, 2004). One of the most prominent researchers in expertise is Ericsson, who proposed that the duration of training is positively correlated to improvements in performance that are tailored to typical situational demands. Once automaticity of behavior is achieved, additional experience will not significantly improve performance further or refine mediating neurological mechanisms, leading to arrested development (Ericsson et al., 1993; Ericsson, 1998). An appropriate example includes tying one's shoelaces; once this skill has been mastered, additional experience will not be related to higher levels of performance.

To develop high-level skills, including those relevant to policing, Ericsson defines expertise as an ability to apply one's skills adaptively to perform faster, more accurately, and with less effort under a wide variety of situational constraints and demands. Experts break through the ceiling of arrested development with deliberate practice, which involves effortful cognitive engagement in challenging tasks that may not commonly be encountered (Ericsson and Lehmann, 1996). According to this definition, experts attain higher levels of performance by challenging themselves to meet increasingly difficult demands, in turn developing a repertoire of increasingly complex motor representations. Ericsson's theoretical framework is especially relevant for police who train for highly dynamic, uncertain, and potentially dangerous encounters. Section "Bridging the Gap Between Science and Practice: Evidence-Based Police Training" will review the current state of the art for police training paradigms that consider the principles of deliberate practice, as well as the influence of physiological responses to occupationally induced stress, to promote motor learning and effective recall during critical incidents.

Through the overt (sensory reafferents) and covert (efference copy) feedback processes described above, expert sensorimotor networks facilitate decision-making, performance, and novel

motor learning that is faster and more accurate than among novices. The refinement of complex networks that encompass sensory, motor, language, and cognitive (i.e., memory, decision-making) brain regions suggest a high potential for skill transfer across domains and bear important implications for the therapeutic application of motor learning and training for a variety of disorders (see section "Therapeutic Benefits of Complex Motor Learning").

Situational Awareness

By their very nature, high-stakes police encounters are highly complex and always changing. Among police instructors, it is understood that motor skill learning in and of itself is not sufficient to cope with the complex reality of police encounters. An example would be a situation in which the police have the conditions and necessity to use a firearm toward a target person, but there are many bystanders in the vicinity. In this case, using a firearm could be a serious threat to public safety. In addition to the basic motor competency and handling of the weapon, the officer must also be able to assess and change their positioning effectively so that discharging the firearm can minimize collateral damage and effectively resolve the situation. If an officer lacks knowledge (and training) in situational awareness and decision-making, the outcome of highly unpredictable, time-pressured, and stress-inducing encounters like the one described here is likely unfavorable. Therefore, situational awareness and subsequent selection of the best course of action are fundamental procedural skills for police that inform behavioral outcomes just as much as basic motor learning.

Although the conditions and circumstances to every situation are unique, police instructors and practitioners generally agree that situations can be understood as a whole, within which there are fundamental elements that can be separately understood and trained. An officer's perception and evaluation of a situation directly informs what motor skills they will employ. This online assessment of the environment is known as situational awareness. Several definitions of situational awareness exist for different fields but has been defined by Endsley (1995) as possessing three components: perception, comprehension, and projection. In other words, sensory perceptions signify elements of the environment, whose meanings must be understood in order to anticipate their future status in relation to the objectives of the action. Before we are able to understand our perceptions, it is important that we learn to make proper perceptions. Selective attention is an important function of the sensory system because all of the information received by the senses cannot be consciously perceived at the same time (Tiippana, 2006). Therefore, what part of the external environment is the subject of conscious awareness at any given time is controlled by attention, which is highly influenced by stress (see section "Stress-Induced Memory Deficits, Perceptual Distortions, and Performance Errors in Police"). According to this view, selective attention divides the external totality of a situation into meaningful and non-meaningful elements, the latter of which is ignored and the remaining essentials are attended (Varila and Rekola, 2003).

In the case of training aimed at developing situational awareness, it would be advisable to develop methods of visual exploration and subsequent processing of critical information (Salas et al., 1995). Once essential features of the environment have been identified, complicated situations can be broken down into smaller elements or "chunks." Just as with fundamental motor learning described above, situational awareness training can afford novices the opportunity to recognize chunk patterns in different contexts and combinations, and link them to appropriate motor strategies (Varila and Rekola, 2003). As shown by previous research (Bläsing, 2015), police experts may sum up several observations into larger entities that include both situational awareness and tactical elements. Indeed, an examination of police shooting strategies found significant overlap in stepping and shooting behaviors (Nieuwenhuys et al., 2017), reflecting concatenation of component motor and perceptual chunks during a high-threat shooting exercise. Without investigation, standardization, and validation of situational awareness training strategies, police officers may be learning wrong patterns and encoding stimulus-response tendencies instead of effective critical thinking skills.

Fast, Flexible, and Accurate Decision-Making

In both policing and basic science, actions are typically evaluated by the final outcome. In reality, human behavior is far more complex than a hierarchical, step-wise process that begins with a goal, is followed by a conscious motor plan, and concludes with an appropriate movement. Researchers in the field of computational neuroscience have provided an alternative school of thought that suggests multiple behavioral outcomes, or "affordances," unconsciously competes for final selection (Cisek, 2006, 2007). Based on current perceptions of the environment, the brain considers multiple potential motor affordances to achieve a desired outcome. For instance, a suspicious individual in a dark alley may elicit multiple behaviors from an officer, including verbal commands, change in positioning, and accessing one of multiple force options [e.g., baton, oleoresin capsicum (OC) spray, conducted electrical weapon, firearm]. As the situation unfolds over time, goals and available options for action selection are continuously updated by the prefrontal cortex (PFC) and basal ganglia, respectively.

In the current example, the suspect could charge toward the officer with a weapon necessitating a use of lethal force, or the suspect may comply with officer's verbal commands and allow for safe approach. Cisek's (2006, 2007) model suggests that updated sensory information biases competition among multiple motor affordances toward a single response that is released into execution. Further, there is evidence to suggest that high levels of threat narrow perceived and actual motor affordances for possible action (Pijpers et al., 2006). We propose that complex decision-making undertaken by police officers during high-stakes encounters involves several other factors, including stress-induced perceptual biases and prior experience acquired through training or in the field.

These considerations and their unconscious influence on police performance and motor selection will be discussed in detail in section "The Influence of Stress on Police Performance."

Once motor learning is engrained, and officers are adequately trained in situational awareness, how is this knowledge functionally used "in the moment"? Based on acquired knowledge from training and work experiences, officers make well-informed decisions very quickly under conditions of extreme time pressure, high stakes, and shifting conditions (Klein, 2017). However, they may not be able to describe how or why they chose to act (Ropo, 1991). Decades of investigations with experts in several fields, including emergency first responders and military personnel, support two prominent theories that characterize "intuitive" decision-making. In contrast to deliberate, slow, and controlled reasoning, Kahneman and Tversky's Two-System Model (Stanovich and West, 2000; Kahneman, 2003) stipulates that intuitive decision-making is automatic, effortless, and not available to introspection. Often emotionally charged, intuitive decision-making elicits habitual responses that are difficult to control or modify, highlighting the importance of cementing correct (or optimal) intuitions with police training.

Klein's Recognition-Primed Decision Model (RPDM) (Klein, 1989, 1993) characterizes proficient decision-making as a fusion of two mental processes – situational awareness and mental simulation (or visualization). Experienced officers recognize familiar cues and patterns of information in the environment and quickly identify what goals and actions are feasible or not. In contrast to competitive affordance models (Cisek, 2006, 2007), the RPDM stipulates that there is no concurrent deliberation of alternate options. Rather, a single action plan that is most likely to meet a sufficient outcome is mentally simulated. If any pitfalls are expected, the action plan is adjusted until a satisfactory outcome is realized and executed. Because there is no deliberation, decision makers often cannot explain their rationale.

The difficulty of articulating implicit decision-making also poses a problem for training and evaluation of police motor learning, which is largely outcome based. Steps should be taken to ensure that the physical tactics and cognitive thought processes leading up to (and including) the decision to act are adequately addressed in police training. Experts are also shown to make "rookie mistakes" when ignoring relevant cues for the sake of fast decision-making (Kahneman, 2003). Through more introspective pedagogical approaches, police trainers can use mistakes in both novice and expert officers' performance to recalibrate and reinforce correct intuitive cognitive and motor strategies.

Confidence and Action Competency

Finally, we suggest that the practical application of procedural motor skills, situational awareness, and expert decision-making might also be linked to the officer's individual perception of their own skills and abilities that precedes action. As reflected in military pedagogy, the concept of action competence refers to one's self-perceived ability to act, which includes physical (i.e., operational) and mental capability, competence, knowledge, and skills that are essential to an individual's survival in demanding situations (Toiskallio and Mäkinen, 2009). Action competence can also be defined with respect to social and ethical considerations, including ownership and justification of one's actions that undoubtedly influence police and law enforcement performance. Action competence is another aspect of complex motor learning that trainers and curriculum developers should be aware of when reimagining police training methods and approaches.

Changes to Brain Structure and Function With Long-Term Training and Expertise

Investigations of motor learning are typically examined in highly controlled experimental settings using simple tasks, including arm reaching, finger tapping, and eye movements. However, the physical skills of police and other law enforcement personnel require complex, whole-body movements that are highly dynamic and dependent on the unique situation at hand. To investigate learning-induced neural plasticity that is more applicable to real-world experiences, we look to other areas of research including sport psychology of athletics, dance, and music. These domains have served as ideal models for measuring ecologically valid, reproducible, sequential movements that have established standards for correct performance. Neurological evidence for motor learning among police is a largely unexplored area of study (see section "Live Versus Virtual Scenario-Based Training"), and the few empirical research studies investigating training-induced changes to police physiology (i.e., cardiovascular) and performance will be reviewed in section "The Gold Standard for Complex Motor Learning for Police: Scenario-Based Training."

To facilitate dynamic expert performance, neuroimaging findings of long-term training have shown greater structural organization and neural efficiency among brain regions involved in motor planning among experts relative to novices. Specifically, expertise has been linked to reduced gray matter volume in superior frontal gyrus, left PMC, SMA, and putamen relative to non-experts, and lower white matter volumes in bilateral corticospinal tracts and corpus callosum (Hänggi et al., 2010). Fractional anisotropy, which measures the extent of fiber integrity (Assaf and Pasternak, 2007), is also lower in white matter tracts underlying PMC among experts, reflecting less diffusion across white matter tracts (Hänggi et al., 2010).

Reorganization of expert brain networks also facilitate faster and less effortful learning of new information related to one's area of expertise (Shmuelof et al., 2012), lending empirical evidence to the old adage that "you can teach old dogs new tricks." Brain imaging studies of novel sequence learning among longstanding experts show initial increases in neocortical activation (SMA), reflecting effortful cognitive motor planning. Once the motor sequence has been automated and over-learned (i.e., practiced daily for several weeks with a high degree of accuracy), there is a dramatic decrease in neocortical activation and greater activation in subcortical regions including the striatum (Bar and DeSouza, 2016). The striatum is a critical part of the brain's motor and reward systems, is reciprocally connected to the PFC and thalamus, and coordinates numerous cognitive functions including action planning, decision-making,

motivation, and goal/reward processing (Yager et al., 2015). These connections enable optimal expert performance and involve processes that directly inform police decision-making as discussed above. Despite the body of neuroimaging evidence reviewed here, there is a dearth of investigations examining training-induced changes to brain structure and function among police (see section "Future Directions for Evidence-Based Police Training: Neurophysiological Mechanisms" for current evidence and future directions).

THE INFLUENCE OF STRESS ON POLICE PERFORMANCE

Despite the comprehensive overview of occupationally relevant motor learning presented above, an important problem for police training remains: how can we promote recall of training during high-stress, time-limited encounters in the real world? By examining how physiological responses to stress influence police performance, perception, learning, and memory, we provide a framework for understanding effective training programs that use evidence-based principles to prepare police officers for the realities of the frontline.

Physiological Responses to Stress

The most scrutinized decisions made by police officers usually occur under highly stressful conditions resulting in a use of force and particularly lethal force. Despite expectations to perform in accordance with the law and their training, law enforcement personnel and other first responders are not immune to the body's automatic physiological responses to threat and stress (for detailed description, see Schwabe and Wolf, 2013; Ness and Calabrese, 2016). By initiating the "fight or flight" response, stress adaptively promotes survival by mobilizing individuals to escape threat (Lovallo, 2016). Stress can be measured by various objective physiological markers. Cardiovascular indexes of stress include heart rate (HR), heart rate variability (HRV), blood pressure, and galvanic skin response. Cortisol obtained through saliva or blood samples provide a neurochemical measure of stress. Very little research has been conducted on police using non-invasive brain imaging techniques, including magnetic resonance imaging (MRI) or electroencephalography (EEG) (see section "Future Directions for Evidence-Based Police Training: Neurophysiological Mechanisms"). Both neuroimaging techniques stand to illuminate structural and functional changes to the brain following acute and long-term exposure to stress, as well as learning-induced plasticity.

Seminal work by Yerkes and Dodson (1908) has been supported by basic and applied research in several fields to establish the stress-memory continuum (**Figure 2**), which demonstrates that low to moderate levels of stress "arousal" adaptively facilitate learning, memory, and cognitive performance (Jameson et al., 2010). The strength of a memory is proportional to the level of arousal it elicits (Thayer and Sternberg, 2006), with stronger encoding of new information with more robust stress responses. However, at extreme levels, stress is maladaptive for learning by blocking both encoding of novel information and memory retrieval.

Basic science and animal research shows that the precise timing of stress-induced release of neurochemicals is key to successful encoding of novel information. Improved learning outcomes are observed when epinephrine is administered immediately prior to or during learning (Cahill and McGaugh, 1998; Cahill and Alkire, 2003), and severe impairment in

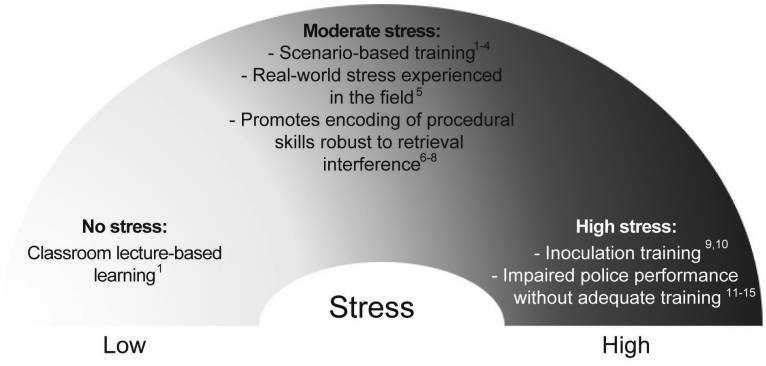

FIGURE 2 | The stress-memory continuum. As established by Yerkes and Dodson's (1908) seminal work, stress influences learning and memory processes on an inverted U-shaped continuum. At moderate levels, stress promotes attentional arousal and encoding (i.e., learning) of novel information. At extremely high levels, stress interferes with both encoding and retrieval processes and is maladaptive in training contexts. Based on empirical physiological evidence from police officers, scenario-based training lies at an optimal position of the continuum whereby ecologically-valid levels of stress are induced and result in measurable improvements in performance, including use of force decision-making. [1]Andersen et al., 2016a; [2]Andersen and Gustafsberg, 2016b; [3]Andersen et al., 2018; [4]Armstrong et al., 2014; [5]Anderson et al., 2002; [6]Jameson et al., 2010; [7]Cahill and Alkire, 2003; [8]Cahill and McGaugh, 1998; [9]Morgan III et al., 2004; [10]Tavernier et al., 2013; [11]Oudejans, 2008; [12]Nieuwenhuys and Oudejans, 2010; [13]Nieuwenhuys et al., 2012a; [14]Nieuwenhuys et al., 2009; [15]Nieuwenhuys et al., 2012b.

memory recall is observed when glucocorticoids are administered before retention testing (De Quervain et al., 1998, 2000; Diamond et al., 2006). These findings reveal unique influences of the various neurochemicals released during human stress responses on learning (i.e., memory formation). An important consideration for developers of police training programs is to identify an optimal level of stress that adaptively promotes learning without crossing the threshold for maladaptive stress that interferes with encoding and retrieval processes.

Stress-Induced Memory Deficits, Perceptual Distortions, and Performance Errors in Police

There is a limited yet growing body of research investigating the effects of stress on police performance, learning (see section "Bridging the Gap Between Science and Practice: Evidence-Based Police Training"), and memory (e.g., Yuille et al., 1994; Stanny and Johnson, 2000; Hope et al., 2016; Lewinski et al., 2016), with several insights offered from studies on military personnel (Morgan et al., 2004, 2006; Taverniers et al., 2013). These studies tend to focus on declarative memories of extremely stressful training and work situations, including prisoner of war exercises and police-involved shootings. Results consistently show stress-induced impairments to both immediate and delayed memory. For instance, officer recall of their path of travel during a simulated high-stress traffic stop significantly deviates from their actual path of travel, highlighting the influence of stress on officers' spatial memory (Lewinski et al., 2016). These outcomes bear greatly on the accuracy of police or eyewitness memory of traumatic encounters, as well as recall accuracy during stressful questioning procedures like evaluations, inquests, and trial proceedings. Considerations of stress on police memory lie beyond the scope of the present review (see Hope, 2016), which aims to clarify the influence of stress on police motor learning and performance.

Qualitative evaluation of police officers' accounts of encounters where they shot citizens reveal several consistent perceptual distortions, including diminished sound, slowed time, tunnel vision (i.e., narrowed attention), and heightened sense of visual detail (Klinger and Brunson, 2009). Even though officers are inherently aware of the temporal dynamics of action-reaction, they have been shown to systematically underestimate the distance between themselves and suspects in both low- and high-threat conditions (Nieuwenhuys et al., 2012a). In fact, research showing that an officer already pointing their gun at an armed suspect is unable to fire before the suspect does (Blair et al., 2011). These natural, untrained tendencies can lead to devastating outcomes unless stress-induced perceptual distortions are also considered and integrated into training procedural motor skills relevant to police (see section "Bridging the Gap Between Science and Practice: Evidence-Based Police Training").

Based on the significant overlap of brain networks involved in movement, learning, attention, and physiological stress responses, several psychological theories offer possible mechanisms for stress-induced impairments in police performance. Where an officer directs their attention informs their perception, evaluation, and available behavioral options for motor selection. To enable fast decision-making, the brain predictively "sees" before conscious perception (Barrett and Bar, 2009; Barrett, 2012). This phenomenon is known as affective realism, whereby external stimuli are assigned an emotional or affective "value" (i.e., gun = bad) that informs downstream physiological processes to approach or avoid the stimulus. As such, reporting negative emotions can increase the likelihood that a benign object like a wallet or cellphone is visually perceived to be a gun (Baumann and DeSteno, 2010). While this type of perceptual distortion rarely contributes to misinterpretation in violent police encounters, it has been reported in the past (e.g., 1999 police shooting of Amadou Diallo in New York City). An empirical research study on military cadets found faster and more accurate identification of a weapon versus a tool when visually primed with a threatening image but also an increase in "false positives" for weapons when presented with a tool under high anxiety conditions (Fleming et al., 2010). Training that integrates realistic levels of stress can help promote accurate perceptions over false positives that bear significant implications for occupational safety and security.

Applied research on police shooting performance has shown greater stress (self-report and HR), faster reaction times, and decreased shooting accuracy during high-threat conditions, where a live actor or canon shoots back at officers with simulated ammunition, versus low-threat conditions where officers shoot a static target (Oudejans, 2008; Nieuwenhuys and Oudejans, 2010; Nieuwenhuys et al., 2012b). Stress-induced decrements in police performance have also been found for other complex procedural skills, including arrest and self-defense behaviors typically used in the field (Nieuwenhuys et al., 2009). According to attentional control theory (ACT), a stressful or threatening stimulus exerts both negative and positive influences on attention, respectively, by: (1) drawing attention away from task-relevant information toward distracting threat-relevant information and internal worries, leaving fewer attentional resources to effectively perform the task at hand and (2) increasing motivational cognitive or mental effort on task performance to counteract negative attentional effects (Eysenck et al., 2007).

Consistent with ACT principles, head and eye tracking reveal increased attention toward the suspect (i.e., threat) and away from task-relevant targets. Increased motivation is supported by higher reported mental effort during high-threat conditions, as well as faster reaction times to eliminate the threat but at the cost of shooting accuracy (Oudejans, 2008; Nieuwenhuys and Oudejans, 2010; Nieuwenhuys et al., 2012a; for discussion on conflicting attentional mechanisms, see Hope et al., 2016). Similar to Fleming et al. (2010), Nieuwenhuys et al. (2012b) found a greater bias toward shooting unarmed targets in high-threat conditions, in addition to faster reaction times and decreased shooting accuracy to armed targets. Despite sampling highly trained police officers, the high-threat condition in these investigations influenced subconscious attentional and

motivational processes that superseded officers' training to respond to a threatening situation, impairing task-related shooting performance. These findings highlight the urgent need to address occupationally relevant stress during police training to mitigate impairments in perception and subsequent decision-making and performance.

"I Don't Feel Stressed": Subjective Versus Objective Measures of Stress

Further contributing to the nuanced and highly complex relationship between stress, learning, and memory is the fact that stress is a highly individual experience. What may be perceived as extremely stressful for one individual may not be stressful at all to another. One's perceived level of stress may also differ from objective physiological measures, especially among police and law enforcement personnel who may be hesitant to admit "feeling stressed." Physiological stress responses in police have been shown to manifest in very similar ways during an encounter (e.g., physical use of force interactions) or in anticipation of an encounter (e.g., driving to event with lights and sirens; hand on gun) (Anderson et al., 2002). Stress can also be triggered by "real" external cues in the environment (e.g., presence of a lethal weapon) or by internal psychological states (e.g., fear or anticipation of observing a lethal weapon), further complicating the investigation of how stress impacts police performance. Recent evidence shows that law enforcement personnel have significantly higher baseline levels of cortisol relative to the general population, and that tactical officers exposed to greater occupational threat have even higher levels of cortisol than frontline police officers (Planche et al., 2019), bearing greatly on the long-term health trajectories for individuals in high-risk occupations. Thus, individual and occupationally mediated differences in stress responses confound the determination of where any single police officer (or individual) lies on the stress-memory continuum (**Figure 2**), and what level of stress meets the threshold for maladaptive arousal. Objective measures of behavior and physiological stress such as HR, HRV, and salivary cortisol are crucial in evaluating the true influence of stress on individual performance.

BRIDGING THE GAP BETWEEN SCIENCE AND PRACTICE: EVIDENCE-BASED POLICE TRAINING

In recent years, there has been significant development and progress in the field of evidence-based policing, which uses empirical research to validate the effectiveness of various training approaches. The most studied training, and relevant for our discussion on complex motor learning, is use of force training. Most investigations of police behavior examine firearm use (i.e., shoot/no-shoot decisions), accuracy, and timing, but a use of force can range from physical (i.e., hands-on) tactics to any tools available to police officers including baton, OC spray, conducted electrical weapon, or firearm. In addition, we have proposed that situational awareness and decision-making are essential procedural motor skills for effective policing that are also influenced by occupationally relevant stress. The following section will review the current state of the art in evidence-based training that attempts to find a balance in the stress-memory continuum (**Figure 2**) and promote effective motor learning for police.

The Adaptive Role of Real-World Stress in Police Training

Through occupational experience, police officers can learn to adapt and overcome the negative influences of stress on perception and performance described above. A study comparing novice and expert police officers found improved shooting behavior and gaze control in the expert group under high-threat conditions (Vickers and Lewinski, 2012). Police officers who have better regulation of their stress responses have been shown to use the associated physiological cues in an adaptive way to promote performance (i.e., fewer shooting errors, de-escalating potentially violent encounters) (Akinola and Mendes, 2012; Haller et al., 2014). These findings suggest that increased exposure to, and familiarity with, occupationally relevant stress can offset its interfering effect on performance.

In a series of investigations on athletes and police officers, Oudejans and colleagues have established efficacy for performance training that integrates occupationally relevant stress. Beginning with basketball and darts players, Oudejans and Pijpers (2009, 2010) found that training with mild levels of anxiety improved post-training performance under stressful conditions compared to control groups that did not train with stress and who showed stress-induced deterioration of performance. Expanding on the police performance studies mentioned previously (Oudejans, 2008; Nieuwenhuys and Oudejans, 2010; Nieuwenhuys et al., 2012a,b), Oudejans and colleagues examined the efficacy of training police officers in high-stress (with a live actor or canon shooting back simulated ammunition) and low-stress (officer shoots at static target or mannequin) conditions. Officers completed pre- and post-training tests on firearms use of force performance under high- and low-stress conditions. All officers showed increased HR, poorer shooting accuracy, greater mental effort, and greater attentional fixation on threat- (versus task-) relevant stimuli during high-stress pre-training evaluations. Officers trained under high-stress conditions no longer showed impaired shooting performance during stressful post-training evaluations (Oudejans, 2008) or at 4-month follow-up evaluations (Nieuwenhuys and Oudejans, 2011).

Similar to the principles of motor adaptation described earlier in the section on "Applied Motor Learning in Law Enforcement", the researchers suggest that training-induced performance gains are facilitated by recalibration of officers' selected motor plans (Nieuwenhuys and Oudejans, 2011). Even though officers still exhibited physiological stress responses post-training, their performance improved as a result of training under the same high-stress conditions in which they were expected to perform. Further, there is a relationship between stress and an officers' motor selection

strategy, such that inhibiting a preferred motor plan (e.g., shooting with a grounded stance) due to situational constraints results in greater reported anxiety and reduced shooting accuracy, even if the preferred motor plan is slower and puts the officer at greater risk (Nieuwenhuys et al., 2017). Therefore, integrating stress into a repetitive training paradigm not only promotes police performance during subsequent high-stress conditions but also facilitates motor learning that can override preferred movement strategies that would put the officer at risk.

The Gold Standard for Complex Motor Learning for Police: Scenario-Based Training

Consistent with scientific principles of motor learning (section "Applied Motor Learning in Law Enforcement"), police trainers generally agree that basic skills training should begin with learning the fundamentals, or component "chunks", in order to develop proficiency, comfort, and safety with a given technique (Pryor, 1999). Once motor skills are overlearned and deeply encoded in long-term "muscle memory," training approaches must evolve in order to ensure the motor skill can be flexibly applied to a variety of stressful circumstances that necessitate a use of force. Surveys from experienced police trainers (Aldred, 2017) and a growing body of empirical research support the efficacy of scenario-based training, which simulates the stress and complexity of real-world situations to a greater extent than classroom lecture-based learning or static drills (Armstrong et al., 2014; Andersen et al., 2016a).

Scenario-based training is fully immersive, utilizing real and artificially constructed environments (e.g., schools, communities, and housing complexes), props, sounds, and lighting to create realistic environments that require various behavioral strategies. Professional actors or experienced police instructors are used to role-play various types of encounters ranging from violent offenders to domestic disputes and individuals in psychological crisis.

In accordance with Ericsson's framework for deliberate practice (Ericsson and Lehmann, 1996; Ericsson, 1998, 2004), scenario-based training promotes expert motor learning among police by engaging the following principles:

1. Once police officers acquire proficiency through basic skill training, expertise is developed through exposure to increasingly complex and demanding situations.
2. By affording officers the opportunity to "feel" the physical sensations that accompany high-stress encounters, arousal-based mechanisms promote encoding of the learning experience and also allow officers to work through the stress response to achieve outcomes.
3. Trainees are afforded integrated practice of verbal, physical, and cognitive (i.e., decision-making, situational awareness) skills, building a repertoire of varied experience that increases the likelihood that skills will be generalized to other situations (Barney and Shea, 2007).
4. With constructive and immediate feedback from qualified instructors, multiple behavioral options can be explored for successfully resolving an encounter through discussion and mental simulation. This is especially beneficial to novices (i.e., new recruits) that can work through errors and dangerous encounters in a safe environment (see section "Reinforcing Motor Learning in the Brain" for anti-STDP mechanism for erasing unwanted information).
5. Deliberate practice through repeated attempts or trials reinforces the neural pathways of mental and physical skills (section "Reinforcing Motor Learning in the Brain").
6. Training is administered at an appropriate level of difficulty to challenge the learner but not to ensure failure (i.e., no-win situations) or be too easy.

Very few studies have investigated the efficacy of scenario-based training on police performance or attitudes but show significant improvements after even a single day of training. Krameddine et al. (2013) administered a 1-day scenario-based mental health training program and found significant improvements in verbal de-escalation, communication, and empathy with the public up to 6 months post-training. With respect to procedural use of force training, Andersen and Gustafsberg (2016b) and Andersen et al. (2018) have shown immediate and long-term efficacy of a 4-day performance and resilience program (iPREP). Officers use real-time HRV biofeedback (HRV-BF) during immersive live-action scenarios to modulate their individual stress responses and promote recovery from threat by engaging adaptive peripheral nervous system dominance (Thayer and Sternberg, 2006; Lehrer and Gevirtz, 2014). Officers condition adaptive autonomic stress responses through repeated practice of various breathing techniques and mental simulation during various scenarios that increase in complexity and stress. Investigations of special forces and frontline officers have shown significant reductions in use of force shooting errors, improved situational awareness (Andersen and Gustafsberg, 2016b), and faster autonomic recovery to baseline following stressful training scenarios up to 18-month post-training (Andersen et al., 2018).

By integrating pure motor skill practice with realistic environments, stress, and various decision-making options and outcomes, scenario-based training ensures cognitive motor skills (i.e., situational awareness, decision-making, visualization, breathing techniques) are adequately encoded and reinforced in learning and memory systems.

Mental Skills Training

The "mental skills" engaged during iPREP, including visualization and stress-reducing breathing techniques, are physically conditioned (i.e., become implicit and are performed without conscious effort) using HRV-BF. Other police training interventions that incorporate mental skills have shown efficacy in improving use of force performance, reported and objective (HR) measures of stress, and negative mood during high-stakes scenarios (Arnetz et al., 2009). However, this training paradigm spanned 10 weeks, and post-training evaluations were conducted 12 months later. Therefore, it is unclear whether significant

findings are due to the specific training intervention or 1 year of training and field experience.

Another investigation on the efficacy of two 75-min breathing, imagery, and attentional control training sessions found improved memory for details during a stressful OC training drill compared to controls. However, training did not improve autonomic stress responses, and the authors did not report post-training performance results (Page et al., 2016). While these findings suggest a modest added benefit of mental skills training to motor learning paradigms, direct comparison of different learning strategies have shown that combined physical and mental practice is not as effective in training procedural skills compared to 100% physical practice (Hird et al., 1991).

Live Versus Virtual Scenario-Based Training

Despite the efficacy of the training interventions by Oudejans and colleagues discussed in section "The Adaptive Role of Real-World Stress in Police Training," the test and training conditions were not truly scenario based, such that officers were instructed to shoot at targets (or individuals) that were directly in front of them, and no other suspect engagement (i.e., verbal communication, other physical tactics) or decision-making (i.e., deciding whether or not to shoot the target) was involved. It is also unclear what duration of training, experimentally induced practice effects, or occupational experience could result in performance improvements, as the low-stress training group performed equally well during the high-stress condition at 4-month follow-up (Nieuwenhuys and Oudejans, 2011). One investigation also found no post-training improvements in performance or gaze control, which could be due to the use of a video presentation for the stimuli instead of live actors (Nieuwenhuys et al., 2015).

There is increasing investment in virtual simulation technologies for occupational training among police agencies and training institutes. However, there has not been any empirical validation of simulators for police training, specifically in the use of force decision-making. One validation study found that virtual emergency medical training failed to induce the same level of cardiovascular stress as a live training scenario (Baker et al., 2017). Despite the appeal of using advanced technologies in an applied setting, video or virtual simulators lack the perceptual depth cues present in live environments that inform police decision-making and motor selection strategies. Further empirical validation of simulator systems relative to live scenario-based training is needed before police agencies make the considerable investment in implementing these methods for the use of force training.

Future Directions for Evidence-Based Police Training: Neurophysiological Mechanisms

While the studies reviewed so far have helped reveal the peripheral cardiovascular physiological mechanisms of police performance under stress, investigations are lacking on the impact of stress on central neurological mechanisms underlying police behavior. Stress has typically been operationalized with measures of HR, HRV, and cortisol, but neurological patterns measured by EEG scalp electrodes can also indicate increased anxiety or threat. Asymmetry in the extent of activation in left versus right frontal cortex is related to emotional and motivational processing (for review, see Harmon-Jones et al., 2010) and may predict which officers are more (or less) susceptible to stress-induced impairments in perception or performance. In a single pilot study, Johnson et al. (2014) investigated the differences in psychophysiological measures of HR, HRV, EEG, and lethal force decision-making (i.e., correct responses and errors) between civilians and military or police experts during high-stakes video scenarios. In addition to significantly higher pass rates, researchers found expertise-driven differences in HR and EEG measures but not HRV or alpha asymmetry. Further, these effects were greater for experts with more experience (10+ years versus intermediate experts with 6–10 years of experience). In spite of the study's limitations, this preliminary investigation is an important step in the right direction toward understanding the complex relationship between training/experience and different biological systems to high-stakes decision-making by police.

Other brain signals that can shed light on the neural correlates of police learning and behavior include the error-related negativity (ERN), which occurs within milliseconds following motor execution to monitor action and detect errors, as with reafferent feedback during motor learning (see section "Reinforcing Motor Learning in the Brain"). ERNs are enhanced among highly anxious individuals (Hajcak et al., 2003) and are sensitive to internal appraisals of threat (Weinberg et al., 2016). Enhanced ERNs were also observed following false positive identification of tools as weapons by military cadets primed by a threatening stimulus (Fleming et al., 2010), establishing a clear link between brain signals preceding or generated by the use of force decisions (both correct and incorrect) under stressful conditions.

A single pilot study on athletes compared the effects of HRV-BF training on cardiovascular and neurophysiological measures of arousal but not physical performance. For the HRV-BF group only, results show reductions in reported anxiety, increased HRV amplitude indicative of increased vagal tone and enhanced parasympathetic activity, as well as reduced frontal asymmetry and improved emotional control (Dziembowska et al., 2016). Future studies investigating the efficacy of HRV-BF training on police including iPREP can perform similar analyses on the bidirectional communication between central neurological and peripheral physiological systems and compare these biological markers to objective performance measures.

CLINICAL APPLICATIONS OF COMPLEX MOTOR LEARNING

The neurophysiological mechanisms underlying motor learning in a law enforcement context have been summarized above from the lens of cognitive neuroscience, with a call for more applied research that investigates police in occupationally relevant settings outside of a laboratory. Further insights on how motor learning is facilitated and stored in the brain are provided by

examining clinical populations that experience breakdowns in these mechanisms, including people with Alzheimer's disease (AD), Parkinson's disease (PD), stroke, and traumatic brain injuries. This review will not go into detail on the prevalence of, and therapies for, psychological injuries and mental health disorders common among law enforcement (e.g., Carleton et al., 2018) but rather will consider the brain-based therapeutic benefits of complex motor learning.

Motor Learning Mechanisms Revealed by Disease-Related Impairments

Several clinical populations have demonstrated various deficits in how they chunk or segment continuous streams of movement. These deficits result in significant impairments to the "online" or real-time perception, and subsequent learning and memory, of motor information. Research on individuals with PD (Tremblay et al., 2010) and stroke patients (Boyd et al., 2009) show impaired concatenation of motor chunks, suggesting a crucial role for the basal ganglia in understanding and consolidating movement sequences into long-term memory (Yin and Knowlton, 2006). Other clinical populations, including patients with schizophrenia (Zalla et al., 2004) and frontal lobe lesions (Zalla et al., 2003), show deficits in segmentation ability such that the location of event borders vary from normative ones. Individuals with mild dementia and AD also show poor recognition and order memory of segmented action (Zacks et al., 2006), demonstrating a clear link between online attention, visuomotor, and memory functioning.

Visuomotor deficits have been revealed in clinical populations using simple tasks (e.g., moving a cursor on a screen with one's finger) presented on touchscreen tablets that can record reaction times and movement accuracy as proxy measurements of motor recalibration and adaptation (section "Reinforcing Motor Learning in the Brain," e.g., Tippett and Sergio, 2006). Not only is this methodology useful in determining disease-related impairments in visuomotor functioning (for review, see Joddrell and Astell, 2016), modified reaction time and adaptation tasks could also be used as screening and/or training tools for policing skills similar to their application in athletics as performance and injury evaluation tools (Ventura et al., 2016).

Therapeutic Benefits of Complex Motor Learning

Based on the neurophysiological mechanisms underlying complex motor learning described above, the following section will review the therapeutic application of complex motor learning for movement and memory disorders. There is demonstrated efficacy for improved attention and memory following relatively short (18 min) training with simple eye movements (Di Noto et al., 2013), including eye movement desensitization and reprocessing (EMDR) therapy. While EMDR has shown significant neurological and clinical improvements in post-traumatic stress disorder (PTSD) among police officers involved in on-duty shootings (Lansing et al., 2005), the following sections go beyond traditional forms of simple movement therapy (i.e., physical, pharmacological) to review how multisensory dance and music practice facilitate perception, understanding, and learning of complex sequences of movement.

Various forms of music and dance practice have been employed as alternative forms of therapy for a wide variety of disorders (for comprehensive review of therapies and specific outcomes, see Dhami et al., 2015). Especially during the last 25 years, music therapy has become internationally recognized as part of health care maintenance and rehabilitation, with systematic developments in training and research during this time (Ala-Ruona, 2007). In addition to improving primary disease symptoms and increased functional connectivity between motor planning (SMA) and control (cerebellum) regions of the brain, music and dance therapy have proven social and emotional benefits, including improved reports of mood, anxiety, and quality of life among individuals with AD-related dementia and PD (Heiberger et al., 2011; Westheimer et al., 2015; King et al., 2019). The holistic benefits of dance and music therapy for general well-being are significant, as an estimated 35% of individuals with PD also exhibit symptoms of depression (Reijnders et al., 2008). Further, the social and emotional benefits of dance and music therapy are suggested to drive high rates of adherence, which in turn contributes to the efficacy of these types of therapy for individuals suffering from impaired motor and memory functioning.

Seeing and Hearing Is Believing: Superadditive Mechanisms of Multisensory Inputs

By their nature, dance and music engage multimodal (i.e., sensory, motor, and memory) regions of the brain that individually may be affected by disease or injury. Regular participation in dance or music therapy capitalizes on the neurophysiological mechanisms underlying complex motor learning to recover functioning in one of two ways: by promoting neural activation in damaged multimodal brain regions and/or by forging novel and alternate neural pathways among multimodal networks. Similar to Hebbian principles described in section "Reinforcing Motor Learning in the Brain," individuals with AD show impaired STDP between regions of the MNN (**Figure 1**). reflecting impaired learning mechanisms (Di Lorenzo et al., 2018). Just as research in healthy individuals reveal how the brain retains new information, investigations on clinical populations can demonstrate how neurological processes manifest in functional (i.e., cognitive, motor) impairments.

Therapeutic efficacy of music and dance are also potentially driven by additive (or superadditive) activation of multisensory neurons that fire equal to (or greater) than the sum of two unisensory inputs (Stevenson et al., 2007; Werner and Noppeney, 2010). That is, concurrent presentation of visual and auditory stimuli will elicit greater activation from the same neurons than when either stimulus is presented on its own. Just as in fundamental motor learning, the neural representations of novel dance and music-producing movements are reinforced by reafferent feedback. However, music and dance movements are additively reinforced by external musical (i.e., auditory) stimuli

together with reafferent feedback signals from multiple sensory inputs, including vision, audition, and proprioception (sense of body position and movement). When there is a failure to distinguish self-generated efference copy signals from external sensory stimuli, it can lead to perceived hallucinations as seen in schizophrenia (Pynn and DeSouza, 2013). Multisensory cues are also present in and relevant to police contexts, especially for situational awareness (see section "Situational Awareness") and should be integrated into procedural training to reinforce motor learning.

Entrainment of External and Internal Rhythms to Promote Learning and Recover Disease-Related Functioning

Music and dance typically involve regular rhythmic patterns, which are also present in various physiological functions including heart rate, respiration, and gait (i.e., walking). The activation of billions of neurons also produces oscillatory brain rhythms of various frequencies, much like the different frequencies of radio stations. Internally generated biological rhythms can be paired to, or cued by, external rhythms by a mechanism known as "entrainment" (for review, see Thaut, 2015). Driven by basic principles in physics, entrainment causes two asynchronous frequencies to coordinate themselves into a common or synchronous period. A stronger or faster frequency, such as that provided by an external stimulus (e.g., metronome, musical beat), will lock a weaker or slower frequency (e.g., neural activity) into a stable rhythmic period.

A growing body of evidence on dance therapy for people with PD has shown almost immediate (i.e., after a single session) and lasting improvements in disease-related impairments to gait, rigidity, balance, and tremor (Heiberger et al., 2011; Westheimer et al., 2015; Bearss et al., 2017). Improvements in motor functioning following dance therapy are suggested to be mediated by entrainment mechanisms (Thaut et al., 1996; McIntosh et al., 1997), whereby dominant external musical rhythms offset the slowing of brain rhythms observed in people with PD (Soikkeli et al., 1991; Moazami-Goudarzi et al., 2008). These findings bear significant implications for the application of dance and music therapy for police officers and other individuals with PTSD, which has shown a breakdown in cross-frequency communication between emotional and sensory-motor brain regions (Cohen et al., 2013). By repairing neurophysiological rhythms through training with external rhythmic stimuli, research shows that improvements in motor functioning can potentially translate to improvements in emotional processing as well, reducing the lasting negative impact of disease, injury, and trauma.

Together, these findings synthesize seminal research from basic and clinical neuroscience to illuminate how learning-induced neuroplasticity facilitates the recovery of motor and cognitive functioning for various clinical disorders. Identifying the neurophysiological mechanisms underlying effective movement therapies provides significant insights for the development of police training programs that can withstand the realities of occupationally relevant situations.

CHALLENGES TO IMPLEMENTING EVIDENCE-BASED POLICE PRACTICES

Given the wealth of multidisciplinary empirical evidence presented thus far on complex motor learning as relevant to policing, there remain several practical, organizational, and systemic challenges to implementing evidence-based approaches. We will briefly review some of these challenges before providing recommendations for best practices in police training.

How Much Training Is Needed? Establishing Universal Standards

Basic Recruit Training Versus Continued Education at the Agency Level

A problem that exists in the practical application of motor learning research is the specification of precisely how many repetitions or hours of training are required to develop adequate competency. Individual differences in physical, cognitive, and learning abilities further complicate identifying a universally prescribed training regimen. This problem is especially relevant for policy makers and educators in all industries, who are challenged to balance finite resources with maintaining occupational safety and performance standards that are often highly variable and poorly defined.

Police training begins with an introduction to the basic skills that an officer will require and use in their day-to-day practice, which is subsequently expanded upon and specialized at the local agency or precinct level. There is no universal occupational standard for the duration or content of basic (or extended) police training and varies across jurisdictions. For instance, the Justice Institute of British Columbia (JIBC) delivers basic recruit training for 12 police agencies in Western Canada post-hire. In addition to a minimum requirement of 2 years of post-secondary education, officers partake in a 38-week basic training program that includes a middle block of field within their employers' police agency. In contrast, all police officers in Finland complete a 3-year Bachelor of Police Services at the national Police University College (PUC), qualifying them for full-time employment at any local precinct in the country. Trainees complete approximately 40 weeks of mandatory in-field training to develop professional competencies during the 3-year period. Reviewing and contrasting current training programs lie beyond the scope of this review (see also section "Cultural Challenges and Access to Information" regarding access to this information), but the two basic recruit programs described above reflect relatively long training durations. Relative to other occupations that require high-stakes life-or-death decision-making (e.g., surgeons, emergency medical personnel) and several years of basic and specialized training, even the JIBC and PUC programs are significantly shorter. Given the complexity and inherent stress associated with police work, training should adequately prepare officers from all backgrounds to safely meet occupational demands.

Learning Theory and the "10,000 h" Principle

One of the earliest theories quantifying the progression of motor learning is Galton's (1869) *lifespan development theory*, which states that this ceiling in performance is bound by immutable biological genetic factors including physical (i.e., height, weight, body composition) and mental attributes (i.e., intelligence). More recently adapted by Fitts and Posner (1967), it is suggested that expert-level performance can be reached with approximately 50 h of training, after which no additional amount of training will further improve an individual's performance. However, these training paradigms evaluated simplistic physical skills. As such, 50 h of basic firearms training may result in expert performance of this skill but is likely not sufficient for more complex physical and mental skills (i.e., deciding how and when to use a firearm, or any other tactical option, during a variety of stressful encounters).

Yet another estimate of prescribed training time to achieve expert-level skill is based on Simon and Chase's (1973) investigations of elite chess players, whose successful performance at international competitive tournaments was not possible without at least a decade of practice. These findings were popularized to form the "10,000 h rule" (Gladwell, 2008), but Simon and Chase (1973) posited that expertise arises from repeated exposure to an increased variety of chess combinations and strategies. Each of these unique scenarios created stored memories for successful or failed experiences that experts could rely on to promote future success in similar situations. Similar to the principles of intuitive decision-making described earlier, scenario-based training exposes officers to multiple varied encounters that can inform the best course of action in similar future situations. Many more hours of training and occupational experience are needed to develop a repertoire of high-level skills (e.g., use of force decision-making, situational awareness) that can be flexibly and accurately applied to a variety of circumstances, relative to basic skill competency.

Tracking Motor Learning in the Brain Through Neuroplasticity

Neuroscientists have tried to observe incremental changes to brain structure and function following novel motor skill learning. Observable increases in structural gray matter (i.e., neural cell bodies and synaptic connections between them) are evident as early as 1 or 2 weeks of daily practice, and decaying 2–4 months once training has stopped (Driemeyer et al., 2008). However, functional neuroimaging research suggests learning-induced plasticity or reorganization of synaptic connections in the brain as early as the very first training session. Karni et al. (1995) identified a switch between initial "fast learning" and consolidated "slow learning" that corresponds with improvements in performance speed and accuracy and less variability across movement trials (Shmuelof et al., 2012). Further, M1 activity increased over several weeks of daily practice and was maintained for up to 5 months with no additional training (Karni et al., 1995). Cross et al. (2009) conducted a neuroimaging study comparing physical and observational training of brief dance sequences among non-experts. After only 5 days of training, they found common gains in activation of premotor and inferior parietal MNN regions (**Figure 1**) but better performance and significant M1 activation for physically versus visually trained dance sequences (Cross et al., 2009).

Lending empirical evidence to the principle of "use it or lose it," these findings show fast initial training gains that decay relatively quickly once training ends. Although they did not measure neurological indexes of motor learning, Andersen et al. (2018) investigated skill decay following a 4-day iPREP training program. Officers' gains in performance (reduction of lethal force errors) and autonomic stress regulation (decreased maximum HR and faster recovery to resting HR) were maintained up to 12-month post-training, returning to pre-training levels at 18-month follow-up. Together with the neuroscientific evidence presented here, these findings underscore the importance of continued practice and regular refresher training to maintain learning-induced changes to performance, brain structure, and function.

Organizational Challenges

Leveraging Finite Training Resources: Funding and Qualified Personnel

Before adopting evidence-based training approaches, individual police agencies must leverage finite available resources, including time away from regular duties, funding, and qualified personnel. Scenario-based training is especially resource-intensive and educationally challenging, despite demonstrated efficacy. Many unique and relevant scenarios need to be developed and executed with a high degree of realism to preserve the value of the teaching opportunity. However, evidence-based training may facilitate cost savings in the long run. In an evaluation commissioned by the United States Department of Education of 77 educational interventions that were not evidence-based, 91% were found to have weak or no positive effects (Coalition for Evidence-Based Policy, 2014). The United States military also implemented a $125 million dollar program (Comprehensive Soldier Fitness) to enhance resilience and performance before evaluating its efficacy, which was found to have no objective improvements and at worst may actually cause harm (McCord, 2003; Eidelson et al., 2011). Krameddine et al. (2013) performed a cost-benefit analysis of their scenario-based mental health training program and found that savings incurred from a significant reduction in time spent on mental health calls exceeded the cost of the study and training program. These outcomes are especially significant given a higher incidence of subsequent mental health calls, further underscoring the compelling nature of an evidence-based approach to police training.

In addition to training content and method of delivery, trainers' skills, abilities, and approach are very important from both educational (i.e., during training) and professional (i.e., during regular police work) perspectives (Murphy, 2014), yet no standards or definitions exist for proficient trainers. Novel pedagogical approaches in policing have been explored, including an emphasis on group discussion and active debate

(Birzer, 2003) and the development of "train the trainer" programs (Hammerness et al., 2005, 2007; Darling-Hammond and Bransford, 2007). Qualified trainers are often "those that do" and may not have formal pedagogical training to identify or address the unique learning needs of their trainees. To address this gap in occupational training, Finland's PUC has introduced a 6-week teaching course specifically designed for use of force trainers. In addition to subject knowledge, the course covers general pedagogy including recognizing and solving challenges of the training group. Other learning outcomes include independently organizing a training event and training key issues related to the selection and use of force in a pragmatic and fundamental manner. In addition to a lack of empirical data on police training outcomes, there is a scarcity of research or data on teaching effectiveness. This has led to the definition of training objectives and quality criteria according to available resources over practical consideration of the skills intended for training. Therefore, the systematic evaluation and development of police pedagogy is limited and vulnerable to approaches that are not evidence-based, compromising the learning opportunity for trainees.

Cultural Challenges and Access to Information

There are strong differences in opinion surrounding police training and practices more general among various stakeholders, including policy makers, police supervisors, trainers, management, officers, as well as the public. Due to the sensitive nature of training content (i.e., specific tactical plans and maneuvers that involve lethal force), information is often kept secret from the public to maintain safety. However, the confidential nature of police training practices can also foster a culture of unwillingness to share ideas among stakeholders and creates an additional barrier to collecting and comparing useful information to promote best practices. Updating existing police training models is also met with a great deal of controversy, despite mounting empirical evidence for the benefits of various training approaches including problem-based learning (Makin, 2016) and a societal need for changes to various policing practices. However, newer motor learning models currently used in military training have adopted a more holistic approach and consider factors like environment, cognitive skills, and kinematic movement options on various continuums (Schmidt et al., 2019). The primary goal of effective training for stressful and unpredictable situations is to protect both public and police and should not be compromised due to extraneous factors (i.e., resources, personal, or political motivations).

Similarly, academic research is often inaccessible to police practitioners unless findings are published in open-access format at a significant financial cost to the researchers. This "silo effect" of information stunts knowledge exchange between sectors and is a barrier to disseminating useful research evidence to practical end-users. Despite containing very relevant insights for policing, scientific articles laden with jargon and field-specific terminology are often not translated into a language that is accessible or understandable to an applied audience or the general public. However, there are peer-reviewed journals and publications available that seek to combine academic and applied perspectives in policing, including *Police Practice and Research*, *Policing and Society*, and *Policing: An International Journal*. Evidence-based reports are also published in industry-specific periodicals such as *The Police Chief* and *The Blue Line*. Indeed, the purpose of this Special Edition of *Frontiers* is to disseminate relevant and timely knowledge across domains for the purpose of improving current practices in policing, identifying areas of future research and development, and saving time and resources by understanding what has already been done.

RECOMMENDATIONS: BEST PRACTICES FOR EVIDENCE-BASED POLICE TRAINING

Common practice should not be confused with best practice or evidence-based practice. The following recommendations are based on the empirical and applied research evidence summarized in this review and are intended to promote training effectiveness as well as occupational safety.

Training

1. Officers need to be prepared for the perceptual and physiological impacts of stress that they will experience on the job (section "The Influence of Stress on Police Performance"). An important consideration for developers of police training programs is to identify an optimal level of stress that adaptively promotes learning without crossing the threshold for maladaptive stress that interferes with encoding and retrieval processes (**Figure 2**).
2. In addition to the benefits outlined in section "The Gold Standard for Complex Motor Learning for Police: Scenario-Based Training," scenario-based training facilitates motor learning by inducing realistic levels of occupational stress that helps override perceptual distortions and preferred movement strategies that could put the officer at risk. In addition, the physiological arousal elicited by scenario-based training can promote adherence to and active engagement with training, maximizing the learning opportunity afforded during limited training time with finite resources.
3. Police work is similar around the world; regardless of the laws and regulations specific to their jurisdictions, officers are uniquely tasked with addressing the needs of people in crisis. Without investigation, standardization, and validation of training strategies, police officers may be learning wrong or ineffective patterns, and encoding stimulus-response tendencies instead of effective critical thinking skills. On a larger scale, standardization of minimal training requirements should align practices across jurisdictions, as is currently done in Finland and under development in Canada (Canadian Association of Chiefs of Police, 2018).
4. Training delivery (i.e., duration, methods) needs to be appropriate to the skills intended to be trained. As

such, complex motor, verbal, and cognitive skills including situational awareness, decision-making, and de-escalation should be trained in live environments with trained actors or instructors that can dynamically respond to officers' behaviors. Further empirical validation of virtual simulator systems relative to live scenario-based training is needed before police agencies make the considerable investment in implementing these methods for the use of force training. However, virtual technology can be useful as complimentary training tools (i.e., in addition to contextually relevant training settings) as well as for psychophysical performance screening similar to its application in athletics (section "Live Versus Virtual Scenario-Based Training").

5. Action competence and an officer's self-confidence should be considered by trainers and curriculum developers when reimagining police training methods and approaches (section "Confidence and Action Competency").
6. Through more introspective pedagogical approaches, police trainers can use mistakes in both novice and expert officers' performance to recalibrate and reinforce correct intuitive motor and cognitive strategies when training situational awareness and use of force decision-making.
7. By repairing neurophysiological rhythms through training with external rhythmic stimuli, clinical research shows that improvements in motor functioning can potentially translate to improvements in emotional processing as well (section "Clinical Applications of Complex Motor Learning"), reducing the lasting negative impact of disease, injury, and trauma. Officers are encouraged to seek out extracurricular activities that incorporate social engagement and rhythmic and/or multisensory components such as music, dance, or athletics to promote physical and emotional health.

Knowledge Dissemination

8. To facilitate knowledge exchange between academic and applied professionals, and police practitioners around the world and across jurisdictions, new research should be published in open-access journals, and practitioners should attend relevant conferences and workshops wherever possible, and when resources permit. Becoming involved and engaged with research will not only help generate new knowledge but will provide police practitioners with an understanding of the scientific process, from generating a research question, to implementing an experimental study, and observing and communicating the results.
9. Police management should recognize and accept the importance of evidence-based policing and offer their trainers and officers opportunities to access and/or engage in applied research with partnerships at local academic institutions.
10. More importantly, a systematic cultural change within policing needs to occur in which stakeholders from multiple levels and sectors can meet and openly share knowledge and be willing to accept evidence in favor of opinions fuelled by political, financial, or personal motives.

CONCLUSIONS

An elite athlete such as a javelin thrower has one precise task to perform under a narrow range of controlled conditions. In police work, even a simple motor skill is never standardized or used in isolation. Officers have to constantly evaluate, consider, decide, and update what is appropriate or possible given the unfolding situation. As such, motor skills cannot be considered without all other aspects of police encounters, including occupationally relevant stress, situational awareness, and complex decision-making.

The current review is a synthesis of empirical and applied research on the fundamental principles of motor learning as relevant to police. Insights from the fields of applied policing, cognitive and computational neuroscience, and clinical and health psychology lend empirical evidence to the knowledge inherently possessed by police trainers, officers, and practitioners through their first-hand experience. Especially relevant to law enforcement, we consider the influence of occupationally relevant stress on the physiological and neurological mechanisms underlying police learning and performance. Training policies and protocols should be updated accordingly to reflect current knowledge and to promote motor learning and skill retention.

Bridging research across fields and industries also provides solutions to several systemic challenges to evidence-based policing, including a lack of universal training standards and knowledge exchange. Ultimately, we hope that this review will inspire practitioner engagement with applied research, and spark open and productive debate among various stakeholders on best practices surrounding training the complex motor skills required in policing.

AUTHOR CONTRIBUTIONS

PD and J-MH wrote the manuscript, conducted all background literature research to inform the contents, and approve the submitted version.

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REFERENCES

Akinola, M., and Mendes, W. B. (2012). Stress-induced cortisol facilitates threat-related decision making among police officers. *Behav. Neurosci.* 126, 167–174. doi: 10.1037/a0026657

Ala-Ruona, E. (2007). Initial assessment as a clinical procedure in music therapy of clients with mental health problems - strategies, methods and tools (Dissertation). *Jyväskylä Stud. Humanit.* 91 (ISSN 1459-4331).

Aldred, K. (2017). Be confident, practise skills, stay healthy: Four RCMP instructors talk training. RCMP Gazette, 79. Available at: http://www.rcmp-grc.gc.ca/en/gazette/be-confident-practise-skills-stay-healthy (Accessed December 3 2018).

Andersen, J. P., Di Nota, P. M., Beston, B., Boychuk, E. C., Gustafsberg, H., Poplawski, S., et al. (2018). Reducing lethal force errors by modulating police physiology. *J. Occup. Environ. Med.* 60, 867–874. doi: 10.1097/JOM.0000000000001401

Andersen, J. P., and Gustafsberg, H. (2016b). A training method to improve police use of force decision making: a randomized controlled trial. *SAGE Open* 6, 1–13. doi: 10.1177/2158244016638708

Andersen, J. P., Pitel, M., Weerasinghe, A., and Papazoglou, K. (2016a). Highly realistic scenario based training simulates the psychophysiology of real world use of force encounters: implications for improved police officer performance. *J. Law Enforcement* 5, 1–13. http://hdl.handle.net/1807/73822

Anderson, G. S., Litzenberger, R., and Plecas, D. (2002). Physical evidence of police officer stress. *Policing* 25, 399–420. doi: 10.1108/13639510210429437

Armstrong, J., Clare, J., and Plecas, D. (2014). Monitoring the impact of scenario-based use-of-force simulations on police heart rate: evaluating the Royal Canadian Mounted Police Skills Refresher Program. *Criminology, Crim. Just. Law Soc.* 15, 51–59. http://wcr.sonoma.edu/v15n1/Armstrong.pdf

Arnetz, B. B., Nevedal, D. C., Lumley, M. A., Backman, L., and Lublin, A. (2009). Trauma resilience training for police: psychophysiological and performance effects. *J. Police Crim. Psychol.* 24, 1–9. doi: 10.1007/s11896-008-9030-y

Assaf, Y., and Pasternak, O. (2007). Diffusion tensor imaging (DTI)-based white matter mapping in brain research: a review. *J. Mol. Neurosci.* 34, 51–61. doi: 10.1007/s12031-007-0029-0

Baker, B. G., Bhalla, A., Doleman, B., Yarnold, E., Simons, S., Lund, J. N., et al. (2017). Simulation fails to replicate stress in trainees performing a technical procedure in the clinical environment. *Med. Teach.* 39, 53–57. doi: 10.1080/0142159X.2016.1230188

Bar, R. J., and DeSouza, J. F. X. (2016). Tracking plasticity: effects of long-term rehearsal in expert dancers encoding music to movement. *PLoS One* 11:e0147731. doi: 10.1371/journal.pone.0147731

Barney, C., and Shea, S. C. (2007). The art of effectively teaching clinical interviewing skills using role-playing: a primer. *Psychiatr. Clin. N. Am.* 30, 31–50. doi: 10.1016/j.psc.2007.03.001

Barrett, L. F. (2012). Emotions are real. *Emotion* 12, 413–429. doi: 10.1037/a0027555

Barrett, L. F., and Bar, M. (2009). See it with feeling: affective predictions during object perception. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 364, 1325–1334. doi: 10.1098/rstb.2008.0312

Baumann, J., and DeSteno, D. (2010). Emotion guided threat detection: expecting guns where there are none. *J. Pers. Soc. Psychol.* 99, 595–610. doi: 10.1037/a0020665

Bearss, K. A., McDonald, K. C., Bar, R. J., and DeSouza, J. F. (2017). Improvements in balance and gait speed after a 12 week dance intervention for Parkinson's disease. *Adv. Integr. Med.* 4, 10–13. doi: 10.1016/j.aimed.2017.02.002

Binkofski, F., and Buccino, G. (2006). The role of ventral premotor cortex in action execution and action understanding. *J. Physiol. Paris* 99, 396–405. doi: 10.1016/j.jphysparis.2006.03.005

Birzer, M. L. (2003). The theory of andragogy applied to police training. *Policing* 26, 29–42. doi: 10.1108/13639510310460288

Blair, J. P., Pollock, J., Montague, D., Nichols, T., Curnutt, J., and Burns, D. (2011). Reasonableness and reaction time. *Police Q.* 14, 323–343. doi: 10.1177/1098611111423737

Blakemore, S.-J., Rees, G., and Frith, C. D. (1998). How do we predict the consequences of our actions? A functional imaging study. *Neuropsychologia* 36, 521–529. doi: 10.1016/S0028-3932(97)00145-0

Bläsing, B. E. (2015). Segmentation of dance movement: effects of expertise, visual familiarity, motor experience and music. *Front. Psychol.* 5, 353–311. doi: 10.3389/fpsyg.2014.01500

Bo, J., and Seidler, R. D. (2009). Visuospatial working memory capacity predicts the organization of acquired explicit motor sequences. *J. Neurophysiol.* 101, 3116–3125. doi: 10.1152/jn.00006.2009

Boyd, L. A., Edwards, J. D., Siengsukon, C. S., Vidoni, E. D., Wessel, B. D., and Linsdell, M. A. (2009). Motor sequence chunking is impaired by basal ganglia stroke. *Neurobiol. Learn. Mem.* 92, 35–44. doi: 10.1016/j.nlm.2009.02.009

Cahill, L., and Alkire, M. T. (2003). Epinephrine enhancement of human memory consolidation: interaction with arousal at encoding. *Neurobiol. Learn. Mem.* 79, 194–198. doi: 10.1016/S1074-7427(02)00036-9

Cahill, L., and McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends Neurosci.* 21, 294–299. doi: 10.1016/S0166-2236(97)01214-9

Canadian Association of Chiefs of Police (2018). Human resources & learning committee annual report 2017–2018.

Carleton, R. N., Afifi, T. O., Taillieu, T., Turner, S., Krakauer, R., Anderson, G. S., et al. (2019). Exposures to potentially traumatic events among public safety personnel in Canada. *Can. J. Behav. Sci.* 51, 37–52. doi: 10.1037/cbs0000115

Carleton, R. N., Afifi, T. O., Turner, S., Taillieu, T., Duranceau, S., LeBouthillier, D. M., et al. (2018). Mental disorder symptoms among public safety personnel in Canada. *Can. J. Psychiatry* 63, 54–64. doi: 10.1177/0706743717723825

Cisek, P. (2006). Integrated neural processes for defining potential actions and deciding between them: a computational model. *J. Neurosci.* 26, 9761–9770. doi: 10.1523/JNEUROSCI.5605-05.2006

Cisek, P. (2007). Cortical mechanisms of action selection: the affordance competition hypothesis. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 362, 1585–1599. doi: 10.1098/rstb.2007.2054

Cisek, P., and Kalaska, J. F. (2004). Neural correlates of mental rehearsal in dorsal premotor cortex. *Nature* 431, 993–996. doi: 10.1038/nature03005

Coalition for Evidence-Based Policy (2014). Which study designs are capable of producing valid evidence about a program's effectiveness? Available at: http://coalition4evidence.org/wp-content/uploads/2014/10/Which-Study-Designs-areCapable-of-Producing-Valid-Evidence-of-Effectiveness.pdf (Accessed May 15 2017).

Cohen, J. E., Shalev, H., Admon, R., Hefetz, S., Gasho, C. J., Shachar, L. J., et al. (2013). Emotional brain rhythms and their impairment in post-traumatic patients. *Hum. Brain Mapp.* 34, 1344–1356. doi: 10.1002/hbm.21516

Cressman, E. K., and Henriques, D. Y. P. (2009). Sensory recalibration of hand position following visuomotor adaptation. *J. Neurophysiol.* 102, 3505–3518. doi: 10.1152/jn.00514.2009

Cross, E. S., Kraemer, D. J. M., Hamilton, A. F. D. C., Kelley, W. M., and Grafton, S. T. (2009). Sensitivity of the action observation network to physical and observational learning. *Cereb. Cortex* 19, 315–326. doi: 10.1093/cercor/bhn083

Darling-Hammond, L., and Bransford, J. (2007). *Preparing teachers for a changing world: What teachers should learn and be able to do*. Hoboken, NJ: John Wiley & Sons.

De Quervain, D. J., Roozendaal, B., and McGaugh, J. L. (1998). Stress and glucocorticoids impair retrieval of long-term spatial memory. *Nature* 394, 787–790. doi: 10.1038/29542

De Quervain, D. J., Roozendaal, B., Nitsch, R. M., McGaugh, J. L., and Hock, C. (2000). Acute cortisone administration impairs retrieval of long-term declarative memory in humans. *Nat. Neurosci.* 3, 313–314. doi: 10.1038/73873

DeSouza, J. F. X., Menon, R. S., and Everling, S. (2003). Preparatory set associated with pro-saccades and anti-saccades in humans investigated with event-related fMRI. *J. Neurophysiol.* 89, 1016–1023. doi: 10.1152/jn.00562.2002

Dhami, P., Moreno, S., and DeSouza, J. F. (2015). New framework for rehabilitation–fusion of cognitive and physical rehabilitation: the hope for dancing. *Front. Psychol.* 5:1478. doi: 10.3389/fpsyg.2014.01478

Di Lorenzo, F., Ponzo, V., Motta, C., Bonnì, S., Picazio, S., Caltagirone, C., et al. (2018). Impaired spike timing dependent cortico-cortical plasticity in Alzheimer's disease patients. *J. Alzheimers Dis.* 66, 983–991. doi: 10.3233/JAD-180503

Di Nota, P. M. (2017). Short-and long-term changes in attention, memory and brain activity following exercise, motor learning, and expertise. Dissertation. Toronto, (ON): York University.

Di Noto, P. M., Uta, S., and DeSouza, J. F. X. (2013). Eye exercises enhance accuracy and letter recognition, but not reaction time, in a modified rapid serial visual presentation task. *PLoS One* 8:E59244. doi: 10.1371/journal.pone.0059244

Diamond, D. M., Campbell, A. M., Park, C. R., Woodson, J. C., Conrad, C. D., Bachstetter, A. D., et al. (2006). Influence of predator stress on the consolidation versus retrieval of long-term spatial memory and hippocampal spinogenesis. *Hippocampus* 16, 571–576. doi: 10.1002/hipo.20188

Doane, S. M., Pellegrino, J. W., and Klatzky, R. L. (1990). Expertise in a computer operating system: conceptualization and performance. *Hum. Comput. Interact.* 5, 267–304. doi: 10.1207/s15327051hci0502&3_5

Driemeyer, J., Boyke, J., Gaser, C., Büchel, C., and May, A. (2008). Changes in gray matter induced by learning—revisited. *PLoS One* 3:e2669–5. doi: 10.1371/journal.pone.0002669

Dziembowska, I., Izdebski, P., Rasmus, A., Brudny, J., Grzelczak, M., and Cysewski, P. (2016). Effects of heart rate variability biofeedback on EEG alpha asymmetry and anxiety symptoms in male athletes: a pilot study. *Appl. Psychophysiol. Biofeedback* 41, 141–150. doi: 10.1007/s10484-015-9319-4

Eidelson, R., Pilisuk, M., and Soldz, S. (2011). The dark side of comprehensive soldier fitness. *Am. Psychol.* 66, 643–644. doi: 10.1037/a0025272

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Hum. Factors* 37, 32–64. doi: 10.1518/001872095779049543

Ericsson, K. A. (1998). The scientific study of expert levels of performance: general implications for optimal learning and creativity. *High Abil. Stud.* 9, 75–100. doi: 10.1080/1359813980090106

Ericsson, K. A. (2004). Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad. Med.* 79, S70–S81. doi: 10.1097/00001888-200410001-00022

Ericsson, K. A., Chase, W. G., and Faloon, S. (1980). Acquisition of a memory skill. *Science* 208, 1181–1182. doi: 10.1126/science.7375930

Ericsson, K. A., Krampe, R. T., and Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychol. Rev.* 100, 363–406. doi: 10.1037/0033-295X.100.3.363

Ericsson, K. A., and Lehmann, A. C. (1996). Expert and exceptional performance: evidence of maximal adaptation to task constraints. *Annu. Rev. Psychol.* 47, 273–305. doi: 10.1146/annurev.psych.47.1.273

Eysenck, M. W., Derakshan, N., Santos, R., and Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion* 7, 336–353. doi: 10.1037/1528-3542.7.2.336

Filimon, F., Nelson, J. D., Hagler, D. J., and Sereno, M. I. (2007). Human cortical representations for reaching: mirror neurons for execution, observation, and imagery. *NeuroImage* 37, 1315–1328. doi: 10.1016/j.neuroimage.2007.06.008

Fitts, P. M., and Posner, M. I. (1967). *Human performance*. Oxford, England: Brooks/Cole.

Fleming, K. K., Bandy, C. L., and Kimble, M. O. (2010). Decisions to shoot in a weapon identification task: the influence of cultural stereotypes and perceived threat on false positive errors. *Soc. Neurosci.* 5, 201–220. doi: 10.1080/17470910903268931

Francois, C., and Schön, D. (2011). Musical expertise boosts implicit learning of both musical and linguistic structures. *Cereb. Cortex* 21, 2357–2365. doi: 10.1093/cercor/bhr022

Gallese, V., Fadiga, L., Fogassi, L., and Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain* 119, 593–609. doi: 10.1093/brain/119.2.593

Gallivan, J. P., and Culham, J. C. (2015). Neural coding within human brain areas involved in actions. *Curr. Opin. Neurobiol.* 33, 141–149. doi: 10.1016/j.conb.2015.03.012

Galton, F. (1869). *Hereditary genius: An inquiry into its laws and consequences*. London, Great Britain: Macmillan. 1–390. doi: 10.1037/13474-000

Gladwell, M. (2008). *Outliers: The story of success*. New York: Hachette Book Group.

Gobet, F., and Simon, H. A. (1998). Expert chess memory: revisiting the chunking hypothesis. *Memory* 6, 225–255. doi: 10.1080/741942359

Grèzes, J., and Decety, J. (2001). Functional anatomy of execution, mental simulation, observation, and verb generation of actions: a meta-analysis. *Hum. Brain Mapp.* 21, 1–19. doi: 10.1002/1097-0193(200101)12:1<1::AID-HBM10>3.0.CO;2-V

Hajcak, G., McDonald, N., and Simons, R. F. (2003). Anxiety and error-related brain activity. *Biol. Psychol.* 64, 77–90. doi: 10.1016/S0301-0511(03)00103-0

Haller, J., Raczkevy-Deak, G., Gyimesine, K. P., Szakmary, A., Farkas, I., and Vegh, J. (2014). Cardiac autonomic functions and the emergence of violence in a highly realistic model of social conflict in humans. *Front. Behav. Neurosci.* 8:364. doi: 10.3389/fnbeh.2014.00364

Hammerness, K., Darling-Hammond, L., Bransford, J., Berliner, D., Cochran-Smith, M., McDonald, M., et al. (2007). "How teachers learn and develop" in *Preparing teachers for a changing world*. eds. L. Darling-Hammond, J. Bransford, P. LePage, K. Hammerness and H. Duffy (Hoboken, NJ: John Wiley & Sons), 390–441.

Hammerness, K., Darling-Hammond, L., Grossman, P., Rust, F., and Shulman, L. (2005). "The design of teacher education programs" in *Preparing teachers for a changing world*. eds. L. Darling-Hammond, J. Bransford, P. LePage, K. Hammerness and H. Duffy (Hoboken, NJ: John Wiley & Sons), 390–441.

Hänggi, J., Koeneke, S., Bezzola, L., and Jäncke, L. (2010). Structural neuroplasticity in the sensorimotor network of professional female ballet dancers. *Hum. Brain Mapp.* 31, 1196–1206. doi: 10.1002/hbm.20928

Harmon-Jones, E., Gable, P. A., and Peterson, C. K. (2010). The role of asymmetric frontal cortical activity in emotion-related phenomena: a review and update. *Biol. Psychol.* 84, 451–462. doi: 10.1016/j.biopsycho.2009.08.010

Hebb, D. O. (1949). *The organisation of behavior: A neuropsychological theory*. New York: John Wiley & Sons, Inc.

Heiberger, L., Maurer, C., Amtage, F., Mendez-Balbuena, I., Schulte-Mönting, J., Hepp-Reymond, M. C., et al. (2011). Impact of a weekly dance class on the functional mobility and on the quality of life of individuals with Parkinson's disease. *Front. Aging Neurosci.* 3:14. doi: 10.3389/fnagi.2011.00014

Hemeren, P. E., and Thill, S. (2011). Deriving motor primitives through action segmentation. *Front. Psychol.* 1, 1–11. doi: 10.3389/fpsyg.2010.00243

Hird, J. S., Landers, D. M., Thomas, J. R., and Horan, J. J. (1991). Physical practice is superior to mental practice in enhancing cognitive and motor task performance. *J. Sport Exerc. Psychol.* 13, 281–293. doi: 10.1123/jsep.13.3.281

Hope, L. (2016). Evaluating the effects of stress and fatigue on police officer response and recall: a challenge for research, training, practice and policy. *J. Appl. Res. Mem. Cogn.* 5, 239–245. doi: 10.1016/j.jarmac.2016.07.008

Hope, L., Blocksidge, D., Gabbert, F., Sauer, J. D., Lewinski, W., Mirashi, A., et al. (2016). Memory and the operational witness: police officer recall of firearms encounters as a function of active response role. *Law Hum. Behav.* 40, 23–35. doi: 10.1037/lhb0000159

Iacoboni, M., Koski, L. M., Brass, M., Bekkering, H., Woods, R. P., Dubeau, M.-C., et al. (2001). Reafferent copies of imitated actions in the right superior temporal cortex. *Proc. Natl. Acad. Sci.* 98, 13995–13999.

Jameson, J. P., Mendes, W. B., Blackstock, E., and Schmader, T. (2010). Turning the knots in your stomach into bows: reappraising arousal improves performance on the GRE. *J. Exp. Soc. Psychol.* 46, 208–212. doi: 10.1016/j.jesp.2009.08.015

Joddrell, P., and Astell, A. J. (2016). Studies involving people with dementia and touchscreen technology: a literature review. *JMIR Rehabil. Assist. Technol.* 3:e10. doi: 10.2196/rehab.5788

Johnson, R. R., Stone, B. T., Miranda, C. M., Vila, B., James, L., James, S. M., et al. (2014). Identifying psychophysiological indices of expert vs. novice performance in deadly force judgment and decision making. *Front. Hum. Neurosci.* 8:512. doi: 10.3389/fnhum.2014.00512

Kahneman, D. (2003). A perspective on judgement and choice: mapping bounded rationality. *Am. Psychol.* 58, 697–720. doi: 10.1037/0003-066X.58.9.697

Karni, A., Meyer, G., Jezzard, P., Adams, M. M., Turner, R., and Ungerleider, L. G. (1995). Functional MRI evidence for adult motor cortex plasticity during motor skill learning. *Nature* 377, 155–158. doi: 10.1038/377155a0

Kilner, J. M., and Lemon, R. N. (2013). What we know currently about mirror neurons. *Curr. Biol.* 23, R1057–R1062. doi: 10.1016/j.cub.2013.10.051

King, J. B., Jones, K. G., Goldberg, E., Rollins, M., MacNamee, K., Moffit, C., et al. (2019). Increased functional connectivity after listening to favored music in adults with Alzheimer dementia. *J. Prev. Alzheimers Dis.* 6, 56–62. doi: 10.14283/jpad.2018.19

Klein, G. A. (1989). *Strategies of decision making*. Yellow Springs, OH: Klein Associates Inc.

Klein, G. A. (1993). *A recognition-primed decision (RPD) model of rapid decision making*. New York: Ablex Publishing Corporation, 138–147.

Klein, G. A. (2017). *Sources of power: How people make decisions*. Boston, MA: MIT press.

Klinger, D. A., and Brunson, R. K. (2009). Police officers' perceptual distortions during lethal force situations: informing the reasonableness standard. *Criminol. Public Policy* 8, 117–140. doi: 10.1111/j.1745-9133.2009.00537.x

Koch, G., Ponzo, V., Di Lorenzo, F., Caltagirone, C., and Veniero, D. (2013). Hebbian and anti-Hebbian spike-timing-dependent plasticity of human cortico-cortical connections. *J. Neurosci.* 33, 9725–9733. doi: 10.1523/JNEUROSCI.4988-12.2013

Krameddine, Y. I., DeMarco, D., Hassel, R., and Silverstone, P. H. (2013). A novel training program for police officers that improves interactions with mentally ill individuals and is cost-effective. *Front. Psych.* 4, 1–10. doi: 10.3389/fpsyt.2013.00009

Lansing, K., Amen, D. G., Hanks, C., and Rudy, L. (2005). High–resolution brain SPECT imaging and eye movement desensitization and reprocessing in police officers with PTSD. *J. Neuropsychiatry Clin. Neurosci.* 17, 526–532. doi: 10.1176/jnp.17.4.526

Lehrer, P. M., and Gevirtz, R. (2014). Heart rate variability biofeedback: how and why does it work? *Front. Psychol.* 5:756. doi: 10.3389/fpsyg.2014.00756

Lerner, Y., Honey, C. J., Silbert, L. J., and Hasson, U. (2011). Topographic mapping of a hierarchy of temporal receptive windows using a narrated story. *J. Neurosci.* 31, 2906–2915. doi: 10.1523/JNEUROSCI.3684-10.2011

Lewinski, W. J., Dysterheft, J. L., Priem, M. M., and Pettitt, R. W. (2016). Police officers' actual vs. recalled path of travel in response to a threatening traffic stop scenario. *Police Pract. Res.* 17, 51–67. doi: 10.1080/15614263.2014.959950

Lovallo, W. R. (2016). *Stress and health: Biological and psychological interactions*. 3rd Edn. Thousand Oaks, CA: SAGE.

Makin, D. A. (2016). A descriptive analysis of a problem-based learning police academy. *Interdiscip. J. Probl. Based Learn.* 10, 1–15. doi: 10.7771/1541-5015.1544

Mattar, A. A., and Gribble, P. L. (2005). Motor learning by observing. *Neuron* 46, 153–160. doi: 10.1016/j.neuron.2005.02.009

McCord, J. (2003). Cures that harm: unanticipated outcomes of crime prevention programs. *Ann. Am. Acad. Pol. Soc. Sci.* 587, 16–30. doi: 10.1177/0002716202250781

McIntosh, G. C., Brown, S. H., Rice, R. R., and Thaut, M. H. (1997). Rhythmic auditory-motor facilitation of gait patterns in patients with Parkinson's disease. *J. Neurol. Neurosurg. Psychiatry* 62, 22–26. doi: 10.1136/jnnp.62.1.22

Moazami-Goudarzi, M., Sarnthein, J., Michels, L., Moukhtieva, R., and Jeanmonod, D. (2008). Enhanced frontal low and high frequency power and synchronization in the resting EEG of parkinsonian patients. *NeuroImage* 41, 985–997. doi: 10.1016/j.neuroimage.2008.03.032

Morgan, C. A. III., Doran, A., Steffian, G., Hazlett, G., and Southwick, S. M. (2006). Stress-induced deficits in working memory and visuo-constructive abilities in special operations soldiers. *Biol. Psychiatry* 60, 722–729. doi: 10.1016/j.biopsych.2006.04.021

Morgan, C. A. III, Hazlett, G., Doran, A., Garrett, S., Hoyt, G., Thomas, P., et al. (2004). Accuracy of eyewitness memory for persons encountered during exposure to highly intense stress. *Int. J. Law Psychiatry* 27, 265–279. doi: 10.1016/j.ijlp.2004.03.004

Murphy, J. J. (2014). *Beyond a split-second: An exploratory study of police use of force and use of force training in Canada (Master's Thesis)*. Simon Fraser University. Retrieved from Semantic Scholar database.

Ness, D., and Calabrese, P. (2016). Stress effects on multiple memory system interactions. *Neural Plast.* 2016, 1–20. doi: 10.1155/2016/4932128

Neva, J. L., and Henriques, D. Y. P. (2013). Visuomotor adaptation and generalization with repeated and varied training. *Exp. Brain Res.* 226, 363–372. doi: 10.1007/s00221-013-3444-1

Nieuwenhuys, A., Caljouw, S. R., Leijsen, M. R., Schmeits, B. A. J., and Oudejans, R. R. D. (2009). Quantifying police officers' arrest and self-defense skills: does performance decrease under pressure? *Ergonomics* 52, 1460–1468. doi: 10.1080/00140130903287981

Nieuwenhuys, A., Cañal-Bruland, R., and Oudejans, R. R. (2012a). Effects of threat on police officers' shooting behavior: anxiety, action specificity, and affective influences on perception. *Appl. Cogn. Psychol.* 26, 608–615. doi: 10.1002/acp.2838

Nieuwenhuys, A., and Oudejans, R. R. (2010). Effects of anxiety on handgun shooting behavior of police officers: a pilot study. *Anxiety Stress Coping* 23, 225–233. doi: 10.1080/10615800902977494

Nieuwenhuys, A., and Oudejans, R. R. (2011). Training with anxiety: short-and long-term effects on police officers' shooting behavior under pressure. *Cogn. Process.* 12, 277–288. doi: 10.1007/s10339-011-0396-x

Nieuwenhuys, A., Savelsbergh, G. J., and Oudejans, R. R. (2012b). Shoot or don't shoot? Why police officers are more inclined to shoot when they are anxious. *Emotion* 12, 827–833. doi: 10.1037/a0025699

Nieuwenhuys, A., Savelsbergh, G. J., and Oudejans, R. R. (2015). Persistence of threat-induced errors in police officers' shooting decisions. *Appl. Ergon.* 48, 263–272. doi: 10.1016/j.apergo.2014.12.006

Nieuwenhuys, A., Weber, J., van der Hoeve, R., and Oudejans, R. R. (2017). Sitting duck or scaredy-cat? Effects of shot execution strategy on anxiety and police officers' shooting performance under high threat. *Leg. Criminol. Psychol.* 22, 274–287. doi: 10.1111/lcrp.12099

Oosterhof, N. N., Tipper, S. P., and Downing, P. E. (2013). Crossmodal and action-specific: neuroimaging the human mirror neuron system. *Trends Cogn. Sci.* 17, 311–318. doi: 10.1016/j.tics.2013.04.012

Oudejans, R. R. D. (2008). Reality based practice under pressure improves handgun shooting performance of police officers. *Ergonomics* 51, 261–273. doi: 10.1080/00140130701577435

Oudejans, R. R., and Pijpers, J. R. (2009). Training with anxiety has a positive effect on expert perceptual–motor performance under pressure. *Q. J. Exp. Psychol.* 62, 1631–1647. doi: 10.1080/17470210802557702

Oudejans, R. R., and Pijpers, J. R. (2010). Training with mild anxiety may prevent choking under higher levels of anxiety. *Psychol. Sport Exerc.* 11, 44–50. doi: 10.1016/j.psychsport.2009.05.002

Page, J. W., Asken, M. J., Zwemer, C. F., and Guido, M. (2016). Brief mental skills training improves memory and performance in high stress police cadet training. *J. Police Crim. Psychol.* 31, 122–126. doi: 10.1007/s11896-015-9171-8

Pijpers, J. R., Oudejans, R. R., Bakker, F. C., and Beek, P. J. (2006). The role of anxiety in perceiving and realizing affordances. *Ecol. Psychol.* 18, 131–161. doi: 10.1207/s15326969eco1803_1

Planche, K., Chan, J., Di Nota, P. M., Beston, B., Boychuk, E. C., Collins, P., et al. (2019). Diurnal cortisol variation according to high risk occupational speciality within police: comparisons between frontline, tactical officers, and the general population. *J. Occup. Environ. Med.* 61, e260–e265. doi: 10.1097/JOM.0000000000001591

Porro, C. A., Facchin, P., Fusi, S., Dri, G., and Fadiga, L. (2007). Enhancement of force after action observation: behavioural and neurophysiological studies. *Neuropsychologia* 45, 3114–3121. doi: 10.1016/j.neuropsychologia.2007.06.016

Pryor, K. (1999). *Don't shoot the dog–the new art of teaching and training (Revised)*. New York, NY: Bantam Books.

Pynn, L. K., and DeSouza, J. F. X. (2013). The function of efference copy signals: implications for symptoms of schizophrenia. *Vis. Res.* 76, 124–133. doi: 10.1016/j.visres.2012.10.019

Rauste-von Wright, M.-L., and Wright, J. (1994). *Oppiminen ja koulutus [Learning and education]*. Juva: WSOY:n graafisetlaitokset.

Reijnders, J. S., Ehrt, U., Weber, W. E., Aarsland, D., and Leentjens, A. F. (2008). A systematic review of prevalence studies of depression in Parkinson's disease. *Mov. Disord.* 23, 183–189. doi: 10.1002/mds.21803

Rizzolatti, G., and Craighero, L. (2004). The mirror-neuron system. *Annu. Rev. Neurosci.* 27, 169–192. doi: 10.1146/annurev.neuro.27.070203.144230

Rizzolatti, G., Fadiga, L., Gallese, V., and Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cogn. Brain Res.* 3, 131–141. doi: 10.1016/0926-6410(95)00038-0

Rizzolatti, G., Luppino, G., and Matelli, M. (1998). The organization of the cortical motor system: new concepts. *Electroencephalogr. Clin. Neurophysiol.* 106, 283–296. doi: 10.1016/S0013-4694(98)00022-4

Ropo, E. (1991). Opettajaeksperttiyden kehittyminen–tutkimustuloksia ja näkökulmia [Developing teacher expertise–research results and perspectives]. *Aikuiskasvatus* 11, 153–163.

Roth, M., Decety, J., Raybaudi, M., Massarelli, R., Delon-Martin, C., Segebarth, C., et al. (1996). Possible involvement of primary motor cortex in mentally simulated movement: a functional magnetic resonance imaging study. *Neuroreport* 7, 1280–1284. doi: 10.1097/00001756-199605170-00012

Sakai, K., Kitaguchi, K., and Hikosaka, O. (2003). Chunking during human visuomotor sequence learning. *Exp. Brain Res.* 152, 229–242. doi: 10.1007/s00221-003-1548-8

Salas, E., Bowers, C. A., and Cannon-Bowers, J. A. (1995). Military team research: 10 years of progress. *Mil. Psychol.* 7, 55–75. doi: 10.1207/s15327876mp0702_2

Salomonczyk, D., Cressman, E. K., and Henriques, D. Y. P. (2011). Proprioceptive recalibration following prolonged training and increasing distortions in visuomotor adaptation. *Neuropsychologia* 49, 3053–3062. doi: 10.1016/j.neuropsychologia.2011.07.006

Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G., and Zelaznik, H. N. (2019). *Motor control and learning: A behavioral emphasis (6th Ed.)*. Champaign, IL: Human kinetics.

Schwabe, L., and Wolf, O. T. (2013). Stress and multiple memory systems: from 'thinking' to 'doing'. *Trends Cogn. Sci.* 17, 60–68. doi: 10.1016/j.tics.2012.12.001

Sherwood, D. E., and Lee, T. D. (2003). Schema theory: critical review and implications for the role of cognition in a new theory of motor learning. *Res. Q. Exerc. Sport* 74, 376–382. doi: 10.1080/02701367.2003.10609107

Shmuelof, L., Krakauer, J. W., and Mazzoni, P. (2012). How is a motor skill learned? Change and invariance at the levels of task success and trajectory control. *J. Neurophysiol.* 108, 578–594. doi: 10.1152/jn.00856.2011

Simon, H. A., and Chase, W. G. (1973). Skill in chess. *Am. Sci.* 61, 394–403.

Soikkeli, R., Partanen, J., Soininen, H., Pääkkönen, A., and Riekkinen, P. Sr. (1991). Slowing of EEG in Parkinson's disease. *Electroencephalogr. Clin. Neurophysiol.* 79, 159–165. doi: 10.1016/0013-4694(91)90134-P

Song, S., Miller, K. D., and Abbott, L. F. (2000). Competitive Hebbian learning through spike-timing-dependent synaptic plasticity. *Nat. Neurosci.* 3, 919–926. doi: 10.1038/78829

Stanny, C. J., and Johnson, T. C. (2000). Effects of stress induced by a simulated shooting on recall by police and citizen witnesses. *Am. J. Psychol.* 113, 359–386. doi: 10.2307/1423364

Stanovich, K. E., and West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate. *Behav. Brain Sci.* 23, 645–665.

Stevenson, R. A., Geoghegan, M. L., and James, T. W. (2007). Superadditive BOLD activation in superior temporal sulcus with threshold non-speech objects. *Exp. Brain Res.* 179, 85–95. doi: 10.1007/s00221-006-0770-6

Taverniers, J., Taylor, M. K., and Sweets, T. (2013). Delayed memory effects after intense stress in special forces candidates: exploring path processes between cortisol secretion and memory recall. *Stress* 16, 311–320. doi: 10.3109/10253890.2012.721824

Thaut, M. H. (2015). "The discovery of human auditory–motor entrainment and its role in the development of neurologic music therapy" in *Progress in brain research*. eds. E. Altenmüller, S. Finger and F. Boller (Amsterdam, NL: Elsevier), 253–266. doi: 10.1016/bs.pbr.2014.11.030

Thaut, M. H., McIntosh, G. C., Rice, R. R., Miller, R. A., Rathbun, J., and Brault, J. M. (1996). Rhythmic auditory stimulation in gait training for Parkinson's disease patients. *Mov. Disord.* 11, 193–200. doi: 10.1002/mds.870110213

Thayer, J. F., and Sternberg, E. (2006). Beyond heart rate variability: vagal regulation of allostatic systems. *Ann. N. Y. Acad. Sci.* 1088, 361–372. doi: 10.1196/annals.1366.014

Tiippana, K. (2006). "Moniaistinen havaitseminen [Multisensory perception]" in *Mieli ja Aivot: Kongnitiivisen neurotieteen oppikirja. [Mind and brain: Cognitive science handbook]*. eds. H. Hämäläinen, M. Laine, O. Aaltonen and A. Revonsuo (Center for Cognitive Neuroscience, University of Turku). Turku, FI: Gummerus Kirjapaino), 177–184.

Tippett, W. J., and Sergio, L. E. (2006). Visuomotor integration is impaired in early stage Alzheimer's disease. *Brain Res.* 1102, 92–102. doi: 10.1016/j.brainres.2006.04.049

Toiskallio, J., and Mäkinen, J. (2009). *Military pedagogy: Military and action competence theory and practice*. Helsinki: Department of Management and Military Education. MPKK Publication Series. Edita Prima.

Tremblay, P.-L., Bedard, M.-A., Langlois, D., Blanchet, P. J., Lemay, M., and Parent, M. (2010). Movement chunking during sequence learning is a dopamine-dependant process: a study conducted in Parkinson's disease. *Exp. Brain Res.* 205, 375–385. doi: 10.1007/s00221-010-2372-6

Varila, J., and Rekola, H. (2003). *Mitä on työssä oppiminen: teoreettisia ja empiirisiä näkökulmia työssä oppimiseen [What is learning at work: Theoretical and empirical perspectives on learning at work]*. Joensuu: Joensuun yliopisto.

Ventura, R. E., Balcer, L. J., Galetta, S. L., and Rucker, J. C. (2016). Ocular motor assessment in concussion: current status and future directions. *J. Neurol. Sci.* 361, 79–86. doi: 10.1016/j.jns.2015.12.010

Vicente, K. J., and Wang, J. H. (1998). An ecological theory of expertise effects in memory recall. *Psychol. Rev.* 105, 33–57. doi: 10.1037/0033-295X.105.1.33

Vickers, J. N., and Lewinski, W. (2012). Performing under pressure: gaze control, decision making and shooting performance of elite and rookie police officers. *Hum. Mov. Sci.* 31, 101–117. doi: 10.1016/j.humov.2011.04.004

Weinberg, A., Meyer, A., Hale-Rude, E., Perlman, G., Kotov, R., Klein, D. N., et al. (2016). Error-related negativity (ERN) and sustained threat: conceptual framework and empirical evaluation in an adolescent sample. *Psychophysiology* 53, 372–385. doi: 10.1111/psyp.12538

Werner, S., and Noppeney, U. (2010). Superadditive responses in superior temporal sulcus predict audiovisual benefits in object categorization. *Cereb. Cortex* 20, 1829–1842. doi: 10.1093/cercor/bhp248

Westheimer, O., McRae, C., Henchcliffe, C., Fesharaki, A., Glazman, S., Ene, H., et al. (2015). Dance for PD: a preliminary investigation of effects on motor function and quality of life among persons with Parkinson's disease (PD). *J. Neural Transm.* 122, 1263–1270. doi: 10.1007/s00702-015-1380-x

Yager, L. M., Garcia, A. F., Wunsch, A. M., and Ferguson, S. M. (2015). The ins and outs of the striatum: role in drug addiction. *Neuroscience* 301, 529–541. doi: 10.1016/j.neuroscience.2015.06.033

Yerkes, R. M., and Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *J. Comp. Neurol. Psychol.* 18, 459–482. doi: 10.1002/cne.920180503

Yin, H. H., and Knowlton, B. J. (2006). The role of the basal ganglia in habit formation. *Nat. Rev. Neurosci.* 7, 464–476. doi: 10.1038/nrn1919

Yue, G., and Cole, K. J. (1992). Strength increases from the motor program: comparison of training with maximal voluntary and imagined muscle contractions. *J. Neurophysiol.* 67, 1114–1123. doi: 10.1152/jn.1992.67.5.1114

Yuille, J. C., Davies, G., Gibling, F., Marxsen, D., and Porter, S. (1994). Eyewitness memory of police trainees for realistic role plays. *J. Appl. Psychol.* 79, 931–936. doi: 10.1037/0021-9010.79.6.931

Zacks, J. M., Kumar, S., Abrams, R. A., and Mehta, R. (2009b). Using movement and intentions to understand human activity. *Cognition* 112, 201–216. doi: 10.1016/j.cognition.2009.03.007

Zacks, J. M., and Sargent, J. Q. (2010). "Chapter 7–event perception: a theory and its application to clinical neuroscience" in *Introduction to functional magnetic resonance imaging*. 1st Edn. Vol. 53. ed. B. Ross (Burlington: Elsevier Inc.), 253–299.

Zacks, J. M., Speer, N. K., and Reynolds, J. R. (2009a). Segmentation in reading and film comprehension. *J. Exp. Psychol. Gen.* 138, 307–327. doi: 10.1037/a0015305

Zacks, J. M., Speer, N. K., Swallow, K. M., and Maley, C. J. (2010). The brain's cutting-room floor: segmentation of narrative cinema. *Front. Hum. Neurosci.* 4, 1–15. doi: 10.3389/fnhum.2010.00168

Zacks, J. M., Swallow, K. M., Vettel, J. M., and McAvoy, M. P. (2006). Visual motion and the neural correlates of event perception. *Brain Res.* 1076, 150–162. doi: 10.1016/j.brainres.2005.12.122

Zalla, T., Pradat-Diehl, P., and Sirigu, A. (2003). Perception of action boundaries in patients with frontal lobe damage. *Neuropsychologia* 41, 1619–1627. doi: 10.1016/S0028-3932(03)00098-8

Zalla, T., Verlut, I., Franck, N., Puzenat, D., and Sirigu, A. (2004). Perception of dynamic action in patients with schizophrenia. *Psychiatry Res.* 128, 39–51. doi: 10.1016/j.psychres.2003.12.026

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Universal Police Behaviours during Critical Incidents and Their Connection to Personality: A Preliminary Study

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Universal Police Behaviours during Critical Incidents and Their Connection to Personality: A Preliminary Study

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Abstract

There is currently no universal standard for training or evaluating operational police performance during critical incident simulations. Accordingly, performance is typically judged on final outcomes (i.e., shoot/no-shoot decision-making) rather than a more detailed set of essential policing skills in both research and practical settings. The current study identifies six behavioural dimensions developed by expert use of force instructors: control of the environment, operational flexibility, initiative, critical decision-making, withdrawal, and target-oriented behaviour. To explore the possible relationship between inherent personality characteristics and primitive (i.e., untrained) police performance, 45 police recruits were assessed during stressful fieldwork simulations. Preliminary findings suggest several possible relationships; scores for control of the environment and operational flexibility were lower in more extraverted and flexible types. Initiative was also lower in more flexible types, and critical decision-making errors were related to higher extraversion. Withdrawal behaviour was greater among more emotional types, and target-oriented behaviour was higher in more extraverted participants. The behavioural dimensions developed in this study can be practically applied to standardize, tailor, and improve current training practices for essential policing skills. Understanding their possible connection to universal personality traits can identify inherent strengths and vulnerabilities that may need more attention and deliberate practice.

Keywords

Situational awareness, personality, decision-making, police training, police evaluation, critical incident simulation

1. Introduction

Police officers have an important role in society in maintaining safety and well-being (Laguna et al., 2013). Every situation encountered by an officer has the potential to evolve rapidly, occurs in a complex and dynamic environment, and can involve a great deal of uncertainty (Saus et al., 2006). In extreme cases, officers have to react very quickly and decide what (if any) use of force is appropriate up to and including lethal force. While these encounters are rare, it is the central goal of use of force training to adequately prepare individual officers to successfully resolve these encounters when they do occur. Therefore, the development of effective training and evaluation are important priorities for police practice and research. The current study aims to establish universal definitions of and standards for operational police behaviour during critical incident scenarios, including decision-making and situational awareness. As a preliminary investigation, the current study will also examine the relationship between these behavioural dimensions and personality traits.

1.1 Defining Police Performance

What components does a police patrol's or an individual police officer's performance on a single assignment consist of? How are an assignment's successful components distinguished from unsuccessful components or those needing improvement? The diverse nature of police work involves a multitude of skills and makes quantification and operationalization of 'performance' broadly defined very difficult (Henson et al., 2010). Accordingly, there are no currently established definitions or standards of practice for training or evaluating the essential skills required during critical incidents. However, there has been recent recognition by police researchers that performance should be defined more specifically than final outcomes (Bertilsson et al., 2019; Di Nota & Huhta, 2019). These elements of performance include situational awareness and decision-making that precede the tactical use of force.

A lack of common concepts also makes the systematic evaluation and analysis of an individual police officer's behaviour more difficult in practice. For the purpose of teaching and learning, if we cannot reliably identify recurring behavioural elements from one assignment to another, evaluating or improving them is not possible either. According to the empirical learning model, abstract conceptualization of one's actions is strengthened and tested through concrete experiences (Kolb, 1984), such as training scenarios. Reflecting on

one's experiences through constructive feedback and discussion with instructors is crucial for effective learning. Therefore, a lack of commonly approved behavioural dimensions for operational skills makes this practice more difficult.

Situational awareness (SA) (also referred to in the literature as 'situation awareness') is perhaps the most important skill for police and other first responders to possess and has been widely investigated in several sectors at the individual, team, and system level (for review, see Stanton et al., 2017). Yet, in the context of operational police training SA remains poorly conceptualized and operationalized. Endsley (1995, 1999) defines SA as closely linked to performance and decision-making, and involves three linear components: perception, comprehension, and projection. Perception refers to visual and other sensory information gathered from the surroundings, comprehension means understanding this information within the context of the current situation, and projection refers to anticipating potential events before they unfold. Endsley (1995) pointed out that SA and performance outcomes do not always go hand in hand, such that superior performance can result even if SA is lacking, and that high levels of SA do not guarantee optimal performance. Understanding the interaction of personality with SA has largely been ignored in police training thus far but could provide an explanation and context for errors in performance especially when perceptions, comprehension, and projection are correct.

We argue that, in reality, there are several recurrent elements within police assignments and performances that meet the broad definition of SA, and which need to be individually operationalized. SA isn't something we can just measure or evaluate on a scale from 0 to 10, or in a binary "yes/no" manner. Instead, SA must be practically operationalized into smaller conceptual elements or "chunks" that are distinguishable, and which can facilitate teaching and learning (Di Nota & Huhta, 2019; Di Nota et al., 2020). In the current study, we have operationalized SA into six distinct behavioural dimensions that together inform police behaviour: control of the environment, operational flexibility, initiative, critical decision-making, withdrawal, and target-oriented behaviour (see Section 2.2.2 for more detailed definitions and evaluation criteria). These dimensions allow for evaluation of multiple aspects of dynamic police performance, so that constructive feedback of specific behaviours exhibited during the unfolding encounter can be given, and not just based on the final outcome.

Decision-making can be challenging to define, as it can be both slow, deliberate, and conscious and fast, intuitive, and unconscious (see Kahnemann, 2003). A review of the theoretical definitions of decision-making is not the focus of the present study, but "critical decision-making" is one of the behavioural dimensions evaluated as defined in Section 2.2.2 and conceptualized here. In psychology, decision-making is described as a cognitive process that requires not only identifying available alternatives for action but also understanding their potential consequences (for review see Gallivan et al., 2018). Wrong decisions may be due to misinterpretation or ignorance of the factors affecting a situation, or insufficient understanding of the consequences. Under stressful conditions, decision-making has been shown to rely more heavily on emotional processing areas of the brain (Roos et al., 2017; Thayer et al., 2009), which can lead to more irrational behaviour (Kahnemann, 2003; Riabacke & Riabacke, 2015) and a greater reliance on implicit, untrained skills. Therefore, it is important to understand the relationships between implicit behaviours, skills, emotions, and personality traits in critical police situations.

In extreme cases, police are required to make difficult decisions (e.g., use of lethal force) very quickly and in highly uncertain conditions. Objective physiological evidence shows significant elevations in heart rate and stress hormone concentrations among police officers in training (Andersen et al., 2016; 2018; Nieuwenhuys & Oudejans, 2011), active duty set-

tings (Anderson et al., 2002; Baldwin et al., 2019), and at rest (Planche et al., 2019). High threat training scenarios that allow officers to safely practice their SA and decision-making skills have consistently shown improvement in performance outcomes (i.e., shoot/no-shoot decision-making) (Andersen & Gustafsberg, 2016; Andersen et al., 2018; Nieuwenhuys & Oudejans, 2011). Despite the evidence, there is often a reluctance within police culture to admit that the job is emotionally demanding, as expressing one's feelings can be taken as a sign of weakness (Carleton et al., 2018; Twersky-Glasner, 2005). However, applied research shows that adaptively engaging emotions and objective physiological stress responses can benefit police officers by reducing burnout (Schaiple & Six, 2016) and performance errors (Andersen et al., 2016; 2018). Understanding the potential impact of implicit personality traits on police behaviour remains unknown but could reveal important insights to promote performance during demanding and stressful situations, and improve police training and learning.

1.2 Personality, behaviour, and policing

Personality is a large field of study within psychology and has been defined as a relatively permanent trait quality and operating model, which defines an individual's typical behaviour regardless of place and time. However, research suggests that personality may change flexibly over the lifespan based on a multitude of factors (Helson et al., 2002). Individual and distinct personality traits have been defined in many ways according to numerous measurement scales (e.g., Big Five Factor Model, Minnesota Multiphasic Personality Inventory, NEO Personality Inventory, Personality Research Form, among others), and can be understood as "individual attributes that consistently distinguish people from another in terms of their basic tendencies to think, feel, and act in certain ways" (Ones et al., 2005, p. 390). Even though personality may change, this does not eliminate the need to understand the connection between *current* personality and *current* activity, especially in the context of teaching the basics of police tactics to recruits. In this study, personality and behaviour are measured at the same time in order to develop teaching and learning techniques. It is extremely important to understand how an inexperienced officer's implicit personality traits may influence their interpretation of, and behaviour in, a critical situation. In this way, instructors will have a better understanding of the reasons that may hinder (or promote) performance and can provide individualized feedback that will enhance learning. The results of the current study will support the general aim of all police training, which is to reduce individual's reliance on inherent (i.e., untrained) personality and behavioural tendencies and increase professional skills through practice and experience.

Psychological tests including aptitude and personality assessments are typically administered during the recruitment phase. In policing, personality is a subject of very high interest especially as it pertains to selecting students or officers for basic or specialist training and predicting success and performance in the field (Ghazinour et al., 2019; Henson et al., 2010; Twersky-Glasner, 2005). Detrick and Chibnall (2006) identified personality profiles (according to the NEO Personality Inventory-Revised) for high- and low-performing entry-level officers. However, these profiles were based on field training officer surveys, and not identified by the behavioural performance of actual trainees. As such, there is limited peer-reviewed empirical research that examines the direct relationship between police officers' personality and occupational performance, especially for implicit untrained behaviours elicited during a critical situation.

Previous research investigating the relationship between police officer personality and performance have defined the latter in several ways. Ortega and colleagues (2007) showed

that personality traits are directly related to work-related stress and job satisfaction, which in turn influence individual coping strategies. Sanders (2008) also investigated the connection between the Big Five personality traits and several occupationally relevant content areas for police, including job knowledge, quality and quantity of work, cooperation, dependability, and interaction with the public. Other researchers have defined police performance as problematic behaviours, including citizen complaints, suspensions, subordination, and termination (Aamodt, 2004; Richardson et al., 2007). However, these studies used numerous different personality measures, none of which significantly predicted individual officer performance (Richardson et al., 2007; Sanders, 2008). Further, the various definitions of performance in these studies did not include operational behaviours typically performed in the field, or evaluated during critical incident training.

More recently, Landman et al. (2016) studied the impact of personality traits and professional experience on police officers' shooting performance under pressure. The authors found that police performance was more strongly predicted by experience than personality. This may be due to the operationalization of personality traits by sensitivity to threat, behavioural inhibition, self-control, and thrill-and-adventure seeking instead of the traditional scales mentioned above. Additionally, the connection between personality and behaviour may also be occluded by the operationalization of police performance by shoot/no-shoot decision-making, shot accuracy, and shot timing, which do not reflect other critical tactical dimensions of police performance such as SA. Therefore, the relationship between police personality and complex behaviours performed under high-threat conditions remain unknown.

1.3 Aims

The aim of this study is to establish a universal set of behavioural dimensions for training and evaluating police performance during operational fieldwork simulations. Essential behavioural dimensions of police performance in critical contexts include: control of the environment, operational flexibility, initiative, critical decision-making, withdrawal, and target-oriented behaviour. Observed behaviours (including errors) are not random; instead, their origins may be linked to inherent personality traits. Therefore, a secondary aim of this study is to conduct a preliminary exploration of the possible relationship between personality traits, SA, and performance during simulated critical incidents. To clarify, this study does not aim to define an optimal police personality profile or classify personality traits as 'good' or 'bad' for policing. Instead, the current findings can improve understanding of the inherent personality factors affecting one's behaviour and facilitate learning through concrete and constructive reflections (Honkela et al., 2000). By distinguishing successful and unsuccessful behavioural components, the current study can enrich police evaluation and inform new evidence-based teaching methods tailored to the workforce.

2. Methods

In the current cross-sectional study, police students completed personality assessments prior to participating in four simulated critical incident scenarios to evaluate their performance on a newly defined set of operational behavioural dimensions.

2.1 Participants

The sample ($N = 45$) consisted of 29 male and 16 female students who were second year police recruits at the Police University College of Finland (PUC). The average age of the

participants was 24 years, ranging from 20 to 37. The PUC Principal and Chief of Research approved the study on 12 August 2015. Personality assessments were completed by all participants on the same day in December 2015, and all behavioural assessments were completed in the following two weeks.

An invitation to participate in the study was sent to eligible students through the institute's internal email (Wilma) program. Eligibility was based on completion of basic training in tactics and use of force. Of 109 eligible students who received an invitation, 45 volunteered to participate in the final study (response rate: 41.3%). One participant missed the second week, resulting in $n = 44$ participants included in analyses of training scenarios 3 and 4.

2.2 Measures and Procedure

2.2.1 Personality questionnaire

Personality was assessed using two inventories that are part of the standard psychological entrance examinations at the PUC – Personality Research Form (PRF) and the Mindfindr assessment instrument. PRF has been used for decades in both practice and research applications and has shown significant connections between personality and performance (Bridgwater, 1982; Von Weissenberg, 2017). The test-retest reliability of the Mindfindr instrument has been tested in several samples, including the general population ($n = 68$, interval = 3 weeks, range = 0.87 – 0.94), and applicants to the PUC ($n = 42$, interval = 6 months, range = 0.74 – 0.82).

The four personality traits identified by Mindfindr and used in the current study are analogous to universal personality traits identified by the PRF (see Mindfindr, 2020). We define and evaluate the following personality traits:

- **Extraversion:** As a measure of social predisposition, this trait reflects to what extent a person is either outgoing, active and assertive, or rather more private and preferring to concentrate on few activities at a time.
- **Intuitiveness:** This trait describes a person's typical ways of gathering and processing information and relating to his or her environment. Intuitive types consider more abstract concepts and future opportunities, while less intuitive types pay more attention to information provided by their senses.
- **Emotionality:** As a basis of spontaneous decision-making especially in new situations, this trait shows that emotional types place emphasis on their own and other people's values and feelings, while less emotional types rely on logic and take into account objective facts.
- **Flexibility:** This trait describes individual's preferred way of acting, and the level of order and structure in their conduct. Flexible types keep their options open, adapting flexibility in new situations while less flexible types are organized, planful, and conscientious.

Each of these personality traits correlates significantly ($p < 0.001$) with subscales of the PRF as evaluated by three samples, including the current study sample (Table 1).
According to the Mindfindr instrument (Mindfindr, 2020), each personality trait had a score from 0 to 100. Intuitiveness, emotionality, and flexibility have been reverse coded so that higher scores reflect more of each personality type for all four types (i.e., higher score means more intuitiveness, emotionality, flexibility, and extraversion).

Table 1. Validation of Mindfindr personality instrument against Personality Research Form (PRF). Personality traits defined by Mindfindr (2020) have been validated against corresponding dimensions of universal personality traits in the PRF in three adult samples, including the current study sample (n = 45). All correlation values are $p \leq 0.001$.

Mindfindr	**PRF**	***r***	***n***
Extraversion	Affiliation	.556	377
		.459	623
		.469	45
	Exhibition	.454	377
		.574	623
		.490	45
Intuitiveness	Harm avoidance	-0.198	377
		– 0.157	623
		N.S.	45
	Sentience	.193	377
		.150	623
		N.S.	45
Emotionality	Succorance	.237	377
		.166	623
		.579	45
Flexibility	Structure	-0.664	377
		– 0.651	623
		– 0.745	45
	Impulsivity	.582	377
		.564	623
		.610	45

To clarify, we have not dichotomized the personality traits but instead define and evaluate them as continuous variables; individuals are described as being 'more' or 'less', or scoring higher or lower on each of the personality traits defined above. As seen in Figure 1, the distribution of participants across the individual personality dimensions is not balanced, such that police officers in the current study sample tend to score higher in extraversion and lower in intuitiveness, emotionality, and flexibility. These distributions should be kept in mind when interpreting the final results.

2.2.2. Definition and Evaluation of Behavioural Dimensions

The behavioural dimensions identified in this study are intended to reflect implicit actions that we suggest are closely tied to personality, and are readily observable in both trained and untrained officers. All behavioural dimensions defined are connected to Endsley's (2012)

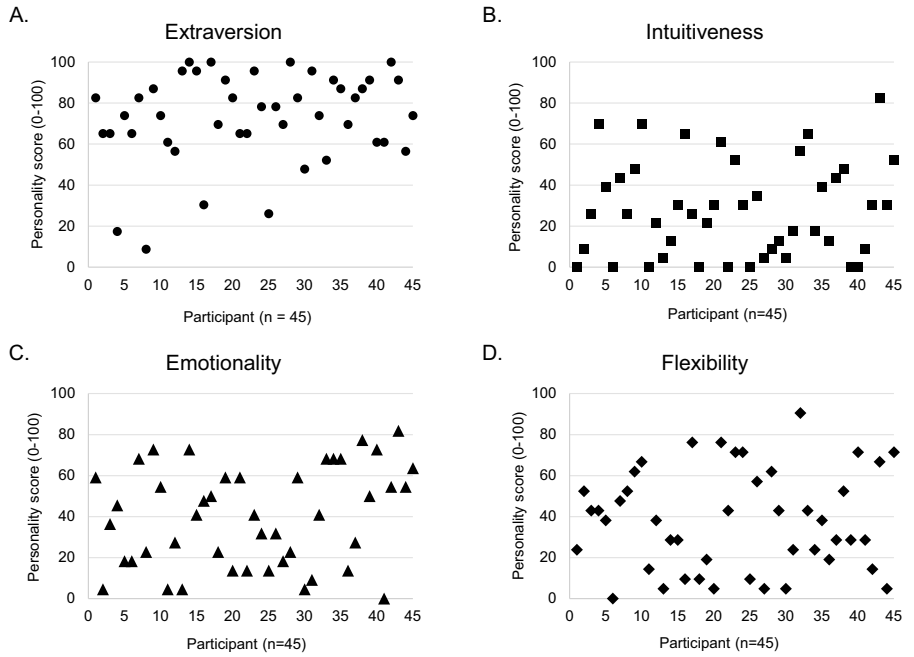

Figure 1. Distributions of personality traits among police recruits. All participants (*n* = 45) completed personality assessments (score 0–100) on four traits: Extraversion (A), Intuitiveness (B), Emotionality (C), and Flexibility (D). Intuitiveness, emotionality, and flexibility have been reverse coded so that higher scores in all personality traits reflect relatively more extraverted, intuitive, emotional, and flexible individuals. Note that the distribution of participants in the current study score relatively higher in extraversion and lower in all remaining personality traits, which means that they tend to be more extraverted and less intuitive, emotional, and flexible.

definition of SA, which involves observing, understanding, and predicting the current situation. However, we acknowledge that this is not an exhaustive list of all possible operational police behaviours required during critical incidents, including tactical manoeuvres (e.g., position, technique, and timing of opening a door, or method of entering a space). The definitions below were mainly established based on the authors' (J-MH and EP) combined 25 years of experience as operators and instructors in use of force and tactics in police, special forces, and military settings. The dimensions identified here reflect untrained, implicit behaviours that are commonly observed during highly stressful and novel situations (i.e., when stress responses elicit primitive actions or reactions). The origins of these behavioural dimensions are unknown but are likely connected to implicit personality traits. The dimensions were also validated by tactical use of force instructors at the PUC and Finnish Federal Special Intervention Unit (SIU) prior to the current study. Definitions and the practical evaluation of the dimensions were further developed based on this feedback.

Individual officer performance was defined according to the following six operational behavioural dimensions, which are followed by example evaluation questions in italics:

Control of the Environment: refers to a person's ability to identify the threats and opportunities posed by the operational environment. Good control of the environment is manifested by being correctly prepared for both unknown ("plus one rule", i.e., the possibility of additional targets or threats) and identified threats, perceiving potential risk elements, taking notice of safe places, and advancing by systematically checking the environment. Good control of the environment allows a police officer to avoid a situation from which there is no escape or being caught by surprise. This behavioural dimension is closely linked to situational awareness, which Endsley (2012) suggested consists of observation of the environment, understanding the "big picture" of the present situation, and anticipating how the situation will develop.

Is the testee able to observe the direction of potential threat in his/her action in space A?

0 = no control of the environs 10 = temporally and spatially comprehensive control of the environs

Operational Flexibility: In police tactical training and the defence forces, operators are often observed showing stereotypical behaviour, which is hard to get rid of even when it proves fruitless. When caught in this kind of behavioural lock, a person does not know how or is unable to change their chosen line of action or break out of their routine. It may be because the individual cannot read the target's reactions or reflect on the target's responses to his/her own actions. Operational flexibility describes a person's ability to adapt his/her own action in relation to the target's response and achieve desired effects. Through reflecting on one's observations, an operationally flexible person is able to adaptively change his/her behavioural pattern, adjust his/her state of preparedness, and respond accordingly to the target's changing actions. An example is a change in the selected instrument of force, or the content of a verbal command as a result of the change in a target's action or the officer's observations. Therefore, operational flexibility can be understood as a combination of personal resilience and purposeful goal orientation, such that this behavioural dimension describes not only an ability to adapt and get through changing and surprising situations, but also vary one's own methods of influence and action in order to achieve the desired goal.

Is the testee able to adjust his/her action in relation to the changing situation after the encounter?

0 = not at all / operational model lock 10 = action flexible as required by the situation

Initiative: Being active and taking initiative are central and widely recognized principles among instructors in military and for police tactics. The party who initiates an action advances the situation actively towards the goal and forces the other party to respond. The initiative to take determined and fast action can stop or limit the opposite party's chances to respond. In police assignments, the initiative in a situation is often first dictated by the opposite party. Therefore, in order to achieve their goal, officers must take initiative. Sometimes, this is possible as a result of actions taken by the opposite party, but often, the officer's initiative must be gained through active, systematic action. A typical way of gaining initiative is limiting the target's choices of action. For example, an officer may take the initiative to block a potential exit or stand in front of bystanders, forcing the target to operate within an allotted space.

Is the testee capable of rational action aiming to take the initiative after establishing contact with the target person at door 3?

0 = no such action 10 = action rational and immediate

Critical Decision-Making: In this study, critical decision-making is expressly defined as an ability to make timely, difficult, yet necessary decisions in challenging circumstances. In extremely stressful situations of police work, these decisions may require carrying out a capture, abandoning an action, or using force up to and including lethal force.

Does the testee shoot (at) the target before the victim gets hit with an axe? Yes/No.

Withdrawal: Eluding a threatening situation is natural human behaviour. However, police work entails facing and responding to human aggression, and suppressing the instinctive drive to evade or withdraw from the threat. As a result, the police can very rarely completely avoid confronting a conflict. Withdrawal can be operationalized through various observable behaviours, including dawdling or replacement behaviour; for instance, when an officer stays put and does less important or less urgent jobs like re-checking spaces they have already cleared, they postpone or avoid going into a threatening situation. Less obvious forms of withdrawal behaviour include doing the right thing unnecessarily slowly, or needlessly repeating completed tasks. Note that a higher score on this scale reflects more inappropriate behaviour (i.e., a lower score is more desirable).

Does the testee show signs of unnecessary replacement behaviour or other efforts to avoid the encounter waiting in space B?

0 = no such signs 10 = very many

Target-Oriented Behaviour: During acutely stressful situations, the human brain instinctively adjusts attention and movement based on target information and decreases priority for addressing larger goals. Therefore, more automatic behaviours are exhibited at the cost of higher order cognitive functioning, like critical decision-making and other processes crucially involved with the behavioural dimensions defined above (Roos et al., 2017; Thayer et al., 2009). Accordingly, adjusting one's behaviour to actively move toward the target (when safe, reasonable, or necessary) is essential for effective police operations. However, if the individual is too focused on the target it can weaken their ability to view the situation as a whole and reduce situational awareness. In the worst case, an officer who exhibits strong target-oriented behaviour may put themselves in a position where they are forced to act; for example, being forced to use a firearm based on the officer's own actions, which could have been avoided by more rational thinking and behaviour. One of the goals of police use of force and tactical training is to limit target-oriented behaviour but instead to perform well-reasoned active and direct behaviours if needed, even in the case of very fast encounters.

Does the testee try to make an immediate arrest as the situation unfolds? Yes/No.

2.2.3. Critical Incident Scenario Description

Behavioural dimensions were evaluated during four simulated police intervention scenarios by highly qualified external evaluators from the PUC. Each participant independently performed the same four scenarios in the same order, which were all arranged indoors at the PUC simulation hall. The hall is an open, heated 272 m^2 space in which partitions were built using mobile walls and doors. Participants wore their personal field outfits and equipment and were given protective glasses and a non-lethal training gun and ammunition (FX-simunition). Evaluators provided participants with background information and instructions orally and in writing one minute before the beginning of each scenario. The four scenarios were demanding encounters that required participants to check and clear various spaces, use lethal force (2 of 4 scenarios), use appropriate verbal commands to safely de-escalate the situation, apprehend an armed suspect, and take into account the security of bystanders.

Each scenario had at least one evaluation question for each behavioural dimension (see above) with the exception of Scenario 3, which was missing withdrawal behaviour. Every set of evaluation questions was tailored to the specific content of each scenario and its environment and surroundings. Most of the behavioural dimensions (control of the environment, operational flexibility, initiative, withdrawal) were evaluated using a visual analogue scale. Evaluators marked a 10-cm line with a traverse depending on how the participant had performed. The traversed line was measured with a ruler to obtain a score in millimetres that ranged from 0 to 100. Target oriented behaviour and critical decision-making were evaluated as binary (yes/no) variables. After determining that independent evaluator responses were highly correlated with each other, average scores were calculated for each question and used in the final analyses.

2.3 Statistical Analysis

Shapiro Wilk tests on the four personality traits and continuous scores on behavioural dimensions showed that several of the variables violated the assumption of a normal distribution (*ps* < 0.05, Figure 1). Therefore, Spearman correlations were used to test the relationship between personality and behaviour. Significance criteria was set at $p < 0.05$ and was not corrected for multiple comparisons in order to explore very preliminary but highly novel insights on the potential relationship between police behaviour and personality during simulated critical incidents.

3. Results

Table 2 provides an overview of the significant relationships identified between personality traits and behavioural dimensions of operational police performance evaluated in the current study.

Table 2. Relationships between personality traits and behavioural dimensions in police. Only significant ($p < 0.05$) correlations are shown, based on the full study sample ($n = 45$) that performed four different critical incident scenarios. *$p < 0.05$ **$p < 0.01$

	Extraversion	**Intuitiveness**	**Emotionality**	**Flexibility**
Control of the environment	$r_s = -0.44^{**}$ $r_s = -0.30^{*}$	–	–	$r_s = -0.32^{*}$ $r_s = -0.31^{*}$
Operational flexibility	$r_s = -0.30^{*}$	–	–	$r_s = -0.38^{*}$ $r_s = -0.36^{*}$ $r_s = -0.32^{*}$
Initiative	–	–	–	$r_s = -0.41^{**}$
Critical decision-making	$r_s = 0.31^{*}$	–	–	–
Withdrawal	–	–	$r_s = 0.31^{*}$	–
Target oriented behaviour	$r_s = 0.30^{*}$	–	–	–

3.1 Control of the environment

Control of the environment was negatively correlated with extraversion scores ($r_S = -0.44$, $p = 0.003$; $r_S = -0.30$, $p = 0.046$), where participants who scored higher in extraversion were less likely to observe the direction of potential threat in his/her space, and less likely to check all

scenario spaces. Control of the environment was also negatively related to flexibility scores, such that individuals who scored lower in this personality trait (i.e., were less flexible) were more likely to observe the direction of potential threat in his/her space (scenario 1: $r_S = -0.31$, $p = 0.036$; scenario 3: $r_S = -0.32$, $p = 0.036$).

3.2 Operational Flexibility

Operational flexibility was negatively correlated to extraversion ($r_S = -0.30$, $p = 0.048$), such that participants who scored lower in extraversion were better able to adjust their own behaviour in response to the changing situation. Several measures of operational flexibility revealed significant negative correlations to the flexible personality trait, such that participants who scored lower in flexibility demonstrated better performance on the following measures: After the suspect shoots, how fast does the participant seek cover? ($r_S = -0.32$, $p = 0.034$, $n = 44$); Does the participant modify his/her level of anticipation (after the shots)? ($r_S = -0.36$, $p = 0.017$); Is the participant able to adjust his/her action to correspond to the changing situation after the encounter? ($r_S = -0.38$, $p = 0.011$).

3.3 Initiative

A significant negative correlation with the flexibility personality trait ($r_S = -0.41$, $p = 0.005$) revealed that participants who scored lower in flexibility had improved capability of logical goal-oriented action in order to gain control of the situation.

3.4 Critical Decision-Making

Critical decision-making was significantly related to extraversion ($r_S = 0.31$, $p = 0.037$), such that participants who shot the target person before it was lawfully justified (scored as a '1') scored higher in extraversion.

3.5 Withdrawal Behaviour

Withdrawal behaviour was positively related to emotionality ($r_S = 0.31$, $p = 0.041$), such that participants who scored higher in emotionality (i.e., more emotional dependence) were more likely to demonstrate signs of unnecessary replacement behaviour or other efforts to avoid the encounter.

3.6 Target-Oriented Behaviour

Target-oriented behaviour was marginally related to extraversion ($r_S = 0.30$, $p = 0.049$), such that more extraverted individuals were more likely to go after the target person in a manner that compromised their safety and tactical position.

4. Discussion

The current study evaluated police performance during simulated critical incidents using six universal dimensions of operational police behaviour, which should be considered during training and evaluation. We provide preliminary evidence for several significant relationships between these functional dimensions of police behaviour and personality traits. More flexible personality types scored lower in operational flexibility, control of the environment, and initiative relative to less flexible individuals. Higher scores in extraversion were related to lower performance in control of the environment and operational flexibility. Similarly, we found that more extraverted participants made more errors in critical decision-making and behaved in a more target-oriented manner putting themselves at risk. Finally, participants

higher in emotionality were more likely to demonstrate signs of unnecessary withdrawal behaviour. There were no significant relationships found between the intuitive personality trait and behaviour during simulated critical incidents. Together, the current findings provide police instructors and educators with a standardized set of criteria for training and evaluating the most essential behavioural skills for police. By understanding the contribution of individuals' inherent personality traits on performance in each dimension, police training and education can be optimized. Specifically, officers who show high levels of extraversion, flexibility, and emotionality in their entrance examinations should receive focused instruction and training to improve their operational performance in critical contexts.

The personality trait of flexibility revealed several significant relationships with behavioural dimensions of police performance. According to the personality assessment used in the current study (Mindfindr, 2020), flexible personality types are curious and open-minded, understanding and adaptive to situations in a more impulsive and spontaneous way. Flexible types might operate adaptably in non-critical police operations, such as during more verbal interactions (e.g., helping a lost elderly person who cannot provide a lot of information). But in the current study, more flexible individuals scored lower in control of the environment, operational flexibility, and initiative during critical incidents. This may be due to the nature of critical incidents that not only require fast action, but also adapting one's actions in relation to the changing situation (i.e., target's responses, environment) in order to achieve the desired goal. Therefore, more systematic, goal-oriented behaviour as seen among less flexible personality types was beneficial to operational flexibility, as well as for initiative and control of the environment. The label of a flexible personality type, in this case, can be misleading, as their thinking and action patterns can also be more 'chaotic'. This may put more flexible individuals at risk in critical situations unless they are trained to be more systematic and methodical in their evaluation and understanding of SA.

In decisions requiring the inhibition of a use of lethal force (i.e., no-shoot decision), participants who scored higher in extraversion performed worse than those who scored lower in extraversion. These results are consistent with observations by experienced police instructors of a natural willingness of extraverts to approach people in general, as well as in dangerous and uncertain situations. While this trait may be advantageous and adaptive for police to exhibit in general and is dominantly reflected in the personality distribution of the current sample (Figure 1A), police training should directly address the potential behavioural vulnerabilities associated with greater extraversion. According to the current results, other potential vulnerabilities include less control of the environment, less operational flexibility, and higher target-oriented behaviour among more extraverted participants, whose natural tendencies to be more instinctual and spontaneous are indicative of lower SA. To mitigate these effects, police trainers could direct more extraverted individuals to utilize their dominant, outgoing, and assertive nature to act in a way that is more focused and objective.

Avoiding threatening situations is a natural, adaptive human response, even in critical police encounters. In moderation, withdrawal minimizes individual risk and facilitates careful and cautious action. When this behaviour increases, however, it may prevent an officer from successfully proceeding through their assignment and postponing more urgent actions. From the involved parties' or victim's point of view, help is unnecessarily delayed, and the situation may worsen as time passes. At worst, withdrawal behaviour can be so strong that an officer will completely evade a threatening situation. The only significant connection between this behavioural dimension and personality was with emotionality. Individuals who are more sensitive to their own subjective impressions and emotions show greater withdrawal behaviours. Conversely, individuals with a more objective, logical, and

evaluative approach may be better at suppressing withdrawal behaviours. This is supported by the findings of greater control of the environment, operational flexibility, and initiative among more structured (i.e., less flexible) personality types.

4.1 Limitations and future directions

Limitations of the current study include homogeneity of personality traits among the sample of police recruits (Figure 1), and possibly among individuals selected for police work in general (Tversky-Glasner, 2005). However, there is no empirical research that systematically reports outcome-based police personality profiles (Detrick & Chibnall, 2006), and indeed a general lack of recent peer-reviewed literature on police personality traits and their direct connection to critical incident behaviours. Contributing to this problem is a lack of standardization for pre-employment personality assessments used across police agencies and in other occupations. Furthermore, there is a lack of universal and evidence-based definitions for police performance that can be utilized during training and evaluation (Di Nota & Huhta, 2019). The behavioural dimensions defined in the current study (Section 2.2.2), and in other recent police performance studies (Bertilsson et al., 2019), are based on the observations and operational experiences of expert instructors, as well as established (but unwritten) standards of police practice. The current study takes a preliminary look at the possible connections between personality data gathered during police pre-employment screening in order to provide important and novel insights to subsequent performance outcomes.

Police culture often tends to 'downplay' the role of emotions and subjective feelings of stress, as they can be seen as signs of weakness and cause doubt in your partner's abilities (Carleton et al., 2018; Twersky-Glasner, 2005). Stress has also been shown to reduce officers' memories of their own performance (Lewinski et al., 2016), as well as degrade performance (i.e., decision-making) during critical incidents (Nieuwenhuys & Oudejans, 2011). Physiological stress responses also lead to a greater reliance on implicit skills, and reduce brain activity responsible for more deliberate, effortful decision-making (Roos et al., 2017; Thayer et al., 2009). Therefore, future research that continues to explore how inherent personality traits inform these automatic, implicit behaviours in critical police encounters is extremely important, and informed the current study design.

Previous studies that provide officers with objective feedback of their stress responses during training have shown significant and long-term improvements in SA and critical decision-making (Andersen & Gustafsberg, 2016; Andersen et al., 2018). Similarly, providing officers with objective feedback on the possible connections between their personality traits and behaviour could also improve learning and future performance outcomes. When the current sample was provided preliminary results and a teaching module on the relationship between personality traits and behaviour, the participants expressed great interest and increased knowledge. Specifically, their feedback on a 6-point Likert scale (0 = *not at all*; 5 = *very much*) suggested that the information was helpful in increasing their understanding of how inherent personality traits can influence operational behaviours and decision-making processes (mean score = 4.3), and that this knowledge could contribute to choosing safer tactical solutions in future situations (mean score = 4.6). These data also provide preliminary evidence for the acceptability of integrating information about individual personality traits into police tactical and use of force training.

Multiple regression is one useful type of analysis that could reveal the predictive relationship between personality traits and performance during high-stakes encounters. Vasilopoulos et al. (2007) investigated the linear and curvilinear relationships between two types

of personality measures (factor and facet scales) and subsequent training scores among law enforcement personnel. Consistent with the Yerkes and Dodson (1908) model, training grades were better predicted among individuals at extreme ends of the personality distributions, suggesting that extreme personality types may show different (i.e., worse) performance than less extreme types. The current findings of lower scores across multiple behavioural dimensions among individuals who scored high in extraversion (Table 2) are consistent with this notion. Although we explored the current dataset with linear and quadratic regression analyses, our relatively small sample size ($n = 45$) contributed to a lack of sufficient statistical power but would be of great interest in future research among police.

5. Conclusion

The current findings connecting personality traits to operational police behaviours should not be interpreted to prioritize (or undermine) specific personality traits relative to others in police pre-employment screening. In contrast to Detrick and Chibnall (2006), the current findings suggest that there is not an ideal police personality profile because different traits might be better than others depending on the specific task. Similarly, Landman et al. (2016) concluded that instead of selecting police officers based on specific personality traits, that these inherent factors should be the focus of training and improving their abilities in challenging circumstances. The current preliminary results identify several personality-behaviour relationships that can be used to develop and implement personalized training and feedback.

Above all, it is our hope that increased understanding of the objective link between an individual's personality and their own actions revealed by the current findings will help to identify potential behavioural tendencies (both adaptive and maladaptive) in critical situations. By clarifying these evidence-based relationships, police training can utilize officers' inherent strengths to exemplify positive performance, while also developing effective training to prevent or reduce performance errors based on inherent vulnerabilities. In this way, the current findings can be used to practically enhance learning, improve self-reflection, and promote effective policing and occupational safety.

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Declaration of Conflicting Interests

Author MN is a cofounder and co-owner of one of the personality assessments used in the current study (Mindfindr) but did not receive any compensation (financial or otherwise) for the collection, analysis, or reporting of data for this article. No other potential or actual conflicts of interest are declared.

References

Aamodt, M. G. (2004). Special issue on using MMPI-2 scale configurations in law enforcement selection: Introduction and meta-analysis. *Applied HRM Research*, *9*(2), 41-52.

Andersen, J.P., Di Nota, P.M., Beston, B., Boychuk, E.C., Gustafsberg, H., Poplawski, S. & Arpaia, J. (2018). Reducing lethal force errors by modulating police physiology. *Journal of Occupational and Environmental Medicine, 60*(10), 867-874. https://doi.org/10.1097/JOM.0000000000001401.

Andersen, J.P. & Gustafsberg, H. (2016). A training method to improve police use of force decision making: a randomized controlled trial. *Sage Open, 6*(2). https://doi.org/10.1177/2158244016638708.

Andersen, J.P., Pitel, M., Weerasinghe, A. & Papazoglou, K. (2016). Highly realistic scenario based training simulates the psychophysiology of real world use of force encounters: implications for improved police officer performance. *Journal of Law Enforcement, 5*(4), 1–13.

Anderson, G. S., Litzenberger, R., & Plecas, D. (2002). Physical evidence of police officer Stress. *Policing: An International Journal of Police Sciences & Management*, *25*(2), 399–420. https://doi.org/10.1108/13639510210429437

Baldwin, S., Bennell, C., Andersen, J., Semple, T. & Jenkins, B. (2019). Stress-activity mapping: physiological responses during general duty police encounters. *Frontiers in Psychology, 10*, 2216. https://doi.org/10.3389/fpsyg.2019.02216

Bertilsson, J., Niehorster, D.C., Fredriksson, P.J., Dahl, M., Granér, S., Fredriksson, O., Mårtensson, J.M., Magnusson, M., Fransson, P.A. & Nyström, M. (2019). Towards systematic and objective evaluation of police officer performance in stressful situations. *Police Practice and Research*, 1–15. https://doi.org/10.1080/15614263.2019.1666006

Bridgwater, C. A. (1982). Personality characteristics of ski instructors and predicting teacher effectiveness using the PRF. *Journal of Personality Assessment*, *46*(2), 164–168. https://doi.org/10.1207/s15327752jpa4602_11

Carleton, R.N., Korol, S., Mason, J. E., Hozempa, K., Anderson, G. S., Jones, N. A., … & Bailey, S. (2018). A longitudinal assessment of the road to mental readiness training among municipal police. *Cognitive Behaviour Therapy, 47*(6), 508–528. https://doi.org/10.1080/16506073.2018.1475504

Detrick, P., & Chibnall, J. T. (2006). NEO PI-R personality characteristics of high-performing entry-level police officers. *Psychological Services*, *3*(4), 274.

Di Nota, P. M., & Huhta, J. M. (2019). Complex motor learning and police training: applied, cognitive, and clinical perspectives. *Frontiers in Psychology*, *10*, 1797.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors, 37*(1), 32–64. https://doi.org/10.1518/001872095779049543

Endsley, M. R. (1999). Situation awareness and human error: Designing to support human performance. In: *Proceedings of the High Consequence System Surety Conference,* pp. 2–9. Sandia National Laboratory.

Endsley, M. R. (2012). Situation awareness. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (4th ed.). John Wiley & Sons, pp. 553–568.

Gallivan, J.P., Chapman, C.S., Wolpert, D.M. & Flanagan, J.R. (2018). Decision-making in sensorimotor control. *Nature Reviews Neuroscience, 19*(9), 519–534. https://doi.org/10.1038/s41583-018-0045-9

Ghazinour, M., Padyab, M., Lauritz, L. E., & Richter, J. (2019). Personality and mental health changes throughout the course of university police training in Sweden. *Nordisk politiforskning*, *6*(1), 7–23. https://doi.org/10.18261/issn.1894-8693-2019-01-03

Helson, R., Jones, C., & Kwan, V. S. (2002). Personality change over 40 years of adulthood: Hierarchical linear modeling analyses of two longitudinal samples. *Journal of Personality and Social Psychology, 83*(3), 752–766. https://doi.org/10.1037/0022-3514.83.3.752

Henson, B., Reyns, B. W., Klahm, C. F., & Frank, J. (2010). Do good recruits make good cops? Problems predicting and measuring academy and street-level success. *Police Quarterly, 13*(1), 5–26. https://doi.org/10.1177/1098611109357320

Honkela, T., Leinonen, T., Lonka, K., & Raike, A. (2000). Self-organizing maps and constructive learning. In *Proceedings of the International Conference on Educational Uses of Communication and Information Technologies, ICEUT* (pp. 339–343).

Kahnemann, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist, 58*, 697–720. https://doi.org/10.1037/0003-066X.58.9.697

Kolb, D. A. (1984). *Experiential learning. Experience as the source of learning and development.* Prentice-Hall.

Laguna, L., Agliotta, J., & Mannon, S. (2015). Pre-employment screening of police officers: Limitations of the MMP-2 K-scale as a useful predictor of the performance. *Journal of Police and Criminal Psychology, 30*(1), 1–5. https://doi.org/10.1007/s11896-013-9135-9

Landman, A., Nieuwenhuys, A., & Oudejans, R. R. (2016). The impact of personality traits and professional experience on police officers' shooting performance under pressure. *Ergonomics, 59*(7), 950–961.

Lewinski, W. J., Dysterheft, J. L., Priem M. M., & Pettitt, R. W. (2016). Police officers' actual vs. recalled path of travel in response to a threatening traffic stop scenario. *Police Practice and Research, 17*(1), 51–67. https://doi.org/10.1080/15614263.2014.959950

Mindfindr. (2020). Scientific background of Mindfindr. Retrieved on 26 May 2020 from https://mindfindr.com/en/articles/scientific-background/

Nieuwenhuys, A., & Oudejans, R. R. (2011). Training with anxiety: Short-and long-term effects on police officers' shooting behavior under pressure. *Cognitive Processing, 12*(3), 277–288. https://doi.org/10.1007/s10339-011-0396-x

Ones, D. S., Viswesvaran, C., & Dilchert, S. (2005). Personality at work: Raising awareness and correcting misconceptions. *Human Performance, 18,* 389–404. https://doi.org/10.1207/s15327043hup1804_5

Ortega, A., Brenner, S.-O., & Leather, P. (2007). Occupational stress, coping and personality in police: An SEM study. *International Journal of Police Science & Management, 9*(1), 36–50. https://doi.org/10.1350/ijps.2007.9.1.36

Planche, K., Chan, J.F., Di Nota, P.M., Beston, B., Boychuk, E., Collins, P.I. & Andersen, J.P. (2019). Diurnal cortisol variation according to high-risk occupational specialty within police: Comparisons between frontline, tactical officers, and the general population. *Journal of Occupational and Environmental Medicine, 6*(6), e260-e265. https://doi.org/10.1097/JOM.0000000000001591

Riabacke A. & Riabacke M. (2015). *Päätöksenteko* [Decision-making]. Talentum. ISBN: 9789521422607

Richardson, D. W., Cave, S. B., & La Grange, L. (2007). Prediction of police officer performance among New Mexico State Police as assessed by the Personality Assessment Inventory. *Journal of Police and Criminal Psychology*, *22*(2), 84–90.

Roos, L.E., Knight, E.L., Beauchamp, K.G., Berkman, E.T., Faraday, K., Hyslop, K. & Fisher, P.A. (2017). Acute stress impairs inhibitory control based on individual differences in parasympathetic nervous system activity. *Biological Psychology, 125*, 58–63. https://doi.org/10.1016/j.biopsycho.2017.03.004

Sanders, B. A. (2008). Using personality traits to predict police officer performance. *Policing: An International Journal of Police Strategies & Management, 31*(1), 129–147. https://doi.org/10.1108/13639510810852611

Saus, E.-R., Johnsen, B. H., Eid, J., Riisem, P. K., Andersen, R., & Thayer, J. F. (2006). The effect on brief situational awareness training in a police shooting simulator: An experimental study. *Military Psychology, 18,* 3–21. https://doi.org/10.1207/s15327876mp1803s_2

Schaiple, L. M., & Six, M. (2016). Emotional strategies of police and their varying consequences for burnout. *Police Quarterly, 19*(1), 3–31. https://doi.org/10.1177/1098611115604448

Stanton, N. A., Salmon, P. M., Walker, G. H., Salas, E., & Hancock, P. A. (2017). State-of-science: Situation awareness in individuals, teams and systems. *Ergonomics*, *60*(4), 449–466.

Thayer, J.F., Hansen, A.L., Saus-Rose, E. & Johnsen, B.H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine, 37*(2), 141–153. https://doi.org/10.1007/s12160-009-9101-z

Twersky-Glasner, A. (2005). Police personality: What is it and why are they like that? *Journal of Police and Criminal Psychology, 20*(1), 56–67. https://doi.org/10.1007/BF02806707

Vasilopoulos, N.L., Cucina, J.M., & Hunter, A.E. (2007). Personality and training proficiency: Issues of bandwidth-fidelity and curvilinearity. *Journal of Occupational and Organizational Psychology, 80*, 109–131. https://doi.org/10.1348/096317906X102114

Von Weissenberg, J. (2017). Zulliger, Wartegg and Personality Research Form (PRF) tests as predictors of investment performance. *SIS Journal of Projective Psychology & Mental Health*, *24*(2), 96.

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18*, 459–482. https://doi.org/10.1002/cne.920180503

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Experience-Dependent Effects to Situational Awareness in Police Officers: An Eye Tracking Study

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Experience-Dependent Effects to Situational Awareness in Police Officers: An Eye Tracking Study

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Abstract: Police work requires making suitable observations which form the basis of situational awareness (SA) of the encounter in progress. Incomplete early-stage SA (i.e., perception) can lead to errors in subsequent judgement and decision-making that can have severe consequences for performance, learning, and occupational health. SA in police contexts is still relatively understudied and requires closer examination using objective measures. The current preliminary study aimed to measure the gaze and fixation patterns among novice and expert police officers to understand early-stage SA at different levels of professional experience. Participants included 23 novices (10 early, 13 intermediate) and 11 experienced officers and instructors in tactics and use of force. Visit duration and fixation order were measured while participants viewed various static images of staged encounters. Results showed that all participants fixated longer on targets compared to the periphery, and fixated earlier on suspects' faces compared to hands, bodies, or the environment. Further, experts fixated earlier on hands and spent less time scanning the environment than early novices. The current findings reveal eye movement patterns while officers engaged in typical police encounters. Future research can inform evidence-based police training to achieve optimal SA and minimize negative outcomes in training and operational field settings.

Keywords: situational awareness; police; eye tracking; fixation; expertise; police encounters; visuomotor neuroscience

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1. Introduction

Police work consists of evaluating and resolving complex situations, quite often under time pressure and uncertainty. Potentially violent encounters are especially demanding and require rapid assessment and effective judgement, decision-making, and actions [1–3]. Therefore, where and how officers visually scan the unique environments they are faced with is a critical professional skill. Repeated and prolonged exposure to potentially traumatic events place police officers at greater risk for developing operational stress injuries (OSIs), which include elevated symptoms of depression, anxiety, and post-traumatic stress disorder (PTSD) [4,5], and exhibiting suicidal thoughts and behaviors [6]. Potentially traumatic exposures may include negative outcomes in operational field settings and/or training contexts, which can diminish officers' confidence and compromise subsequent performance. Therefore, developing effective strategies for navigating critical incidents is an important goal for police work and education.

Situational awareness (SA) (sometimes also referred to as 'situation awareness') is perhaps the most important skill required by police and other first responders, and forms the basis of judgement, decision-making, and action [7]. Although it has been extensively studied in several industries (e.g., sports, aviation, military command, medicine) at the

individual and group level ([8,9], for review, see [10]), there are very few empirical studies that examine, conceptualize, or define SA in policing contexts. One of the main definitions of SA currently employed by police instructors is based on the work of Endsley [11], who divides SA into three components: perception, comprehension, and projection. The current study will focus on early-stage SA, as the information which officers are able to gather via perception will inform downstream comprehension, projection, and decision-making.

Of the very few previous studies that measure SA in police, operational definitions and details on measurement criteria are lacking [12]. In both research and practice, SA is commonly scored on a subjective scale, which makes instructor evaluations vulnerable to potential biases [13]. In light of limited SA police research, we look to studies that measure objective eye movement patterns to understand how training and experience can shape early-stage SA. By understanding how expert police gather essential information, evidence-based SA training can be developed.

Expert police officers (i.e., more field experience and specialized training [7]) and trained emergency responders have shown different patterns of directing their gaze compared to untrained individuals and novice police. Based on a systematic review of eye tracking studies involving police and law enforcement, Heusler and Sutter [14] state that visual perception is strongly related to expertise, such that experts are better able to attend to and focus on essential information (see also [15]). Furthermore, experts' domain-specific knowledge and experience facilitate improved early SA and decision-making under stressful conditions. Specifically, Vickers and Lewinski [2] found that expert officers shot more accurately and made fewer decision-making errors than beginners during live "shoot/no-shoot" scenarios. Using eye tracking equipment, this study also showed that the experts were more likely to look at locations where the firearm could have been hidden in the suspect's clothes, while the novices' eyes were directed to a wider area. Recently, Heusler and Sutter [16] compared gaze and fixation behaviors between tactical unit and patrol officers while they performed video-based "shoot/no-shoot" scenarios. Expert tactical officers spent significantly shorter time fixating on targets' faces, and longer on the hands and hip areas than patrol officers. However, every scenario included in this study involved a weapon, which may have primed participants to search for this highly salient target in every situation.

When comparing visuomotor behaviors during high versus low threat simulations, police officers demonstrate increased blinking and diverting their gaze, and head movements away from target locations under high threat [17]. Following stressful real-world encounters (i.e., officer-involved shootings), officers report several perceptual distortions including tunnel vision and slowed sense of time [18]. High threat can also impact the later stages of SA—comprehension and projection—including a phenomenon referred to as 'affective realism', whereby objects such as a radio or cellphone are mistakenly perceived as a firearm [12,19]. However, training under stressful conditions has been shown to improve deficits in visuomotor gaze behavior, SA, and lethal force decision-making [12,20,21]. In police use of force and tactics training, SA may not be consistently trained as a finite skill despite its relevance to threat assessment, decision-making, and motor skills development [7,22]. Therefore, the development of SA should focus on effective methods of exploration to identify essential features of the situation as it continues to unfold [23].

The purpose of the current study was to understand expert models of early-stage SA (i.e., perception) in police, and specifically, how they search for critical information in various typical police encounters. To clarify, this study was not intended to evaluate SA during high-stress situations where officers needed to make split-second shoot/no-shoot decisions, nor where their gaze behaviors may be impacted by stress physiology. Rather, the current study sought to measure early-stage SA while viewing a variety of encounters that police officers face daily, including critical ones. Early-stage SA was operationalized by objective gaze and fixation behaviors during a scene perception task. By comparing expert visuomotor patterns to those among novice police trainees, the current findings can provide evidence-based insights for police training of SA and tactics.

2. Materials and Methods

2.1. Participants

A total of 34 participants took part in the study, and were divided into expert (n = 11, all male) and novice (n = 23, 11 female) groups based on their experience (see Table 1). Novices were further subdivided based on their studies carried out, such that students in periods 1 to 4 were assigned to the Novice 1 (N1) group, and students in periods 5 to 6 (i.e., had all or almost all tactical training and were just about to start their practical training in the field) were assigned to the Novice 2 (N2) group [24]. Novice students were invited to participate in the study through an email distributed in the institute's internal email system (Wilma). The research recruitment message sent to the students indicated that eligibility required that the participant does not have previous training or work experience in the security sector. Expert police officers had an average of 16.7 years of experience as police officers (SD = 3.9, range: 12−25), and an average of 8.0 years of experience in special units (SD = 2.2, range: 3.5−10) including K-9, special response units, and instructors in tactics and use of force. Experts were invited to participate in the study based on their geographical location and availability.

Table 1. Demographic information.

Group.	*n* (Female)	Age *M* (*SD*)	Years of Experience *M* (*SD*)
Novice 1	10 (6)	25.6 (3.4)	<1.5 education
Novice 2	13 (5)	24.6 (4.4)	<1.5 education + tactical training
Experts	11 (0)	41.6 (4.3)	16.7 (3.9) duty, 8.0 (2.2) special units

The study was approved by the research ethics board of the Police University College of Finland.

2.2. Procedure

The study was conducted at the Police University College of Finland in February 2018 using a computer connected to a 17-inch monitor and built-in eye tracker system (Tobii T60, software version Tobii Pro Lab 1.64). Following informed consent, fitting, and calibration of the eye tracker, participants were told that they will be presented with 13 static photographs of staged encounters of a confrontational nature (see Supplementary Materials). As visualized in Figure 1, participants were given 15 s to observe each image during which time their gaze activity was recorded (see Measures). Following presentation of each image, participants were asked specific questions to probe their SA and tactical decision-making. The qualitative results of the interview data will be presented in a separate study. Once participants had finished answering the interview questions, they were asked to fixate on the center of the computer screen and a button was pressed to present the next image.

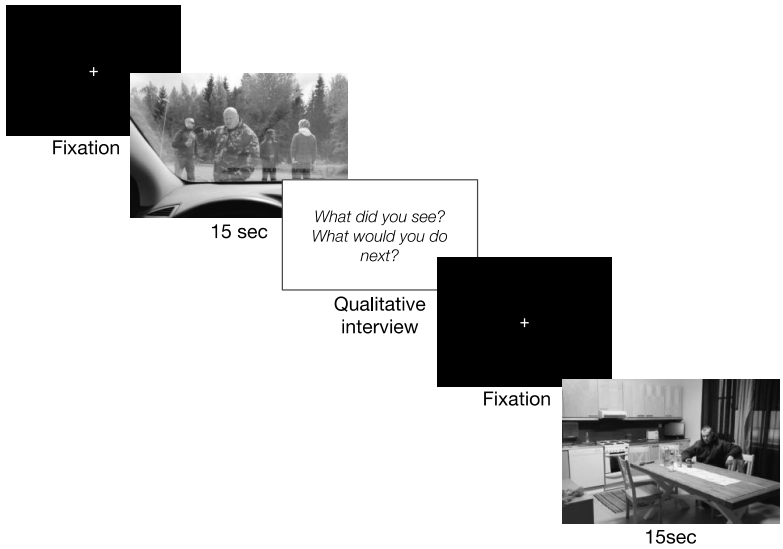

Figure 1. Experimental procedure. Note that interview questions following each image were the same and were not presented on the computer screen. Qualitative analyses of interview data will be presented in a separate study.

2.3. Measures

Using the Gazeplot feature in the Tobii Pro Lab software system, an expert police instructor (J-MH) identified boundary regions around several areas of interest (AOIs) for each image, including the target person(s) and the peripheral environment. Within the target AOIs, further subareas of interest (subAOIs) were marked around suspect faces, hands, and body (i.e., excluding the face and hands), which are most tactically relevant to police SA in critical incidents. Data were obtained within 5 s from stimulus onset for each image to capture early SA (i.e., initial visual perception).

Situational awareness was operationalized by the following objective measures (Figure 2):

(1) *Visit duration*: The total time spent (in seconds) fixating or moving the eyes searching within overall target and environment AOIs.

(2) *Fixation order*: The first fixation point within a predefined AOI was marked and assigned a weighted value of 100. All subsequent fixation points received half of the previous value, such that the second fixation point received a value of 50, the third fixation value was 25, the fourth fixation value was 12.5, and the fifth fixation value was 6.25. Only 2 instances recorded a seventh fixation valued at 3.125 (0.3% of 638 cases). The initial fixation at the center of the image at its onset was excluded, and no target AOIs were located at central fixation. If participants did not fixate within a predefined AOI within the first 5 s, it received a value of zero. Descending weights were assigned for later fixations to reflect decreasing salience in early SA and scene perception among police. Data were averaged across individual images to compute mean weights for face, hand (left and/or right), body, and environment subAOIs.

Due to limitations in the eye tracking equipment and stimulus design (see Limitations in Discussion), visit duration data was obtained from 7 of 13 images, and fixation order data was obtained from 4 of 13 images. For example, Figures S1 and S2 were excluded because target subAOIs were too small, numerous, and close together, and the eye tracker was not sensitive enough to distinguish between them to register valid fixation duration or order values.

(**a**) (**b**)

Figure 2. Sample eye tracking data. In both images, each individual circle represents a participant's point of fixation. The size of each circle represents visit duration, with larger circles representing longer durations. The number within each circle represents the order of fixation following stimulus onset. The color of each circle corresponds to a specific participant: (**a**) Visualized eye tracking data for Novice 1 participants; (**b**) Visualized eye tracking data for expert participants.

2.4. Statistical Analyses

Visit duration and fixation order data were entered into SPSS (Version 25, IBM Corp., Armonk, NY, USA) for statistical analyses. Continuous visit duration data were normally distributed according to Shapiro–Wilk tests (*ps* > 0.05). Therefore, a two-way repeated measures ANOVA was used to examine the main effects and interaction between AOIs (target, environment) and group (Novice 1, Novice 2, Expert). Visit duration data for each image was also descriptively analyzed and presented. Ordinal fixation order data were compared using non-parametric tests (i.e., Kruskal–Wallis, pairwise comparisons using Mann–Whitney U test) to evaluate between-group differences among experts and both novice groups. Within-group differences in fixation order between face, hands, body, and environment were tested using pairwise Wilcoxon Signed-Rank tests separately for each group. Due to the highly novel and exploratory nature of the current dataset, significance criteria were set at $p < 0.05$ with Bonferroni-corrected values reported where available.

3. Results

3.1. Visit Duration

A significant main effect of AOI revealed that all participants spent significantly more time scanning and fixating target areas compared to the environment with a large effect size ($F(1,31) = 30.034$, $p < 0.001$, $\eta^2 = 0.492$) (Figure 3). The main effect of group was not significant ($F(2,31) = 1.384$, $p = 0.266$, $\eta^2 = 0.082$). However, a significant interaction between AOI and group ($F(2,31) = 3.339$, $p = 0.049$, $\eta^2 = 0.177$) revealed that experts spent significantly less time fixating the environment compared to Novice 1 ($p_{Bonf} = 0.050$) and Novice 2 ($p_{Bonf} = 0.015$), with no differences in visit duration for target AOIs.

Within-subject analyses comparing visit duration in target versus environment AOIs were not conducted, as differences in these variables depend on the specific context of each image (Figure 4). For example, all groups spent more time looking at the target person in Pictures 3 and 8 (see Figures S3 and S4 in Supplementary Materials), while the environment was attended to more in Pictures 9 (Figure S5) and 12 (see Figure 2 above). Differences in target versus environment fixation that are consistent across all participants can be accounted for by situational differences that are unique to each image. For example, Pictures 3 and 8 (Figures S3 and S4) mainly feature a central target person with relatively few peripheral cues. In contrast, Pictures 9 and 12 feature relatively more visual cues in

the environment, which directed all participants to spend more time visually exploring the surroundings. As we were not interested in evaluating the differences in gaze patterns *between images*, visit duration data were averaged across individual images to ascertain differences in gaze and fixation patterns between novice and expert police.

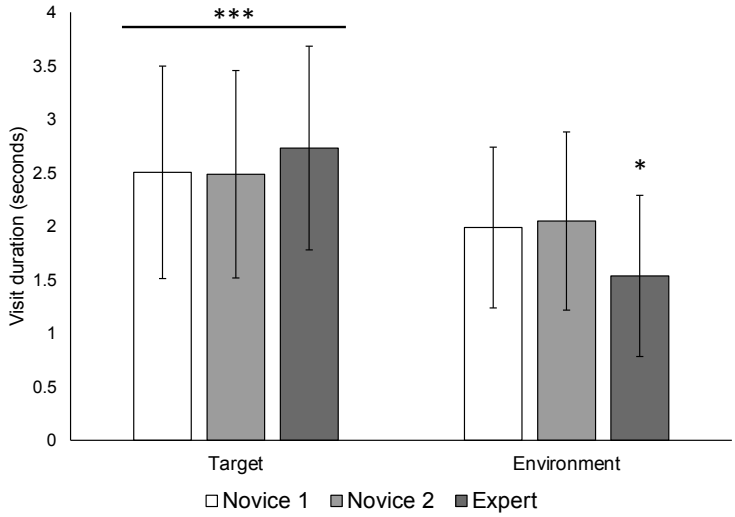

Figure 3. Average visit duration for target versus environment areas of interest. The mean time (in seconds) spent fixating on or scanning pre-defined target (left bars) and environment areas of interest (right bars) for 7 images are presented for each group (shown in different colours). All groups spent significantly more time fixating and scanning target areas compared to the environment. Experts spent significantly less time viewing the environment compared to both novice groups. *** $p < 0.001$, * $p < 0.05$.

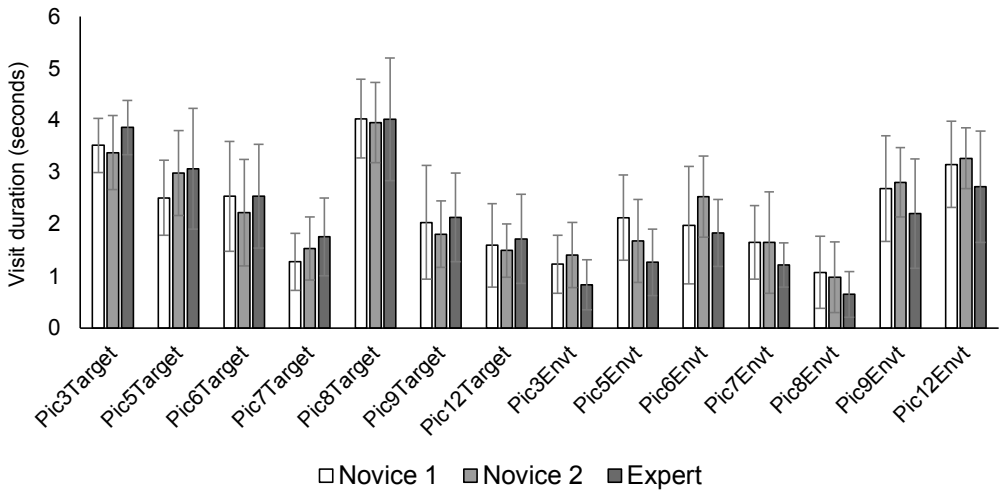

Figure 4. Visit duration for target versus environment areas of interest for seven individual images (see Supplementary Materials).

3.2. Fixation Order

Within-group analyses reveal that all participants fixated on suspect faces earlier than all other AOIs (hands: $Z = -5.054$, $p < 0.001$; body: $Z = -5.089$, $p < 0.001$; environment: $Z = -5.088$, $p < 0.001$), and that there were no significant differences between body and environment AOIs ($Z = -0.966$, $p = 0.334$). For Novice 1, there were no other differences in fixation order between hands, bodies, and the environment ($p > 0.05$). For Novice 2, hands were fixated earlier than bodies ($Z = -3.181$, $p = 0.001$) and the environment ($Z = -2.668$, $p = 0.008$). For Experts, hands were fixated earlier than the environment ($Z = -2.295$, $p = 0.022$) but not bodies ($Z = -1.867$, $p = 0.062$). The only significant between-group difference in fixation order was observed for the hands ($\chi^2(2) = 8.001$, $p = 0.018$), such that early novice participants recorded later fixations and received lower weighted values for this subAOI compared to both later novices ($U = 22.5$, $z = -2.648$, $p = 0.008$) and experts ($U = 24.0$, $z = -2.188$, $p = 0.029$) (Figure 5).

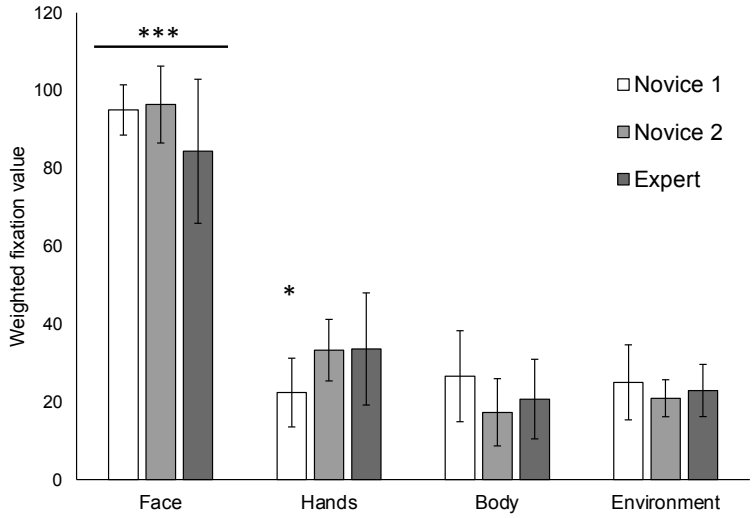

Figure 5. Average fixation order for target versus environment areas of interest among novice (Novice 1, Novice 2) and expert police. All participants fixated on faces earlier than hands, bodies, and the environment. Novice 1 participants fixated on hands significantly later than both Novice 2 and expert officers. *** $p < 0.001$, * $p < 0.05$.

4. Discussion

Utilizing objective gaze and fixation data, the current study measured early-stage SA (i.e., perception) among novice and expert police officers while they observed various images of staged police encounters. Overall, we found that all participants fixated longer on target persons compared to the surrounding environment, and that faces were fixated earlier than suspects' hands or bodies. Furthermore, consistent with previous research [16], expert officers fixated earlier on hands compared to early and intermediate novice police trainees, and spent less time scanning the environment than early novices. By examining objective eye movement patterns while viewing typical police encounters, the current findings provide evidence-based insights for developing police training in SA and tactical decision-making. Training officers on optimal visual search strategies can enhance their SA and, in turn, minimize negative outcomes in operational field settings.

The finding that all participants fixated on targets longer and on their faces earliest compared to other areas of interest is perhaps unsurprising. People's faces and facial expressions are highly salient features for human social interactions and, as demonstrated in our findings (Figure 5), for information gathering among police. Facial cues can provide

information about an individual's emotional and/or mental state, and the direction of a person's gaze can signal their possible intentions and motives [25–27]. For example, a suspect constantly looking at their car's glove compartment could signal a potentially hidden object, such as drugs or a weapon. Therefore, early fixation on target persons' faces provides important information that can help inform officers' predictions about what can happen next.

While the current findings suggest an optimal fixation order (target person's face, hands, proximal environment), the 'correct' duration of fixation remains less prescriptive. That is, it may not always be better to spend less time scanning the environment, especially if the target person is actively moving and can access possible weapons from the environment. According to expert police instructors, optimal SA requires that officers control their gaze beyond automatic primitive responses and continue to evaluate (i.e., visually scan) the situation. In police tactics training, it is a well-known fact that the hands are the most dangerous physical feature of a target person. If a suspect wishes to seek harm against the police or another individual, they will most likely use their hands, either empty or with an object. By extension, a knife or firearm on the floor is not dangerous by itself; rather, these objects become immediately life-threatening if the officer does not see/perceive them (see below for further discussion on seeing versus perceiving) and the target person moves into the immediate vicinity of these instruments. For this reason, continuing to strategically scan the target person (including their face, hands, and waist) and their proximal environment is critically important for SA.

As demonstrated in the descriptive analysis (Figure 4), whether either or both groups attended more to the target or environment depends on the specific situational context of each picture. Importantly however, the gaze and fixation patterns between novice and expert police are consistent across all images, and also in line with previous findings [16]. Specifically, experts fixate significantly less on the environment and spend more time on the target (Figure 3). Considered together with the finding that early novices also fixate later on the hands (Figure 5), these untrained visuomotor patterns could potentially result in missing important cues related to the target person, further increasing risk of OSIs.

The current results show that after receiving at least 75% of basic tactical and use of force training (see [24]), the Novice 2 intermediate group fixated on hands earlier compared to Novice 1, and displayed gaze and fixation patterns that are more similar to experts (Figure 5). Therefore, progressing through the training program offered by the police agency [24], including reality-based use of force scenarios and training in basic tactics, has resulted in the development of more efficient visuomotor patterns among intermediate compared to early novices. In addition, eye tracking technology may be a suitable tool to track objective measures of learning and development for behaviors related to SA and tactical decision-making (see [13]).

4.1. Developing Expert Knowledge through Training

Through formal training and practical experience, experts develop improved behavioral strategies that become automatic and implicit. According to Klein's Recognition Primed Decision Model [28], experts use their previous experiences to recognize patterns of cues (e.g., target person's shifting gaze, nervous demeanor, putting hands in their waistband), and generate faster and more accurate predictions about possible next steps and outcomes. In the same way, visuomotor gaze patterns become refined as part of an experts' motor repertoire, and elicit specific patterns of brain activity in regions responsible for object recognition [29] and motor planning [30]. In this way, visuomotor networks become more efficient following training [16]. By capitalizing on such learning-dependent plasticity, observation-based tasks can be an effective method for training (or re-training) early SA and tactical decision-making. Using a similar paradigm to the current study, officers can be presented with various staged images (or live-action videos) and receive direction on where to focus their attention based on tactically relevant information. Once basic visuo-

motor skills have been established in the learner's repertoire, training can progress to more complex and stressful live scenarios [7,22,31].

To ensure that optimal SA strategies will be transferred to stressful field conditions, we recommend that SA training should also incorporate physiological stress management [12,31]. Police and other public safety personnel (PSP, e.g., firefighters, paramedics, corrections officers) experience significant physical and psychological disorders due to the highly stressful nature of their work [4,6,32]. Therefore, incorporating training that has multiple positive effects for performance and health would maximize limited resources while also achieving learning outcomes. Appropriate measures for evaluating performance and mental health in policing have been described elsewhere [13,33].

4.2. Seeing Is Not Perceiving: The Influence of Stress on Police Gaze, Fixation, and SA

Both applied and scientific research have shown that where an officer's eyes and head are oriented, and what they consciously perceive or remember about a situation is impacted by stress. Under high threat training conditions, officers blink more, turn away, fixate less, and withdraw from target persons [3,17,20]. Following real-world critical incidents, officers report distorted sensory perceptions [18]. Several reviews also demonstrate how stress physiology exerts widespread effects on several cognitive and motoric processes, including memory [7] and motoric skills [34]. Accordingly, an officer's eyes may fixate on an object but similar to the 'look but fail to see' phenomenon identified in driving research [35], the officer may not consciously perceive it. At worst, an officer may misinterpret a benign object as a dangerous weapon [19], or vice versa (i.e., failing to perceive a real threat). According to SA theory and practice, information gathering does not end with visual perception: effective operators must understand how visual information can impact their next steps and inform decision-making (i.e., later stages of SA) [11].

Real-life police encounters are naturally different than still-image simulations. Given the stress-induced decrements to police gaze, fixation, SA, and performance outlined above, the current study was designed to investigate officers' eye movement patterns during a non-stressful task. Experts were evaluated to derive tacit knowledge about implicit, automatic gaze behavior as a proxy for early-stage SA. Together with their qualitative responses to interview questions (see Methods), the current findings can provide a framework for expert SA in order to develop evidence-based SA training that directs novices' attention and gaze to more tactically relevant areas.

4.3. Action versus Reaction: Time as a Critical Factor in Policing

In police work, officers must be prepared to make informed decisions in a matter of milliseconds, including the use of lethal force. These decisions can have significant consequences (i.e., life or death, physical or psychological injury), therefore, empirical investigation of the bases of officers' decision-making (i.e., their perceptions) is crucial [7]. Especially in early SA, it is highly important to recognize what is immediately or potentially threatening to bystander(s), the target person, or the officer within the first 5 s of a situation. This includes identifying what is available to the target person by scanning the environment. It is interesting that such a small mean difference in visit duration in the environment (Novice 1 = 1.99 s, Novice 2 = 2.05 s, experts = 1.54, Figure 3) is statistically significant for the experts, but in a real-world context, many things can happen in 0.45 s, especially when it comes to high-stakes decision-making.

In a reaction time study by Blair et al. [36], it was found that officers were unable to shoot an armed suspect before they were shot at, even when officers were aiming at the target. According to fundamental time laws, reaction is always slower than action. Therefore, police officers should be trained to recognize and assess the situation as fast and as accurately as possible. When a situation is unfolding very quickly, officers must make decisions about their own behavior before things happen (that is, predicting what will happen before it even does) [1,11,28]. To achieve optimal early SA, evidence-based training of the visuomotor skills revealed in the current study can ensure that officers perceive the

most critical information in an efficient and accurate manner. In turn, errors in judgement and decision-making that can lead to OSIs can be reduced.

4.4. Limitations

Out of 13 images presented in the current study, only a subset provided visit duration and fixation order data for two primary reasons. Firstly, due to technical limitations of the eye tracking apparatus, visit duration and fixation order data were not registered in small and/or adjacent AOIs (for example, see Figures S1 and S2 in the Supplementary Materials). Secondly, the images used in the current study were not designed for the specific purpose of an eye tracking study, but rather for the qualitative analyses that will be presented separately. For instance, the researchers were unaware that close proximity of hands, faces, and target items within a picture would interfere with the eye tracking methodology. Nonetheless, the current data generated results that were in line with other previous and very limited eye tracking studies in police [16]. Future research on scene perception among police should more deliberately consider placement and arrangement of targets as well as areas of interest to avoid such confounds.

As discussed above, eye tracking can only detect the physiological shift of gaze but not the shift of attention. Even though an individual's eye may fixate on an object (e.g., bystander), they may not consciously perceive it [35]. Accordingly, missed visual cues will not be included in subsequent judgement, decision-making, or informed action. Therefore, future studies should also explicitly probe attention, understanding, and memory to understand their relationship to visual fixation.

Relative to eye tracking studies in non-specialist populations, the current study had small sample sizes, but is consistent with applied police research samples ([16]; for review see [7]). Additionally, this is an important preliminary dataset that compares an objective measure of early SA between expert officers and two levels of novice police trainees. Future research can continue to investigate the neurophysiological basis of police SA using carefully designed stimuli of static and/or moving images, simulating stressful operational conditions, and functional neuroimaging.

5. Conclusions

The purpose of the current study was to use experts' automatic gaze behavior to identify what is 'correct' or ideal early-stage SA, as measured by fixation order and visit duration, while viewing typical police encounters. In line with previous eye tracking research in police, optimal SA involves less time scanning the environment (Figure 3), and more efficiently searching the target person's hands beyond their facial expression (Figure 5). However, every situation is unique, and there is no single correct procedure or outcome. The goal of every encounter is to maintain personal and public safety by the best means possible.

The current study also highlights the importance of partnerships between police practitioners and scientists that can provide access to cutting-edge methodologies (i.e., eye tracking, neuroimaging) and guidance on designing effective experimental studies that answer targeted research questions that are directly relevant for police. Police and academic partnerships will also generate empirical knowledge that can be directly implemented into evidence-based training and practice that, in turn, minimize the occurrence of OSIs.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijerph19095047/s1, Figure S1: Picture 4 from experimental stimulus (excluded); Figure S2: Picture 7 from experimental stimulus (excluded); Figure S3: Picture 3 from experimental stimulus (target versus environment); Figure S4: Picture 8 from experimental stimulus (target versus environment); Figure S5: Picture 9 from experimental stimulus (target versus environment).

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References

1. Keampf, G.L.; Klein, G.; Thordsen, M.L.; Wolf, S. Decision making in complex naval command-and-control environments. *Hum. Factors* **1996**, *38*, 220–231. [CrossRef]
2. Vickers, J.N.; Lewinski, W. Performing under pressure: Gaze control, decision making and shooting performance of elite and rookie police officers. *Hum. Mov. Sci.* **2012**, *31*, 101–117. [CrossRef]
3. Huhta, J.-M.; Di Nota, P.M.; Nyman, M.; Pietilä, E.; Ropo, E. Universal police behaviours during critical incidents and their connection to personality: A preliminary study. *Nord. J. Stud. Polic.* **2021**, *8*, 1–8. [CrossRef]
4. Carleton, R.N.; Afifi, T.O.; Turner, S.; Taillieu, T.; Duranceau, S.; LeBouthillier, D.M.; Sareen, J.; Ricciardelli, R.; MacPhee, R.S.; Groll, D.; et al. Mental disorder symptoms among public safety personnel in Canada. *Can. J. Psychiatry* **2018**, *63*, 54–64. [CrossRef] [PubMed]
5. Carleton, R.N.; Afifi, T.O.; Taillieu, T.; Turner, S.; Krakauer, R.; Anderson, G.S.; MacPhee, R.S.; Ricciardelli, R.; Cramm, H.A.; Groll, D.; et al. Exposures to potentially traumatic events among public safety personnel in Canada. *Can. J. Behav. Sci./Rev. Can. Des Sci. Du Comport.* **2019**, *51*, 37–52. [CrossRef]
6. Di Nota, P.M.; Anderson, G.S.; Ricciardelli, R.; Carleton, R.N.; Groll, D. Mental disorders, suicidal ideation, plans and attempts among Canadian police. *Occup. Med.* **2020**, *70*, 183–190. [CrossRef] [PubMed]
7. Di Nota, P.M.; Huhta, J.-M. Complex motor learning and police training: Applied, cognitive, and clinical perspectives. *Front. Psychol.* **2019**, *10*, 1797. [CrossRef]
8. Desvergez, A.; Winer, A.; Gouyon, J.B.; Descoins, M. An observational study using eye tracking to assess resident and senior anesthetists' situation awareness and visual perception in postpartum hemorrhage high fidelity simulation. *PLoS ONE* **2019**, *14*, e0221515. [CrossRef]
9. Damji, O.; Lee-Nobbee, P.; Borkenhagen, D.; Cheng, A. Analysis of eye-tracking behaviours in a pediatric trauma simulation. *Can. J. Emerg. Med.* **2019**, *21*, 138–140. [CrossRef]
10. Stanton, N.A.; Salmon, P.M.; Walker, G.H.; Salas, E.; Hancock, P.A. State-of-science: Situation awareness in individuals, teams and systems. *Ergonomics* **2017**, *60*, 449–466. [CrossRef]
11. Ensley, M.R. Toward a theory of situation awareness in dynamic systems. *Hum. Factors* **1995**, *37*, 85–104. [CrossRef]
12. Andersen, J.P.; Gustafsberg, H. A training method to improve police use of force decision making: A randomized controlled trial. *Sage Open* **2016**, *6*, 2158244016638708. [CrossRef]
13. Di Nota, P.M.; Chan, J.F.; Huhta, J.-M.; Andersen, J.P. Considering objective and subjective measures for police use of force evaluation. *Int. J. Environ. Res. Public Health* **2021**, *18*, 5351. [CrossRef] [PubMed]
14. Heusler, B.; Sutter, C. Gaze control and training for high-stress situations in law enforcement: A systematic review. *J. Police Crim. Psychol.* **2020**, *35*, 401–413. [CrossRef]
15. Prytz, E.G.; Norén, C.; Jonson, C.O. Fixation differences in visual search of accident scenes by novices and expert emergency responders. *Hum. Factors* **2018**, *60*, 1219–1227. [CrossRef]
16. Heusler, B.; Sutter, C. Gaze Control in Law Enforcement: Comparing a Tactical Police Unit to Patrol Officers. *J. Police Crim. Psychol.* **2020**, 1–17. [CrossRef]
17. Nieuwenhuys, A.; Oudejans, R.R. Effects of anxiety on handgun shooting behavior of police officers: A pilot study. *Anxiety Stress Coping* **2010**, *23*, 225–233. [CrossRef]
18. Klinger, D.A.; Brunson, R.K. Police officers' perceptual distortions during lethal force situations: Informing the reasonableness standard. *Criminol. Public Policy* **2009**, *8*, 117–140. [CrossRef]
19. Barrett, L.F.; Bar, M. See it with feeling: Affective predictions during object perception. *Philos. Trans. R. Soc. B Biol. Sci.* **2009**, *364*, 1325–1334. [CrossRef]
20. Nieuwenhuys, A.; Oudejans, R.R. Training with anxiety: Short-and long-term effects on police officers' shooting behavior under pressure. *Cogn. Processing* **2011**, *12*, 277–288. [CrossRef]

21. Oudejans, R.R. Reality-based practice under pressure improves handgun shooting performance of police officers. *Ergonomics* **2008**, *51*, 261–273. [CrossRef] [PubMed]
22. Staller, M.S.; Zaiser, B. Developing problem solvers: New perspectives on pedagogical practices in police use of force training. *J. Law Enforc.* **2015**, *4*, 1–5.
23. Salas, E.; Prince, C.; Baker, D.P.; Shrestha, L. Situation awareness in team performance: Implications for measurement and training. *Hum. Factors* **1995**, *37*, 123–136. [CrossRef]
24. Police University College of Finland. The Structure of the Degree. Available online: https://polamk.fi/en/the-structure-of-the-degree (accessed on 20 March 2022).
25. Ekman, P. Facial expression and emotion. *Am. Psychol.* **1993**, *48*, 48–384. [CrossRef]
26. Surakka, V.; Hietanen, J.K. Facial and emotional reactions to Duchenne and non-Duchenne smiles. *Int. J. Psychophysiol.* **1998**, *29*, 23–33. [CrossRef]
27. Hietanen, J.K. Does your gaze direction and head orientation shift my visual attention? *NeuroReport* **1999**, *10*, 3443–3447. [CrossRef] [PubMed]
28. Klein, G.A. A recognition-primed decision (RPD) model of rapid decision making. *Decis. Mak. Action Models Methods* **1993**, *5*, 138–147.
29. Di Nota, P.M.; Levkov, G.; Bar, R.; DeSouza, J.F.X. Lateral occipitotemporal cortex (LOTC) activity is greatest while viewing dance compared to visualization and movement: Learning and expertise effects. *Exp. Brain Res.* **2016**, *234*, 2007–2023. [CrossRef]
30. Di Nota, P.M.; Chartrand, J.M.; Levkov, G.R.; Montefusco-Siegmund, R.; DeSouza, J.F.X. Experience-dependent modulation of alpha and beta during action observation and motor imagery. *BMC Neurosci.* **2017**, *18*, 28. [CrossRef]
31. Di Nota, P.M.; Andersen, J.P.; Huhta, J.-M.; Gustafsberg, H. Evidence-based instruction of police use of force: Practical methods and pedagogical principles. In *Interventions, Training, and Technologies for Improved Police Well-Being and Performance*; Arble, E., Arnetz, B., Eds.; IGI Global: Hershey, PA, USA, 2021; pp. 72–101. [CrossRef]
32. Violanti, J.M.; Charles, L.E.; McCanlies, E.; Hartley, T.A.; Baughman, P.; Andrew, M.E.; Fekedulegn, D.; Ma, C.C.; Mnatsakanova, A.; Burchfiel, C.M. Police stressors and health: A state-of-the-art review. *Polic. Int. J. Police Strateg. Manag.* **2017**, *40*, 642–656. [CrossRef]
33. Shields, R.E.; Korol, S.; Carleton, R.N.; McElheran, M.; Stelnicki, A.M.; Groll, D.; Anderson, G.S. Brief mental health disorder screening questionnaires and use with public safety personnel: A review. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3743. [CrossRef] [PubMed]
34. Anderson, G.S.; Di Nota, P.M.; Metz, G.A.; Andersen, J.P. The impact of acute stress physiology on skilled motor performance: Implications for policing. *Front. Psychol.* **2019**, *10*, 2501. [CrossRef] [PubMed]
35. Brown, I. A review of the 'look but fail to see' accident causation factor. *Behav. Res. Road Saf.* **2002**, *11*, 116–124.
36. Blair, J.P.; Pollock, J.; Montague, D.; Nichols, T.; Curnutt, J.; Burns, D. Reasonableness and reaction time. *Police Q.* **2011**, *14*, 323–343. [CrossRef]

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Deriving Expert Knowledge of Situational Awareness in Policing: a Mixed-Methods Study

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Deriving Expert Knowledge of Situational Awareness in Policing: a Mixed-Methods Study

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Abstract
Situational awareness (SA) is the most important skill required by police to effectively assess and respond to encounters, including critical incidents. Incomplete or sub-optimal SA strategies can lead to errors in subsequent judgement, decision-making, and action, including tactics and use of force (UOF). Errors in UOF, especially lethal force, in training or operational field settings, have severe consequences for learning, occupational health, and public safety. Therefore, adequately defining and instructing SA is an important gap to fill in existing applied police literature and practice. Using a mixed-methods approach, the current study aimed to define and conceptualize SA in police-specific contexts. Participants included 23 novice trainees and 11 experienced officers and instructors in tactics and UOF. Participants were shown 13 static images of various staged encounters, ranging from non-threatening to high-threat. Following each image, participants were interviewed and asked to describe what they saw and how they would respond. Thematic analyses of the interview data revealed the following seven themes that are highly interrelated and more completely define police-specific SA: distance/time laws; partner/roles; profiling the suspect; tactical options and opportunities; ongoing assessment of own tactical activities and outcomes; surrounding environment and conditions; and dangerous objects. Expert officers provided more detailed and multidimensional descriptions of the themes and statistical analyses confirmed that experts identified more themes compared to novices. By making tacit knowledge visible, the current findings establish a professional standard for SA formation, which can inform evidence-based police training in SA, tactical decision-making, and UOF while improving operational safety.

Keywords Situational awareness · Policing · Training and education · Qualitative analysis · Tactical decision-making

Introduction

Police officers are entrusted to protect and serve the public and respond to potentially dangerous and violent encounters in addition to their routine duties (Saus et al. 2006). As they do so, officers need to rely on several different types of information, including learned tactical skills, laws and regulations and rapidly changing external cues from the environment (Di Nota and Huhta 2019). Sometimes police work involves dynamic and complex situations that demand rapid assessment, judgement, decision-making, and actions that may require a use of force (UOF) (see Hine et al. 2018; Huhta et al. 2021; Keampf et al. 1996; Vickers and Lewinski 2012). Situational awareness (SA) (sometimes also referred to as "situation awareness") is essential and forms the basis of all of the above functions. However, there is currently no universal definition or standardized method for training, measuring, or evaluating SA in police contexts (Di Nota and Huhta 2019). According to Endsley (1995), SA is linked to decision-making and overall performance and can be understood as three components: perception, comprehension, and projection. Making observations using our multiple senses in the first stage informs the second stage of SA, which involves developing an understanding of the current situation. In the third stage, the officer anticipates how the situation might change. Although SA has been studied in several industries (e.g., medicine, aviation,

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military command, sports), there are still only a few studies specifically evaluating SA in policing contexts (Andersen and Gustafsberg 2016; Di Nota et al. 2021a, b, c; Huhta et al. 2022; Saus et al. 2006). New studies are needed to concretely and operationally define SA and its components, and especially how SA is formed in police-specific contexts.

In a recent investigation, early-stage SA (i.e., Endsley's Stage 1—perception) has been operationalized using officers' gaze and fixation patterns (Huhta et al. 2022). While these objective visuomotor behaviors may indicate where an officer is looking, it does not guarantee that the officer will consciously perceive, encode, or recall what their eyes have seen. Therefore, the current study uses a mixed methods qualitative and quantitative approach to investigate aspects of police SA that are not readily observable from an officer's performance or behavior. Furthermore, the current set of investigations aims to determine the elements of police work used by expert officers to build SA, whose tacit knowledge can inform the development of evidence-based SA training for police.

Linking Situational Awareness to Police Tactics

SA is a critical step in deciding which tactical approach officers will use in any given situation. Tactics are the methods and techniques used by law enforcement professionals to try to work safely and effectively. Police tactics are typically not shared with the public, which is sometimes forbidden by law. For example, in Finland it is stated in Article 24 (1) (5) of the Law on the Declaration of Authorities (21.5.1999/621) that information and documents related to the technical and tactical methods of the police must be kept confidential. The release of such information could endanger public order and security. For this reason, there is no comparative peer-reviewed study of police tactics or detailed explanations of what the tactics are and how they should be applied in different situations. Accordingly, this study does not cover police tactics in detail, although we recognize the importance of different tactical options, how to manage them, and that they are critically and reciprocally linked to SA and decision-making. For instance, having less competence and relying on fewer tactical options will limit useful information gathering and SA, further limiting potential alternatives for action.

At the same time and similar to SA, the content, extent, and delivery of police tactical training are unclear across individual agencies and around the world. Partly due to the legal restrictions mentioned above, a lack of open information sharing related to SA and tactical training and operations may result in "opinion-based" practices. Without a solid understanding of SA or the use of evidence-based educational practices, training may be ineffective, or at worst, lead to a completely wrong understanding of police tactics. Evidence-based police training is therefore informed by applied research insights from other fields including cognitive and sport psychology and exercise sciences. A growing number of research teams and articles provide definitions and standards of practice relating to police-specific SA, tactics, decision-making, and behavior (Andersen et al. 2017; Bennell et al. 2020; Bertilsson et al. 2020; Huhta et al. 2021; Koerner and Staller 2021; Koedijk et al. 2021; Martaindale and Blair 2019).

Deriving Expert Tacit Knowledge to Understand Situational Awareness in Police

While police are acting out their duties, they are also constantly taking into account tactical considerations, opportunities, and safety concerns. This is always the case, even though it may not be obvious from an outside perspective. There are therefore numerous mental and technical processes occurring that may, at least in part, be unconscious to the officer themselves. Given that mental processes are implicit and not easily detected from the outside (even to experienced police instructors), articulating or passing on such knowledge and skills can be challenging. To develop evidence-based instruction on SA for police, it is relevant to ask the following question: what are police actions, and the related mental processes preceding them, based on?

According to Michael Polanyi (1966), "we can know more than we can tell" (p. 4). Tacit knowledge is a widely used concept that broadly defined refers to experiential knowledge. In working life, tacit knowledge refers to the skills and competences generated through practical experience. It is typical of experts to intuitively make decisions and act, often quite accurately even with little time or uncertainty of circumstances, without knowing how "they know." Experts have also been described as possessing a subconscious understanding of how to act in new situations (Ropo 1991). The ability to dynamically adapt to changing situations has been well documented in the literature on expertise (Ericsson 1998). Gary Klein has investigated experts in critical decision-making for decades and has observed that tacit knowledge enables "flexecution," in which solving a problem not only seeks to achieve a specific goal, formed in advance or in the early stages of the situation but at the same time strives to clarify and redefine goals (Klein 2007). In other words, locking in on one goal without the ability to read, interpret, and update the situation in real-time and formulate new goals when needed, is not adaptive for effective performance.

Related to the definition of SA by Endsley (1995) described above, the brain organizes sensory input (i.e., Stage 1 SA) into understandable and coherent stories (i.e.,

Stage 2 SA) that can help us predict what might happen next (i.e., Stage 3 SA) (Barrett and Bar 2009). Expert knowledge is organized into multilevel and interconnected structures in the brain (i.e., areas responsible for sensory, motor, and language functions) (Di Nota 2017). Following early-stage perception, experts are highly tuned to recognize patterns in their observations that will prime previous experiences under similar circumstances. By understanding what goals are feasible, experts are able to quickly determine a suitable course of action, a strategy called "satisficing" (Klein 1993). Proficient decision-makers do not try to search for the best option (i.e., deliberate and time-consuming optimization processing) but rather intuitively select a course of action that is most likely to work, especially under time pressure (Okoli and Watt 2018). For this type of decision-making to occur, one must know what might happen by mentally simulating possible events (Moulton and Kosslyn 2009). Therefore, the later stages of SA (understanding, prediction) are dependent on the existence of expert knowledge structures. For the purpose of cultivating expert SA in police, the question remains how to develop or train these expert knowledge structures in novice or rookie officers, and under the current lack of operational definitions and evaluation standards for SA (Di Nota et al. 2021a, b, c; Di Nota and Huhta 2019; Huhta et al. 2022).

To enhance evidence-based police education of SA, we can explore experts' tacit knowledge. As employed in constructive learning models (Honkela et al. 2000), learning can be facilitated through concrete and constructive reflections on an officers' current options, what they are doing, and why. To understand expert UOF decision-making, Mangels et al. (2020) analyzed responses from novice and expert police while they observed body-worn camera footage of citizen encounters. Videos were paused at certain points to obtain responses to both closed- and open-ended questions regarding what the officer would do in the next few seconds, what cues the officer remembered attending to, and how they would describe what is happening. Mangels et al. (2020) found that experts considered verbal de-escalation and methods to reduce the UOF (i.e., find the distance, seek cover, ask for backup) relatively more than novices who reported more physical solutions to control or resolve the situation. The key difference between the current study and Mangels et al. (2020) is that we are interested in identifying the elements involved in creating an expert's SA, which in turn informs subsequent decision-making, tactics, and actions. That is, we are more interested in first understanding what cues or specific situational elements an expert officer perceives and understands to form SA before decision-making even occurs. Identification of these elements can be used to develop evidence-based SA and tactical training to improve decision-making and performance outcomes.

Present Study

The aim of the current study is to provide novel insights into how expert SA is developed in police-specific encounters. Using a mixed-method study design, we qualitatively examined interview data from expert and novice police officers who were asked about what they observed and how they would act in response to several images of staged police encounters. Thematic analyses revealed an expert model of SA that can be used as a framework to develop evidence-based police training. Overall findings and between-group comparisons are summarized descriptively and quantitatively analyzed with simple statistics.

Methods

Participants

A total of 34 participants took part in the current study and were divided into groups based on their experience (see Table 1). Novices ($n = 23$, 11 female, 12 male) were further subdivided based on their completed studies; the Novice 1 group included students in periods 1 to 4, and the Novice 2 group included students in periods 5 to 6 (i.e., all or most tactical training complete, just prior to beginning their practical training in the field) (Police University College of Finland 2022). Novice students were invited to participate in the study through a message distributed in the institute's internal email system. The recruitment message indicated that eligibility in the current study required that the participant does not have previous training or work experience in the security sector. Officers in the expert police group ($n = 11$, all male) had an average of 16.7 years of experience as police officers ($SD = 3.9$, range: $12 - 25$), and an average of 8.0 years of experience in special units ($SD = 2.2$, range: $3.5 - 10$) including K-9 and special response units. Experts were further subdivided based on experience as instructors

Table 1 Demographic information

Group	*n* (female)	Age *M* (*SD*)	Years of experience *M* (*SD*)
Novice 1	10 (6)	25.6 (3.4)	< 1.5 education
Novice 2	13 (5)	24.6 (4.4)	< 1.5 education + tactical training
Expert 1	5 (0)	42.0 (3.8)	17.2 (3.0) duty, 9.0 (0.7) special units
Expert 2	6 (0)	41.2 (5.0)	16.3 (4.8) duty, 7.1 (2.6) special units, 10.6 (5.8) instructor

The Novice groups are trainee officers at the Police University College of Finland

in tactics and UOF (Expert 2, range: 4.5–20 years, see Table 1). Experts from various regions and operational backgrounds were invited to participate in the study based on their availability. The study was approved on 19 February 2018 by the research ethics board of the Police University College of Finland.

Procedure

The current study was conducted at the Police University College of Finland in February 2018. Following informed consent, participants were seated at a computer and told that they will be presented with 13 static photographs of staged encounters of a confrontational nature (see Fig. 1 and Supplementary Materials in Huhta et al. 2022). Each image was shown for 15 s, after which participants were asked specific questions to probe their SA and subsequent actions:

1. "Tell us about the situation: what there is, what can happen next, and how can the situation develop?" This question was used to determine what cues (e.g., persons, objects, hallway) the participant consciously perceived, and their understanding of how these cues could affect their SA, tactical decision-making, and possible next steps and/or outcomes.
2. "How do you act: tell us about your decisions and actions. Also, tell us about possible alternative ways to act and justify your actions."

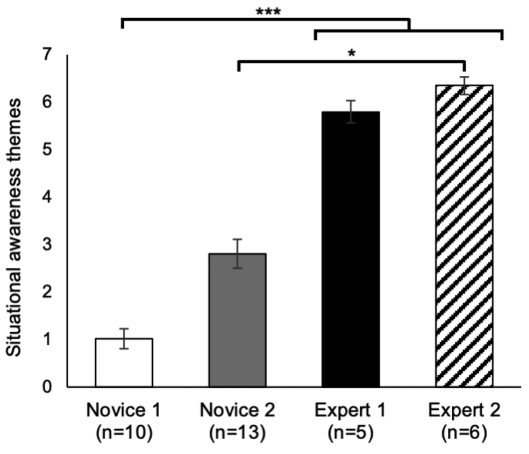

Fig. 1 Average number of situational awareness themes identified by group. Novice 1 participants identified significantly fewer themes than both Expert groups and Novice 2 participants identified significantly fewer themes than Expert 2 participants. Error bars show standard error of the mean (SEM). $*p_{Bonf} < 0.05$ $***p_{Bonf} < 0.001$

This interview method can be described as "protocol analysis," in which thinking aloud can be used to reveal the individual's problem-solving process, including the search and use of information from short- and long-term memory (Anttila 2006; Ericsson and Simon 1984).

Data Analyses

Data from the eye tracking portion of the experiment has been reported in a separate study (Huhta et al. 2022). The current study will analyze the qualitative interview data to expose the elements of SA and tactical decision-making among expert and novice police.

Qualitative Analyses

All participant responses were recorded on a voice recorder and later transcribed verbatim. Two of the study authors (J-MH & TH) independently read the transcripts thoroughly to become familiarized with the data. Next, the authors systematically and iteratively read and manually identified categories and codes (i.e., meaningful sentences and words) that were used to classify discrete themes. According to Eskola and Suoranta (2014), there are many ways to qualitatively analyze verbal material in addition to coding. Coding units can include words, phrases, lines, paragraphs, or longer sections of text depending on starting points and goals. Manual coding can be done, for example, by underlining or overlining statements that are often repeated or abnormal from the material, or using characters (i.e., letters, numbers) and/or different colors and their shades. The current study coded transcribed material by hand on printed papers using different colored highlighters. The researchers chose not to use coding software (e.g., NVivo) because they did not want to miss any information because of a possibly inadequate code word list. For instance, it can be assumed that participants in the novice groups may not have the vocabulary to describe specific police tactics or situational elements, so the code word list would not be meaningful to use in these cases. In addition, the terminology associated with police tactics may differ by geographic location and regional dialects.

Overall, our qualitative analyses and the codes used to identify themes were conceptually driven (i.e., as opposed to word-specific codes), meaning that sometimes whole sentences were used as a code to fulfill the criteria of one or more specific themes. For example, "distance" is both a theme and a code word for the same theme. The word code "distance" was found many times, although there were also other word codes (e.g., "close," "cut the distance," "steps," "stay," "fast") or sentences that referred to the overall theme of "distance" (e.g., describing the situation as "being too close to the subject," "just a few steps away," or "I'm way too close"). In these examples, participants were estimating

distance without using the word "distance," which satisfied the theme.

It was also possible for participants to identify two themes at the same time in a single statement. For example:

> (Expert 2—Participant 5): "…target person physically seemed to be in good condition, quickly cut that distance, so I'd prefer to stay there in the previous doorway to give the command and speak…"

The theme distance is to be found ("quickly cut that distance," "I'd prefer to stay there in the previous doorway"), as well as Profiling the Suspect ("target person," "physically in good condition," "quickly").

Once all of the themes were identified and saturated (i.e., no more themes or codes were identified), both authors independently and manually analyzed the blinded data (i.e., without consideration of who or from which group the respondent was) several times. As a final step, both authors cross-checked all responses to extract quantitative data (see below) and ensure that nothing was missed. During the entire coding process, only two discrepancies were identified and these were carefully discussed and reconciled.

Quantitative Analyses

In addition to qualitative analyses, the interview data was also analyzed quantitatively by comparing the number of themes identified by each group. For each participant, image, and theme, a spreadsheet was marked with a 1 = yes if a participant mentioned the theme, and 0 = no if the theme was not mentioned. This binary classification was intentionally chosen for simplicity of summarizing the results, even though it does not reflect the extent to which participants may have briefly or extensively discussed a given theme. For instance, responses from the experts were generally found to be more diverse and descriptive, so a theme could have been described by several different code words and meaningful sentences, while responses from the novices could be one-worded. Nonetheless, if there was a meaningful code or codes for a given theme, a value of 1 was given. Quantitative data were imported into SPSS (Version 24, IBM Corp.) and analyzed descriptively for means and standard deviations. Between-group analyses were conducted using a non-parametric Kruskall-Wallis test and pairwise comparisons were conducted using the Mann–Whitney U test, which also accounts for differences in sample sizes between $k = 4$ groups. Statistical significance was set at $p < 0.05$ and Bonferroni corrections for multiple comparisons are reported where relevant. Therefore, this study combines complimentary qualitative and quantitative methods to answer the research questions.

Results

The interview data raised seven specific themes that define the elements from which SA is derived in police-specific situations (Table 2):

- Distance/time law
- Partner/roles
- Profiling the suspect
- Surrounding environment and conditions
- Tactical options and opportunities
- Ongoing assessment of own tactical activities and outcomes
- Dangerous objects

The themes have not been listed in any particular order, are not intended to be listed from most to least important, or occurring in a discrete or chronological order. That is, depending on the situation the assessment of current tactical options can occur after a dangerous object has been identified.

Distance/Time Law

In their verbal responses, participants assessed the distance between the police (i.e., the perspective of the image) and the target person(s), as well as the distance between themselves and targets relative to bystanders in situations where bystanders were present. Participants' estimations of distance were directly related to their judgements of how much time they had to respond, and also informed what behavioral response they could use (e.g., verbal instruction, command, means, and UOF). For instance, the estimated distance informed whether an officer could cut the distance for quick and surprising apprehension or be able to get between a target and bystanders to protect them. The distance was also directly related to the evaluation of the speed with which the target person could attack and whether there would be opportunities to react if the distance was not actively increased by the officer. In this regard, the evaluation of available time was closely linked to profiling of the target person. In the initial responses to most of the presented situations, experts noted that there was too little distance for safe activities and therefore their very first maneuver would be to increase their distance from target persons.

Partner/Roles

Participants assessed the situation according to roles related to patrol activities (i.e., taking a primary lead or secondary support role). Participants identified various specific tasks

Table 2 Themes defining situational awareness in police-specific contexts

Theme	Novice participant statement	Expert participant statement
Distance/time law	N2-11: "…need to be prepared for going farther." (Picture 5) N1-9: "…ask the man to go back a little bit, to get into the apartment." (Picture 1) N1-6: "…then I would ask for a little distance, that [the target person] goes a little farther away." (Picture 4)	E2-6: "Well, first taking distance." (Picture 5) E2-2: "He has the opportunity to target us, target the police with something of a violent attack if he wants to, he has a chance … to do so. The distance is so short." (Picture 1) E2-5: "… distance I took a little more and my partner kept the door still in control. That is, I took a couple of steps back…" (Picture 1) E1-3: "Being pretty close to the target person, getting out of the car can be a nasty situation. You should take a little distance to the person by car, withdrawing 15-20 m." (Picture 4)
Partner/roles	N2-1: "Also be prepared for having to go with partner to capture that fist-wielding guy." (Picture 2) N2-9: "I would feel like this so I would go with my partner to catch the target." (Picture 3) N2-6: "Possibly a patrol buddy would move the wounded to the side of the corridor a bit from the situation to shelter." (Picture 10)	E1-4: "Another acts as a shelter officer or observes the environment. Efforts to be in such a way as to maintain observation of all persons in the room." (Picture 2) E2-5: "…either one speaks so the other observes three-sixty environments." (Picture 2) E2-6: "…that [officer] clearly takes this target person and the other [officer] is trying the best possible way then to save the child from in between them." (Picture 3) E1-1: "… and partner can be prepared for example the use of a taser." (Picture 10) E2-3: "I'd say that drop the ax on the floor, again that my partner knows that I see a person with an ax in his hand." (Picture 11)
Profiling the suspect	N1-4: "A big-sized bald man, in a military-patterned fleece jacket like that, stands in the apartment, looks a bit angry." (Picture 6) N1-5: "…a little like that threatening." (Picture 4) N1-3: "It looked pretty gentle, not at all aggressive … he didn't look like aggressive." (Picture 12)	E2-3: "… heavy-duty shoes, so his kicks would be risky." (Picture 6) E2-5: "…this guy seems to be physically in very strong condition." (Picture 4) E2-3: "There was a man with a short sleeve shirt. The other hand was left hand, it was hidden and it was not visible. There was some fist shape in my opinion in that other hand. That little look is not just curious, somewhat defiant but not aggressive … jeans were wearing, belt, wristwatch, long hair, a little beard, slim, … athletic guy and the watch was obviously something of [trademark brand]. The person could be judged based on the watch, and he may be [capable] in a way I would take [the situation] a little differently…[with] that kind of wristwatch…he's probably doing some sport or doing some kind of shooting or fighting, … there is a reason for that watch… Clear place, left the impression that pretty neat… apartment where no heaps of rocks were visible which is often the case in normal "police customers'" places, but that this could be such a precise, careful guy." (Picture 1)
Tactical options and opportunities	N1-9: "I ask that man, I tell him to move further away from that table and other instruments he can throw at us." (Picture 6) N2-13: "I'd tell the guy to calm down and lower the kid out of his hands on that bed." (Picture 3)	E1-2: "The best way would be to order him to put him in a more appropriate place for us. And, so to speak, to a safer state… The second option is that…we charge the target person, catch [them] and [achieve the] goal, … gain control and calm him down." (Picture 6) E1-5: "…if he does not obey the order, let's pull him out because he is within plucking distance of the doorway, or charge towards the man, if the other hand is empty…" (Picture 1) E1-4: "…Let's talk, let's keep controlling the door." (Picture 1)
Ongoing assessment of own tactical activities and outcomes	N2-5: "If you can't 'talk' the baby out of his arms, you can't use the means of force in [the situation], because there's a risk of hitting the baby." (Picture 3)	E2-5: "No means of force, if you think about a situation like that, then you can't use. The baton may be the only sensible one besides the handcuffs, but even that there is a risk that he will use the child as a shield, which means we will have to use physical force…" (Picture 3) E1-3: "…You should take a little distance to the person by car, withdrawing 15-20 m. In this case, doing so you would receive 'playing time' if the person does not obey and the hand remains in the pocket. It is easier to use force in this case. At the same time, we can tell bystanders to stay put…" (Picture 4) E2-1: "First to actually be informed that we [the police] are on the scene … substantially influences what that person does immediately thereafter." (Picture 7) E2-3: "…I would cut through the left … block [the suspect's] access to possible blades and… see in his lap." (Picture 12)

Table 2 (continued)

Theme	Novice participant statement	Expert participant statement
Surrounding environment and conditions	N2-7: "The corridor would be safer, good space and it is known that there are no surprises as inside the apartment could be." (Picture 1) N2-4: "…the front room, behind which there was a balcony both right and left in that room, the viewing angle did not open so there may be additional persons or something else." (Picture 10)	E2-2: "Seems that the space would continue to that direction…The visibility of the apartment was good that if you had to go there, it wasn't so dim but very bright." (Picture 1) E2-5: "Big man who would go on a rampage in a small space." (Picture 10) E2-4: "…an apartment, from which a rather narrow sector of the doorway can be seen…" (Picture 13)
Dangerous objects	N1-1: "It seemed that there might have been something on the left side under the shirt, maybe even a knife, a gun, or something else." (Picture 8)	E2-2: "…left hand a little bit like it would be close to the mouth of the pocket and… the left helm of the t-shirt… was elevated, [so] there is probably something there in the trousers of the target person… He might start to dig a possible weapon, firearm, or knife, or something." (Picture 8) E2-5: "[The left hand is] pretty surprisingly high, which means you can imagine that either he's leaning against that doorway or wall, or he's got something there in hand. It is not likely to be his phone, because the phone is already in his pocket. But mainly you can imagine that it is something else. And as the worst-case scenario, there could be a blade, striking weapon, or possibly a handgun." (Picture 1)

Participant group (N1 = Novice 1, N2 = Novice 2, E1 = Expert 1, E2 = Expert 2) and number (following the "– ") have been identified before each statement. For example, E2-5 is Participant #5 from the Expert 2 group. To facilitate direct comparison of responses between novices and experts, the picture each statement is referring to has also been provided in parentheses following each quotation. Some of the pictures described above have been previously published as supplementary materials in Huhta et al. (2022): Picture 3 = Fig. S3, Picture 4 = Fig. S1, Picture 7 = Fig. S2, Picture 8 = Fig. S4, Picture 9 = Fig. S5. Additional pictures can be requested from the first author

or goals that they or their partners could execute at the same time (see Table 2). Specifically, experts stressed the importance of primary and secondary roles and tasks, which may change during the situation. Thus, both patrol members act as enablers of different functions—one provides support while the other can work. Officers can facilitate the overall patrol's common understanding of the situation through their verbal orders to the target person (e.g., "drop the knife and stand still") so that even if another patrol member does not see the situation, they would be able to form their own situational assessment through the content of the order (in policing often referred to as "communication through the target"). Therefore, roles were aimed at better assessment and control of the situation, making so-called 360-degree perception and action more efficient. Roles were tightly tied to tactics as well and were used to ensure the most safe and effective UOF (if necessary).

Profiling the Suspect

Participants assessed the situation by profiling the target person. At the very least, participants tried to judge the target person's mood (e.g., angry, aggressive). Experts mostly evaluated the functional capacity of the target person, in particular assessing how strong, fast, or possibly skilled and therefore dangerous they might be. While novices described the clothes of the target person, experts evaluated how their dress might influence the officer's own UOF and what they should be especially careful about; for example, a target person's heavy shoes may pose a danger by possibly kicking the officer or bystanders. Experts also used their evaluation of the surrounding environment to inform their suspect profile. For example, the way an individual maintained their apartment (e.g., messy or tidy) could suggest their functional capacity.

Tactical Options and Opportunities

Part of evaluating SA through tactics is identifying options as dictated by the situation. The specific tactics used by the police are, in principle, confidential information, so this study does not distinguish what these tactics might have been. At a general level, tactical options included verbal instructions, orders, or having a conversational interaction to de-escalate or resolve the situation. Another part of tactics was the evaluation of opportunities and possibilities for very detailed motor functions (e.g., cross hold) and other various UOF techniques or equipment. For instance, if a target person was seated it would dictate which tactical options were possible for the officer to take control of the situation. Therefore, tactical options and opportunities were directly related to other themes, especially partner/roles, profiling the

suspect, estimation of distance and time, and the surrounding Environment (including the presence of bystanders).

Ongoing Assessment of Own Tactical Activities and Outcomes

Participants' assessments included trying to predict how their own actions will affect the situation as it unfolds. In particular, experts assessed how their own tactical decision-making could affect the behavior of the target person and how the officer's own actions could affect the safety of bystanders. This theme of self-evaluation also included consideration of the selection and effectiveness of various UOF tools including physical force techniques. In other words, experts seek to predict the effects of their own action alternatives on the overall development of the situation. Self-assessment of the consequences of one's own actions was also partly based on confidence in one's own abilities and competencies. This, in turn, can affect the tactics and techniques chosen by the officer, either increasing or limiting potential options.

Surrounding Environment and Conditions

The reality created by the surrounding environment also informed participants' situational assessments; for instance, whether there were "dark" (i.e., unseen or occluded) corners hidden from the officer's sight, the size of a room/place, the placement of furniture relative to possible activity. Officers also evaluated other physical structures, such as hallways or doors that could be seen as either supporting or impairing safe operation. Ambient environmental conditions such as lighting or weather also impact SA and subsequent tactical decision-making, such that an officer might not use OC spray in windy conditions or in a housing unit with many apartments. The perspective of one officer alone may not be sufficient such that assessing the environment requires active engagement and shared knowledge between members of the patrol. In this way, information related to the environment is continuously updated during the operation and forms a more complete picture of the situation. This includes assessing the + 1 rule (Huhta et al. 2021), a common concept in police tactics that refers to the possibility of an unknown or additional threat including target persons or items.

Dangerous Objects

Participants evaluated the situation through the real or potential presence of dangerous objects, which can include weapons (e.g., knives, firearms) or objects that could be used to cause harm to the officer or bystanders (e.g., chair, bottles). Dangerous objects were either directly visible and thus immediately impacted the situation and tactical options, or their possible presence and impact on the situation were assessed on the basis of assumptions (e.g., there are always knives in the kitchen; there may be something in the target's other hand that is out of sight) including the + 1 rule (i.e., if one weapon is visible, another may be hidden somewhere close by). Experts also noted that their evaluation of dangerous objects would consider previous experience or knowledge generated by computer systems related to the target person or address, such as previous calls for service.

Quantitative Results: Expert Versus Novice Situational Awareness

Overall, significant differences were observed in the number of themes identified between groups ($H(3) = 27.74$, $p < 0.001$). On average, Novice 1 participants identified 1 ($SD = 0.65$) out of the 7 identified themes per image, Novice 2 identified 2.8 ($SD = 1.12$) themes, Expert 1 identified 5.8 ($SD = 0.52$) per image, and Expert 2 identified 6.4 ($SD = 0.45$) themes per image (Fig. 1). Pairwise comparisons reveal that Novice 1 participants reported significantly fewer themes than both Expert groups ($p_{Bonf} < 0.001$) and that the Novice 2 group reported fewer themes than the Expert 2 group ($p_{Bonf} = 0.030$).

The frequency of responses for each theme was converted to a percentage for each group (e.g., for the theme of distance in the Novice 1 group = the frequency of responses for distance/[10 Novice 1 participants × 13 images = 130 total possible response opportunities]) and are shown in Fig. 2. Statistical analyses reveal significant differences between all of the groups for all themes ($H(3) > 16.25$, $ps < 0.001$). Pairwise comparisons are summarized in Table 3.

Both expert groups were able to identify almost every theme in each image presented, especially distance/time law, profiling the suspect, tactical options and opportunities, and surrounding environment and conditions. The Expert 2 group, which comprised police instructors, were particularly effective at identifying partner/roles and ongoing assessment of their own tactical activities and outcomes.

The Novice 1 group identified a relatively low frequency of the themes overall and were identified inconsistently and superficially (i.e., only one word with no elaboration). Out of a total of 130 possible response opportunities (10 participants × 13 images), only one Novice 1 participant indicated ongoing assessment of their own tactical activities and outcomes once in the entire study. Novice 1 participants were often able to identify dangerous objects, as these are quite obvious visual cues that were directly visible in several of the presented images. However, in cases where the dangerous object was not directly visible or in a possible location such as a knife in a kitchen scene, Novice 1 participants

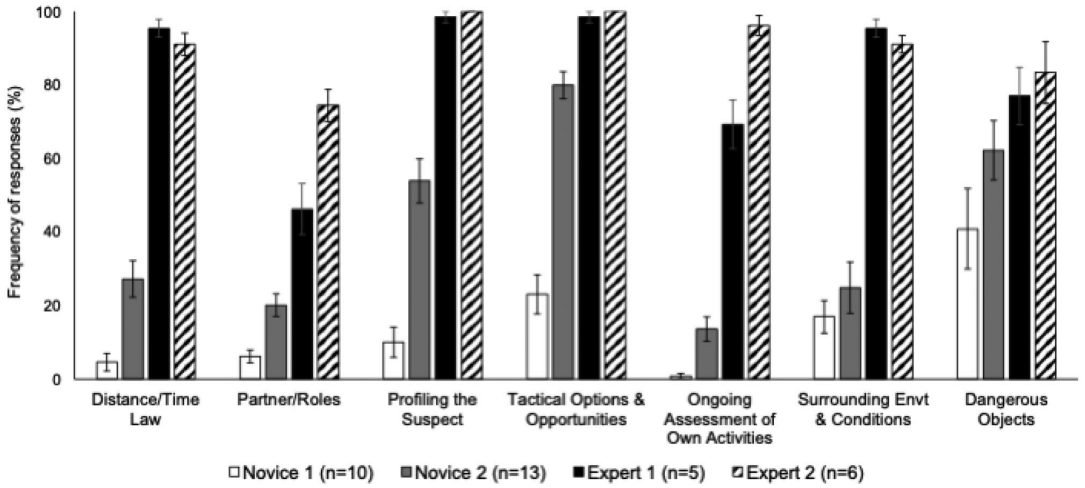

Fig. 2 Average frequency of situational awareness themes by group. Pairwise comparisons reveal that Novice 1 participants identified all themes significantly less than both Expert groups. Novice 1 and 2 only differed significantly for the theme of tactical options and opportunities. Novice 2 participants identified distance/time law significantly less than Expert 1 participants, and partner/roles, profiling the suspect, and ongoing assessment of own tactical activities and outcomes significantly less than Expert 2 participants, and surrounding conditions and environment significantly less than both Expert groups. Frequency of identified themes did not significantly differ between Expert groups. See Table 3 for full reporting of pairwise comparisons. Error bars show standard error of the mean (SEM). $^{*}p_{Bonf} < 0.05$ $^{**}p_{Bonf} < 0.01$ $^{***}p_{Bonf} < 0.001$

did not identify this theme nor were they able to infer its presence (i.e., making an inference using the + 1 rule). In addition, Novice 1 participants did not identify possible next steps for their own actions, their partner's actions, or those of the target person based on the possible presence of a dangerous object. Instead, both Expert groups emphasized these other themes in relation to the consideration of a dangerous object even when it was not explicitly visible.

Relative to the Novice 1 group, Novice 2 participants were able to identify tactical options and opportunities quite well. This finding is understandable as this group had completed all or most of their tactical training with specialized UOF instructors and were about to begin their practical field work. However, Novice 2 participants did not identify the themes of Ongoing Assessment of their own tactical activities and outcomes, distance/time law, partner/roles, and surrounding environment and conditions more than 30% of the time. Novice 2 participants' profiling of the suspect was quite varied, ranging from simple descriptions of subjects' perceived mood to more analytical assessment of their functional capacity in 53% of total response opportunities (Fig. 2).

Table 3 Mann–Whitney *U* pairwise comparisons for between-group differences in identified themes

Pair	Distance/time law	Partner/ roles	Profiling the suspect	Tactical options and opportunities	Ongoing assessment of own activities	Surrounding conditions and environment	Dangerous objects
Novice1-Novice2	0.199	0.444	0.113	0.020*	1.000	1.000	0.137
Novice1-Expert1	0.000***	0.010*	0.000***	0.001**	0.008**	0.001**	0.015*
Novice1-Expert2	0.000***	0.000***	0.000***	0.000***	0.000***	0.001**	0.002**
Novice2-Expert1	0.043*	0.398	0.116	0.591	0.104	0.015*	1.000
Novice2-Expert2	0.062	0.015*	0.037*	0.216	0.001**	0.019*	0.444
Expert1-Expert2	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Significance values have been adjusted by the Bonferroni correction for multiple tests

$^{*}p_{Bonf} < 0.05$; $^{**}p_{Bonf} < 0.01$; $^{***}p_{Bonf} < 0.001$

Discussion

The current mixed-methods study evaluated interview data from novice and expert police officers in response to images of various staged encounters using qualitative and quantitative approaches. The most novel and important finding based on the responses from all participants, and especially the tacit knowledge derived from experts, is the identification of seven themes that are foundational to forming SA in police-specific contexts: distance/time law, partner/roles, profiling the suspect, surrounding environment and conditions, tactical options and opportunities, ongoing assessment of own tactical activities and outcomes, and dangerous objects. These themes are highly connected to one another and can inform each other. Importantly, the themes are not ordered chronologically or by importance to cultivating overall SA. Rather, the identified themes are all essential aspects of individual and collective SA and come into play as situational demands dictate. For instance, a dark corner (i.e., surrounding environment and conditions) can dictate an officer's current Tactical Options and also inform their ongoing assessment of how their own actions can influence situational outcomes. At the same time, missing the dark corner can lead to the selection of a less ideal tactical option, or compromise the patrol's overall situational assessment. At worst, this can lead to errors in SA and subsequent decision-making. These negative outcomes are what the current study aims to reduce by defining and building optimal police SA through evidence-based approaches. This allows for the creation of effective teaching methods, where SA formation is one critically important learning objective for police, which can now be operationally defined and segmented into individual entities or "chunks" based on the themes identified above to promote learning.

Development of SA from Novice to Expert Through Training and Experience

Both expert groups identified more themes for each image (Fig. 1) and there were also qualitative differences in the amount of detail described for each theme. The following example illustrates the multidimensionality of expert responses that identify several themes in a single statement, each of which will be discussed in turn below:

> Expert 1-Participant 1: "That is, one can take a distance [distance] to the man,… one can be prepared for the use of a firearm [Tactical Option], the other to carry out the apprehension [partner/role]... An alternative model would be [ongoing assessment], [officers] should take distance [distance and tactical option], go, for example, seek shelter, structural protection [surrounding environment], and from there give the verbal command that we will use a firearm [tactical option] [if the target person does not comply]." (Picture 9, or Fig. S5 in Huhta et al. 2022)

As exemplified in the quote above, the theme of distance is a prominent and well-known concept among police UOF instructors and researchers alike. Nieuwenhuys et al. (2012) argue that distance is an important factor in deciding how to act/respond in a situation such that large distances usually provide more options and time for action. In a reaction time study, Blair et al. (2011) found that officers in a shooting position aiming at an armed suspect were unable to shoot before they were shot at. Based on fundamental physical laws and experience, action is always faster than reaction, highlighting the necessity for police officers' ability to recognize and assess every situation as fast and as accurately as possible (Huhta et al. 2022). These findings align with the current study, whereby both expert groups estimated distance and time laws in almost every encounter (Fig. 2). Most often, expert participants noted that they were too close to target persons and that their first course of action would have been to try to create more distance to gain more time.

The lowest reported theme among all participants was related to identifying roles for the officer themselves or their partners (Fig. 2). At least in Nordic countries, the specific tasks and goals assigned to each role (e.g., primary lead, secondary support) are well understood. Nonetheless, the actions mediated by specific roles (e.g., secondary officer switching to a lower force option) are often communicated in operational contexts, training scenarios, and were identified in the current study most often by experts (Fig. 2, Table 3). When novices identified this theme, they referred to what "we" would do as a collective, while experts articulated individual roles and tasks.

With respect to profiling the target person, novices primarily conducted this assessment according to the suspect's mood (e.g., "looks angry") while experts assessed their ability to function and potential action competencies (e.g., "… the guy is in good physical shape…"; "…the posture seemed to be a little bit … offensive and suited to martial arts."). As shown in Table 2, experts (and especially Expert 2 participants) provided ample detail on target persons' physical features (e.g., "jeans were wearing, belt, wristwatch, long hair, a little beard, slim") and in some cases even inferred their physical capabilities from very detailed features, including a wristwatch that is commonly worn by high-level athletes or martial artists. Experts also informed their suspect profile by considering the theme of the surrounding environment and conditions, and how these features might indicate something about the suspect (e.g., a very neat apartment indicated that the suspect was a "precise, careful guy"). This example further demonstrates that the seven identified themes are highly interrelated and work together to form more complete SA.

Relating to the development of SA, Novice 1 participants did not possess the fundamental skills of identifying themes individually or discretely, nor had they yet developed the higher-level ability to connect the themes to one another (Fig. 2). This is likely because the Novice 1 group had not yet started their tactical training with specialized UOF instructors, even though they had started the basic tactics curriculum (Police University College of Finland 2022). The Novice 2 group had completed all or part of the tactical training block and were able to identify tactical options and opportunities in 80% of cases (Fig. 2). However, Novice 2 participants were still relatively poor at conducting ongoing assessment of their own tactical activities and outcomes and identifying distance/time laws, partner/roles, and surrounding environment and conditions (Fig. 2). This may be because the Novice 2 group had not yet had the opportunity to apply their tactical skills and knowledge in real-world field settings. This finding also highlights the differences in skills developed through deliberate training exercises versus operational experience in the field. By providing a better understanding of the specific elements that comprise SA, the current study can also inform the development of improved evidence-based training, including an understanding of how SA connects to ongoing assessment of tactical options, opportunities, and actions.

Deriving tacit knowledge from expert practitioners is an important method for developing police training and education, especially for skills and mental processes that are not readily observable. Using quantitative psychophysical methods, the eye-tracking data collected as part of this study have already revealed expert and novice patterns of early-stage SA (Huhta et al. 2022). Interestingly, what the participants saw (i.e., where their gaze was fixated) did not always correspond with what they perceived, understood, or predicted according to their qualitative responses, especially among novices. Despite spending more time scanning the environment relative to experts, novices were unable to identify or understand the importance of themes like the surrounding environment and conditions, the relative distance between themselves, target persons, or bystanders, or the potential presence of dangerous objects (Fig. 2). Similarly, novice participants' eye movement patterns beginning with target person's faces, hands, and bodies did not result in profiling the suspect as expressed in their interviews. These findings are consistent with Mangels et al. (2020), who also identified quantitative and qualitative differences in novice and expert officers' UOF decision-making strategies. The authors found that novices were also less likely to identify or recognize the importance of distance, time, backup, and cover provided by the surrounding environment. Mangels et al. (2020) concluded that an inability to perceive the situational aspects as found in their qualitative analyses led to the selection of more physical tactical and UOF options among novices compared to experts who were more likely to engage in verbal de-escalation.

All of the SA themes identified can be effectively learned in training exercises. However, profiling the target person may require additional consideration. In police training exercises, the target person is often portrayed by a certified UOF instructor or an actor. While other themes like tactical options and opportunities and distance/time laws may be effectively trained with a known actor, trainees' ability to authentically profile the target person can often be artificial in these cases (i.e., the high-level functional capacity of UOF instructors is well known and assumed; variability in instructors' ability to act out a variety of emotional or mental states). As a result, improved suspect profiling skills observed among expert participants may be a result of refinement through specialized training and applied fieldwork experience. That is, experienced officers not only develop a larger repertoire of past experiences (i.e., training and operational) but also develop higher-level SA skills that integrate multiple themes to supplement their profiling abilities (i.e., assessing the target based on the condition of their apartment). At the same time, suspect profiling may be superficial among novice participants due to a lack of explicit and directed training on suspects' functional capacities in existing UOF and tactical training curriculums.

A possible explanation for the Expert 2 participants' ability to identify the greatest number of SA themes, especially partner/roles and ongoing assessment of own tactical activities and outcomes (Fig. 2), could be expert instructors' experience with verbalizing tactical considerations for the purposes of teaching and providing feedback to trainees. Specialized UOF instructor training offered at the Police University College of Finland, which was completed by all Expert 2 participants, requires that the instructors have relevant field experience and complete a "train the trainers" course that includes pedagogical theory, practice, and application of tactical techniques (see Di Nota et al. 2021a). Therefore, the police instructors included in the current study are specifically trained to speak aloud about perceptual, thinking, reasoning, and decision-making processes for the purpose of training others. This results in more detailed and multidimensional responses that reflect "languaging"—a pedagogical concept that describes the development of one's own understanding by expressing their thinking to others using natural language. This method has been observed particularly in mathematical and linguistic learning contexts whereby students express and critically reflect on the key features of a concept to others, in turn structuring their own knowledge and thought processes. At the same time, students can compare their conceptual understandings with the content expressed by others, enabling learning through conversation and shared thoughts (Joutsenlahti and Kulju 2015).

Relevant to all police training and field experiences, learning may not occur unless the officer engages in purposeful reflection whereby the individual recognizes and critically evaluates the underlying assumptions and truisms of their own thinking, emotions, and actions. Reflection is itself a competency without which action becomes routine-based and is a skill that is developed through training with the guidance of instructors and constructive feedback (Mezirow 1998; Di Nota et al. 2021a). Therefore, training serves an important function for both initial skill development, as well as novel skill learning and "refresher" exercises for experienced professionals. Other research teams have provided resources and insights on how to develop effective police training exercises to meet learning objectives (see Jenkins et al. 2021; Koedijk et al. 2021).

Updating SA and Goals Through Self-Awareness

Considered together with previous literature, the current findings provide further insight into how early-stage perceptual processes are intimately linked to higher-level cognitive processes such as understanding and prediction in accordance with Endsley's (1995) model of SA, as well as subsequent decision-making and motor planning. The themes identified in the current study reflect all stages of Endsley's SA, such that an officer's understanding of the low-level perceptual aspects of a room (e.g., placement of furniture, doors, windows) will dictate what higher-level Tactical Options and Opportunities are available to them. Using mental models and established knowledge structures, more experienced officers are better able to put smaller perceptual pieces or "chunks" together and predict how their own actions might influence situational outcomes (Di Nota and Huhta 2019). The current findings highlight a knowledge gap in, or at least an inability to verbalize, self-awareness of the officer's own impact on situational outcomes, which should be explicitly addressed in SA training at all levels.

Police are trained (at least in theory) to continuously repeat the SA process and update their situational assessment as the encounter unfolds and new information is revealed. This practice is also reflected in visual models of police UOF decision-making (see Di Nota et al. 2021b). However, similar to the operational definitions of SA and UOF, training of situational re-assessment is inconsistent and not standardized. Researchers have found that proficient decision-makers in incident command contexts update their current understanding as well as situational tasks and goals based on changing demands or features (Alison et al. 2022). Relevant to police, Klein's (2007) investigations on experts reveals "flexecution." Rather than focusing on achieving goals made during early assessment or planning phases, flexecution refers to the capacity to flexibly change goals based on discoveries made during execution. Therefore, it is essential that officers are able to quickly identify new goals, and if needed abandon previous ones, and to be able to act towards new goals. In this way, police decision-making can be based on SA, and not focus simply on the final outcome.

Practical Implications for Police Training and Evaluation of SA

As mentioned earlier and elsewhere, there is a current lack of standard definitions and evidence-based methods for police training concerning SA (Di Nota and Huhta 2019). We hope that the current findings will provide police educators with an opportunity to have officers reflect on all of the identified themes to develop a more complete skillset for achieving optimal SA. We do not suggest that police officers are not already implementing the themes identified here, but they may not realize when they are engaging self-reflective processes or when they are not. Without such conscientious reflection, officers are not learning, and it may lead to haphazard SA and action that is based on reflexive routines or implicit non-analytical strategies (Hine et al. 2018), especially under stressful conditions that compromise mental and physical performance (for reviews see Anderson et al. 2019; Di Nota and Huhta 2019). Instead, officers should consider their own thought patterns as an important part of SA and the required competencies that they bring to any encounter.

Following previous pedagogical models for developing police competencies (Di Nota et al. 2021a; Jenkins et al. 2021; Koedijk et al. 2021), we propose that revised SA training begin with foundational knowledge of the themes identified in the current study. Instructors can now describe individual situations that can be broken down around these seven themes, allowing officers to conceptualize SA in more manageable and concrete "chunks" that facilitate learning through reflective discussions (Kurby and Zacks 2008). Based on recent eye-tracking studies in police, instructors can also develop observation-based training exercises (Huhta et al. 2022). Various images can be viewed and analyzed as "saliency maps" to guide effective and efficient visual search patterns that promote more complete SA by connecting them to the current themes (Fig. 2). For example, instructors can direct officers' gaze to observe target person's hands earlier and develop their understanding of how this physical feature could be relevant for profiling the suspect, including detecting real or possible dangerous objects. Visuomotor behaviors can also be trained to search the surrounding environment more efficiently to derive relevant information, such that identifying "dark" corners or Dangerous Objects should be linked to Tactical Options and Opportunities (i.e., know where these elements are so that you can prevent the target person's access to them later in the situation).

Once foundational knowledge of SA is established, training exercises should increase in complexity (including the

level of induced physiological stress) to promote encoding and performance in similar stressful situations (Di Nota et al. 2021a; Koerner and Staller 2021). Virtual or live simulations should be designed to elicit consideration of each theme and how it affects SA and later tactical decision-making and motor behaviors. For example, scenarios can manipulate the Distance between officers and the target person to develop a better understanding of whether officers can operate within the time span that their chosen means provides for "safe" apprehension. Specifically, time span can refer to the time it takes to use a given option (e.g., is the target person close enough for a Taser to be effective or should officers "cut the distance" to use one), or it can also refer to the time created by a given option to perform other actions (e.g., considering whether using a flash bang gives time to apprehend the suspect). At the same time, officers must be mindful about whether the surrounding environment and conditions impact the effectiveness of their tactical options and opportunities by conducting an ongoing assessment of their own tactical activities and outcomes. For instance, selecting OC spray would require additional consideration for what effects this option may have on bystanders or the officer themselves in an enclosed space or in windy conditions. In this way, officers can prepare more appropriate and effective motor plans that reduce the likelihood of, and reliance on, higher force options while promoting operational safety.

Instructors should also observe behavioral competencies, such as withdrawal and target-oriented behavior, and evaluate whether the officer is taking initiative to create distance, for example, based on SA-informed decision-making or acting out of fear (Huhta et al. 2021). Instructors need to be able to see, question and understand what officers base their actions on in order to promote correct training and feedback. In this way, instructors can make tacit knowledge visible (or explicit) in training situations where SA-related mental processes may not be readily observable. Guided by the seven SA themes, "languaging" can also increase training efficiency by facilitating observation-based learning among officers watching their colleagues act out simulations. Importantly, the themes identified in the current study also broaden the scope of teaching and learning from considering only the "end result" of the performance and emphasizing continuous thinking and action. This kind of "end result" evaluation (e.g., shoot/no-shoot decision-making, apprehending the suspect) can be problematic because according to Endsley (1995), good performance can be achieved even if SA is defective. The most dangerous implication in police training contexts is if a good result is achieved by luck and serious errors that could endanger safety are overlooked by the trainer and the performer. Failing to consider the SA process may give both the trainer and trainee a false sense of capability, which may result in serious harm in real-life encounters if opportunities to identify and correct SA and tactical skills are missed.

Errors in police decision-making and behavior result in considerable distress and investment into understanding precisely where, when, why, and how things went wrong. Previous studies identify many factors that influence officer decision-making in critical situations, including those related to the environment, target person, and individual officer including physical and psychological stress (Chan et al. 2022; Giessing et al. 2019; James et al. 2019). The themes identified in the current study provide seven specific criteria that can be utilized at the processes level to understand and identify where things went wrong. In this way, these findings can also contribute meaningfully to the training, operations, and investigations surrounding individual police tasks during critical incident management.

Limitations and Future Directions

The current findings do not necessarily represent an exhaustive set of elements that inform police SA. Indeed, various policing roles or contexts (e.g., responding alone, in pairs, or part of a tactical team) may limit or introduce other aspects of SA that were or were not revealed by the current study. However, we are confident that no additional themes were missed, and that full saturation of participant responses was achieved. Particularly among Experts, some participants expressed concern to the researchers that their responses were becoming too repetitive, but were nonetheless encouraged to provide as much detail and information as possible for each image. We also acknowledge that possible differences in legislation, for instance, whether officers carry a duty weapon or not, may also influence training and operational standards as well as SA formation for officers in those jurisdictions. All officers included in the current study are legislated under the same sole centralized police organization, but the Experts are stationed and have operational experience in different regions. While the current elements are applicable to forming SA at the individual officer level in frontline positions (i.e., responding to calls), future studies can investigate the critical aspects of SA in other positions including leadership and management, whose awareness would have to consider the "bigger picture" and involvement of other personnel, agencies, and resources (e.g., paramedics, fire and rescue).

An additional limitation of the current study is the use of static images and a non-stressful experimental paradigm. Building on existing literature (Huhta et al. 2021, 2022; Mangels et al. 2020), future research can evaluate observable aspects of SA (i.e., visuomotor behaviors, tacit knowledge) while viewing dynamic footage (e.g., body-worn cameras, surveillance) or engaging in virtual or live training scenarios that activate physiological stress responses. In this way,

we can begin to understand more naturalistic SA processes in critical contexts, including the order that each theme is addressed and how different elements of SA are impacted by stress physiology.

The current study samples were also relatively small, especially expert groups, which also had no female participants. There are no current or previous female officers serving in Finnish special force units, and females are significantly underrepresented (or completely absent) from these roles in other countries. Therefore, potential sex differences in the themes identified (i.e., the frequency of individual themes, qualitative differences in theme descriptions) could not be analyzed. All study participants and persons included in the images were White European/Caucasian. Previous investigations in European and North American police have shown racial disparities in UOF and lethal force errors in both experimental and field settings (Andersen et al. 2021; Edwards et al. 2019; Essien et al. 2017; Wortley et al. 2020). While these sociocultural factors may influence decision-making by way of modulating threat perception and stress physiology, they still relate to the elements of SA defined in the current study and specifically profiling the suspect. Therefore, future SA training can direct officers' suspect profiles to be based primarily on functional capacity and not suspect race, sex, or gender. Through the current study, we hope to minimize any differences—between sexes, cultures, or individual officers—in how SA is conceptualized, operationalized, and utilized in police-specific contexts.

Conclusion

Police officers require expertise in situational awareness in order to effectively and dynamically apply their knowledge and skills to resolving the task at hand. Therefore, identifying the basic elements of SA is a means to enhance the current understanding of what and how we should teach and train. Through rigorous research methods that tested both novice and expert officers, the current study identified seven unique but interrelated themes that inform SA. Given that all of the themes were identified across all encounters that represented typical frontline tasks with varying levels of threat, the current study reveals universal elements that define SA in police-specific contexts. The present findings will be used to enhance evidence-based frameworks for training SA, tactics, and UOF, and establish a professional standard for SA in policing.

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Data Availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Approval was obtained from the research ethics board of the Police University College of Finland. The procedures used in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors declare no competing interests.

Previous Publication The quantitative eye-tracking data obtained from the current sample has been previously published elsewhere (Huhta et al. 2022). However, the qualitative analyses presented in the current study have not been previously published, and all text is original (i.e., not self-plagiarized).

References

Alison L, Shortland N, Palasinski M, Humann M (2022) Imagining grim stories to reduce redundant deliberation in critical incident decision-making. Public Money & Management 42(1):14–21. https://doi.org/10.1080/09540962.2021.1969085

Andersen JP, Di Nota PM, Boychuk EC, Schimmack U, Collins PI (2021) Racial bias and lethal force errors among Canadian police officers. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement*. Advance online publication. https://doi.org/10.1037/cbs0000296

Andersen JP, Di Nota PM, Poplawski S, Pitel M, Zurowski J, Azmi P (2017) *The science behind de-escalation and use of force decision-making: policy recommendations for police training*. Government of Ontario, Ministry of Community Safety and Correctional Services, June

2017. Available online: https://hartlab.net/policy-recommendations-for-police-training/ (Retrieved 4 October 2022)

Andersen JP, Gustafsberg H (2016) A training method to improve police use of force decision making: a randomized controlled trial. SAGE Open 6(2):2158244016638708. https://doi.org/10.1177/2158244016638708

Anderson GS, Di Nota PM, Metz GAS, Andersen JP (2019) The impact of acute stress physiology on skilled motor performance: implications for policing. Front Psychol 10(2501):1–11. https://doi.org/10.3389/fpsyg.2019.02501

Anttila P (2006) *Tutkiva toiminta ja ilmaisu, teos, tekeminen*. [*Exploratory activities and expressions, work, doing*.] Akatiimi Oy

Barrett LF, Bar M (2009) See it with feeling: affective predictions during object perception. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1521):1325–1334. https://doi.org/10.1098/rstb.2008.0312

Bennell C, Blaskovits B, Jenkins B, Semple T, Khanizadeh AJ, Brown AS, Jones NJ (2020) Promising practices for de-escalation and use-of-force training in the police setting: a narrative review. Polic Intern J 44(3):377–404. https://doi.org/10.1108/PIJPSM-06-2020-0092

Bertilsson J, Niehorster DC, Fredriksson PJ, Dahl M, Granér S, Fredriksson O, Nyström M (2020) Towards systematic and objective evaluation of police officer performance in stressful situations. Police Pract Res 21(6):655–669. https://doi.org/10.1080/15614263.2019.1666006

Blair JP, Pollock J, Montague D, Nichols T, Curnutt J, Burns D (2011) Reasonableness and reaction time. Police Q 14(4):323–343. https://doi.org/10.1177/1098611111423737

Chan J, Di Nota PM, Planche K, Borthakur D, Andersen JP (2022) Associations between police lethal force errors, measures of diurnal and reactive cortisol, and mental health. Psychoneuroendocrinology 142:105789. https://doi.org/10.1016/j.psyneuen.2022.105789

Di Nota PM (2017) Short- and long-term changes in behaviour and brain activity following exercise, motor learning and expertise. [Doctoral dissertation, York University]. York Space Institutional Repository. http://hdl.handle.net/10315/33618

Di Nota PM, Andersen JP, Huhta JM, Gustafsberg H (2021a) Evidence-based instruction of police use of force: practical methods and pedagogical principles. In Arble, E. & Arnetz, B. (Eds.), *Interventions, training, and technologies for improved police well-being and performance* (pp. 72–101). IGI Global. https://doi.org/10.4018/978-1-7998-6820-0.ch005

Di Nota PM, Chan J, Huhta J-M, Andersen JP (2021b) Considering objective and subjective measures for police use of force evaluation. Int J Environ Res Public Health 18(10):5351. https://doi.org/10.3390/ijerph18105351

Di Nota PM, Huhta J-M (2019) Complex motor learning and police training: applied, cognitive, and clinical perspectives. Front Psychol 10(1797):1–20. https://doi.org/10.3389/fpsyg.2019.01797

Di Nota PM, Stoyko P, Jenkinson J, Boychuk EC, Andersen JP (2021c) Critical review of visual models for police use of force decision-making. Vision 5(6):1–20. https://doi.org/10.3390/vision5010006

Edwards F, Lee H, Esposito M (2019) Risk of being killed by police use of force in the United States by age, race-ethnicity, and sex. Proc Natl Acad Sci USA 116(34):16793–16798. https://doi.org/10.1073/pnas.1821204116

Endsley MR (1995) Measurement of situation awareness in dynamic systems. Hum Factors 37(1):65–84. https://doi.org/10.1518/001872095779049499

Ericsson KA (1998) The scientific study of expert levels of performance: general implications for optimal learning and creativity. High Abil Stud 9:75–100. https://doi.org/10.1080/1359813980090106

Ericsson KA, Simon HA (1984) *Protocol analysis: verbal reports as data*. The MIT Press

Eskola J, Suoranta J (2014) Johdatus laadulliseen tutkimukseen [Introduction to qualitative research]. Vastapaino

Essien I, Stelter M, Kalbe F, Koehler A, Mangels J, Meliß S (2017) The shooter bias: replicating the classic effect and introducing a novel paradigm. J Exp Soc Psychol 70:41–47. https://doi.org/10.1016/j.jesp.2016.12.009

Giessing L, Frenkel MO, Zinner C, Rummel J, Nieuwenhuys A, Kasperk C, Plessner H (2019) Effects of coping-related traits and psychophysiological stress responses on police recruits' shooting behavior in reality-based scenarios. Front Psychol 10:1523. https://doi.org/10.3389/fpsyg.2019.01523

Hine KA, Porter LE, Westera NJ, Alpert GP, Allen A (2018) What were they thinking? Factors influencing police recruits' decisions about force. Polic Soc 29(6):673–691. https://doi.org/10.1080/10439463.2018.1432612

Honkela T, Leinonen T, Lonka K, Raike A (2000, August 21–25) *Self-organizing maps and constructive learning*. [Conference paper]. Proceedings of the International Conference on Educational Uses of Communication and Information Technologies (ICEUT), Beijing, China (pp. 339–343). https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.117.2706&rep=rep1&type=pdf

Huhta JM, Di Nota PM, Nyman M, Pietilä E, Ropo E (2021) Universal police behaviours during critical incidents and their connection to personality: a preliminary study. Nord J Stud Polic 8:1–18. https://doi.org/10.18261/issn.2703-7045-2021-01-04

Huhta J-M, Di Nota PM, Ropo E, Surakka V (2022) Experience-dependent effects to situational awareness in police officers: an eye tracking study. Int J Environ Res Public Health 19:1547. https://doi.org/10.3390/ijerph19095047

James L, James S, Davis R, Dotson E (2019) Using interval-level metrics to investigate situational-, suspect-, and officer-level predictors of police performance during encounters with the public. Police Q 22(4):452–480. https://doi.org/10.1177/1098611119857559

Jenkins B, Semple T, Bennell C (2021) An evidence-based approach to critical incident scenario development. Policing: an International Journal 44(3):437–454. https://doi.org/10.1108/PIJPSM-02-2020-0017

Joutsenlahti Jorma J, Kulju P (2015) Kielentäminen matematiikan ja äidinkielen opetuksen kehittämisessä [using languaging to enhance mathematics and native language education]. In: Kaartinen T (ed) *Monilukutaito kaikki kaikessa* [*Multi-literacy is everything*]. Tampereen yliopiston normaalikoulu, pp 57–76

Keampf GL, Klein G, Thordsen ML, Wolf S (1996) Decision making in complex naval command-and-control environments. Hum Factors 38:220–231. https://doi.org/10.1177/001872089606380204

Klein GA (1993) A recognition-primed decision (RPD) model of rapid decision making. In Klein, G.A., Orasanu, J., Calderwood, R. & Zsambok, C.E. (Eds.), *decision making in action: models and methods* (pp.138–147)

Klein G (2007) Flexecution as a paradigm for replanning, part 1. IEEE Intell Syst 22(5):79–83. https://doi.org/10.1109/MIS.2007.4338498

Koedijk M, Renden PG, Oudejans RR, Kleygrewe L, Hutter RI (2021) Observational behavior assessment for psychological competencies in police officers: a proposed methodology for instrument development. Front Psychol 12:552. https://doi.org/10.3389/fpsyg.2021.589258

Koerner S, Staller MS (2021) Police training revisited—meeting the demands of conflict training in police with an alternative pedagogical approach. Policing: a Journal of Policy and Practice 15(2):927–938. https://doi.org/10.1093/police/paaa080

Kurby CA, Zacks JM (2008) Segmentation in the perception and memory of events. Trends Cogn Sci 12(2):72–79. https://doi.org/10.1016/j.tics.2007.11.004

Mangels L, Suss J, Lande B (2020) Police expertise and use of force: using a mixed-methods approach to model expert and novice use-of-force decision-making. J Police Crim Psychol 35(3):294–303. https://doi.org/10.1007/s11896-020-09364-4

Martaindale MH, Blair JP (2019) The evolution of active shooter response training protocols since Columbine: lessons from the Advanced Law Enforcement Rapid Response Training Center. J Contemp Crim Justice 35(3):342–356. https://doi.org/10.1177/1043986219840237

Mezirow J (1998) On Critical Reflection Adult Education Quarterly 48(3):185–198. https://doi.org/10.1177/074171369804800305

Moulton ST, Kosslyn SM (2009) Imagining predictions: mental imagery as mental emulation. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1521):1273–1280. https://doi.org/10.1098/rstb.2008.0314

Nieuwenhuys A, Cañal-Bruland R, Oudejans RR (2012) Effects of threat on police officers' shooting behavior: anxiety, action specificity, and affective influences on perception. Appl Cogn Psychol 26(4):608–615. https://doi.org/10.1002/acp.2838

Okoli J, Watt J (2018) Crisis decision-making: the overlap between intuitive and analytical strategies. Manag Decis 56(5):1122–1134. https://doi.org/10.1108/MD-04-2017-0333

Polanyi M (1966) *The tacit dimension*. Doubleday & Company

Police University College of Finland. The structure of the degree. Available online: https://polamk.fi/en/the-structure-of-the-degree (accessed on 4 October 2022)

Ropo E (1991) Opettajaeksperttiyden kehittyminen: tutkimustuloksia ja näkökulmia. [The development of teacher expertise: research results and perspectives.] *Aikuiskasvatus* [*Adult Education*] 11(3):153–163. https://doi.org/10.33336/aik.96748

Saus E-R, Johnsen BH, Eid J, Riisem PK, Andersen R, Thayer JF (2006) The effect on brief situational awareness training in a police shooting simulator: an experimental study. Mil Psychol 18:3–21. https://doi.org/10.1207/s15327876mp1803s_2

Vickers JN, Lewinski W (2012) Performing under pressure: gaze control, decision making and shooting performance of elite and rookie police officers. Hum Mov Sci 31(1):101–117. https://doi.org/10.1016/j.humov.2011.04.004

Wortley S, Laniyonu A, Laming E (2020, July) Use of force by the Toronto Police Service: final report. Ontario Human Rights Commission, Government of Ontario. Available online: https://www.ohrc.on.ca/en/disparate-impact-second-interim-report-inquiry-racial-profiling-and-racial-discrimination-black# (Retrieved 4 October 2022)