Stress and memory: a systematic state-of-the-art review with evidence-gathering recommendations for police

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Abstract

Purpose – The purpose of this study isto synthesize recent empirical research investigating memory of stressful critical incidents (both simulated and occurring in the field) among law enforcement officers.
Design/methodology/approach – The study used the approach of systematic state-of-the-art review.
Findings – In total, 20 studies of police and military officers show reduced detail and accuracy of high- versus low-stress incidents, especially for peripheral versus target information. Decrements in memory performance were mediated by the extent of physiological stress responses. Delayed recall accuracy was improved among officers that engaged in immediate post-incident rehearsal, including independent debriefing or reviewing body-worn camera footage.
Research limitations/implications – Most studies were not found through systematic database searches, highlighting a need for broader indexing and/or open access publishing to make research more accessible.
Practical implications – By understanding how stress physiology enhances or interferes with memory encoding, consolidation and recall, evidence-based practices surrounding post-incident evidence gathering are recommended.
Social implications – The current review addresses common public misconceptions of enhanced cognitive performance among police relative to the average citizen.

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Originality/value – The current work draws from scientific knowledge about the pervasive influence of stress physiology on memory to inform existing practices surrounding post-incident evidence gathering among police.

Keywords Psychological stress, Critical incident memory, Encoding, Consolidation, Delayed recall, Body worn cameras

Paper type Literature review

Introduction

Law enforcement officers are often expected to demonstrate a high level of cognitive performance, especially in relation to accurately recounting and reporting on work-related events. Indeed, researchers have reported that many members of the public believe police officers are more attentive to the events and persons in their environment and less susceptible to perceptual and memory biases of stressful events compared to the average citizen (Jones *et al.*, 2018). These high expectations of law enforcement officers might not be realistic, as there is no evidence to support the notion that police officers' memory and cognitive abilities are any better (or worse) than that of other individuals (Hope, 2016). What is clear is that stress plays a major role in memory formation and retrieval (de Quervain *et al.*, 2000; McGaugh, 2000; Brewin, 2003) and influences police cognition including learning, decision-making and performance (see Di Nota and Huhta, 2019). What remains unclear is the relationship between stress and officers' memory of critical incidents, which bear significant legal, professional and personal implications. Therefore, the current state-of-the-art review aims to synthesize recent literature investigating police memory of stressful incidents. Based on these findings, we provide pragmatic evidence-based recommendations for police administrators to develop, repeal and/or enhance existing policies and practices to improve the quality of post-incident evidence collection.

Background

Memory, stress and the brain

Memory is a complex cognitive process that involves various brain structures to *encode*, *consolidate* and *retrieve* information. As reviewed below, each of these stages of memory are influenced by automatic, subconscious physiological stress responses. Memories can be broadly categorized into explicit and implicit types, with the former comprising declarative memories of facts (semantic memories) and events (episodic memories) that can be consciously recalled, but which are also susceptible to bias and inaccuracy (Ness and Calabrese, 2016). Processed by the medial temporal lobe, hippocampus and prefrontal cortex (PFC), declarative memories provide an internal representation of the external world that can flexibly guide future behaviours in similar but dynamic contexts (Brewin, 2003). Conversely, implicit non-declarative memories cannot be consciously recalled (i.e. knowledge or skills that one cannot remember learning, only that they "just know it"). As such, these memories are not subject to inaccuracy in the same way as declarative memories and are neither true nor false. Implicit memories can be further divided into several functional subtypes that are mediated by different areas of the brain: procedural memory of habitual automatic skills (e.g. using a firearm), perceptual/priming (e.g. likely outcome of a previously perceived stimulus or situation), conditioning (i.e. emotional or skeletal associations) and non-associative reflexes (Ness and Calabrese, 2016; Schwabe and Wolf, 2013).

Encoding

Initial learning, or *encoding*, results in a representational pattern of neuronal firing in the brain that contains information related to multiple types of memories defined above. For instance, a police officer's first patrol will elicit specific patterns of brain activity for both implicit and explicit information. With the introduction of stress and accompanying

physiological responses, blood flow to the extremities is reduced, resulting in a loss of dexterity, fine motor skills and a narrowing of attention to focus on the source of a threat (Chrousos, 2009). This narrowed focus includes heightened attention to visual detail (while ignoring near objects), auditory and visual distortions (e.g. reduced peripheral vision, depth or distance perception) and disruptions in the sense of time (Klinger and Brunson, 2009). Therefore, stress-induced perceptual distortions influence *what* is encoded into later memory. Evidence from animals and humans suggest that the extent of stress-induced arousal is proportional to the perception of the threat (Cahill and Alkire, 2003; Cahill and McGaugh, 1998). Accordingly, the strength of stress-induced autonomic nervous system (ANS) arousal drives encoding such that memory of a highly threatening event (e.g. an officer-involved shooting) is encoded in a manner that is proportional to its importance (i.e. to a greater extent than an uneventful citizen encounter) (Thayer and Sternberg, 2006).

Consolidation

With repeated practice or exposure, connections between brain cells become strengthened and stabilized (Song *et al.*, 2000), known as *consolidation*. Information that is consolidated, such as the correct maneuvering of one's firearm, results in faster access to this stored information, as well as the ability to flexibly apply one's skills in a variety of situations. These capabilities are also hallmark characteristics of expertise (Ericsson, 1998), with trained individuals demonstrating faster reaction times and greater behavioural accuracy than novices whose experiences have not been consolidated (Maia, 2009). Evidence suggests that deep stage rapid eye movement (REM) sleep helps consolidate emotion- or value-laden memories (Genzel *et al.*, 2015) but could also result in the consolidation of false memories among eyewitnesses (Payne *et al.*, 2009; Loftus, 2005). A pressing question relevant to officer testimony is whether post-incident rehearsal of event details increase accuracy of subsequent memories. Among police officers, consolidation may be influenced by reviewing footage captured by body-worn cameras (BWC), which may or may not capture the same information perceived by an officer at the time of the incident. Just as replaying or rehearsing the information in one's mind facilitates consolidation, so too would observe the details of an event. According to an established psychological phenomenon known as retrieval-induced forgetting (RIF, Anderson *et al.*, 2000), improved memory for rehearsed information comes with the potential cost of forgetting unrehearsed information not captured in the footage (e.g. internal perceptions and level of perceived threat) but which directly inform in the moment decision-making.

Retrieval

The final stage of the memory process is *retrieval* or recall of information. Recall can be conscious or unconscious and accurate or inaccurate, depending on the type of memory being retrieved as noted above. Evidence from victims of repeated and prolonged domestic abuse suggests a decrease in the accuracy, consistency and details of any one event over time (van Golde *et al.*, 2018). Similar to police officers, these inconsistencies may call into question the individuals' credibility and integrity. While investigations into stress and memory typically concern the recall of stressful events (i.e. memory encoded under stress), stress experienced *during* retrieval also bears relevance for police. During fight-or-flight, adrenal hormones stimulate the hindbrain to rapidly process information and power habitual, instinctive responses without the need for conscious thought, thereby maximizing survival (LeDoux and Pine, 2016). Blood vessels in the PFC are constricted, limiting sophisticated cognitive processes like critical thinking, inhibition of automatic behaviours and problem solving (Roos *et al.*, 2017). Research using rodents have shown severe impairment in recall of spatial memory under stressful conditions and when cortisol is administered before retention testing (de Quervain *et al.*, 1998). As such, skills and knowledge that have not been consolidated into long-term, habitual memories are not likely to be recalled during events that are perceived as

highly threatening, including critical incidents as well as post-incident inquiries and court testimonies. The influence of stress on retrieval therefore underscores the importance of encoding and consolidating knowledge and skills into memory through repetition and training (Di Nota and Huhta, 2019).

The scientific evidence reviewed above reveal that physiological responses to stress experienced during all stages of memory processing will influence what is recalled. As such, the purpose of this state-of-the-art review is to summarize recent research investigating the influence of stress on memory among police and other law enforcement agents, including military personnel. We conclude with evidence-based recommendations for post-incident evidence collection procedures to promote and preserve as much accurate information from officers as possible.

Methods

Systematic literature review procedures followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati *et al.*, 2009). Inclusion criteria for studies yielded by the literature search included experimental investigations of memory for stressful events (simulations or in-field) among law enforcement officers, including police and military personnel in order to capture the most relevant and available literature. Exclusion criteria included non-peer-reviewed studies (i.e. theses, dissertations, books, bulletins); studies where the population of interest was "eyewitness", bystander or non-law enforcement; studies including police or law enforcement officials diagnosed with post-traumatic stress disorder (PTSD) and studies with primary outcomes that were cognitive skills other than memory (e.g. visuomotor performance, attention, perceptual distortions), including assessments of working memory (i.e. immediate capacity to perceive, store, manipulate and process information to inform decision-making; Unsworth and Engle, 2007).

Information sources included two electronic databases that index journals in the cognitive, health and applied sciences: PsychINFO and ASSIA. Boolean searches were conducted in April 2020 with the following key terms: police, officer OR law enforcement AND stress AND memory OR encoding OR consolidation OR "memory retrieval" OR recall NOT witness. Limiters included English, human, peer-reviewed studies published in the last 20 years (1999-current). The electronic yield of records was supplemented for further eligible studies with hand searches of reference lists.

Results

The PRISMA selection of eligible studies for the current systematic review is summarized in Figure 1. A total of 969 records were identified, and 263 duplicates were removed, leaving 706 studies for title/abstract screening; 678 records were removed through title/abstract screening, leaving 28 studies for full-text review. A further 19 studies were excluded at the full-text stage for the following reasons: wrong study outcome measures or design ($n = 10$); wrong population ($n = 4$); investigations of officers diagnosed with PTSD ($n = 3$); outside of date limits ($n = 2$), and 11titles were included from searches of reference lists, highlighting limited accessibility of topical applied research within any one electronic database. The systematic review process resulted in 20 eligible studies and is summarized in Table 1.

Discussion

The following sections provide thematic summaries of the studies identified by the systematic review according to their direct investigation of memory performance among law enforcement and military officers.

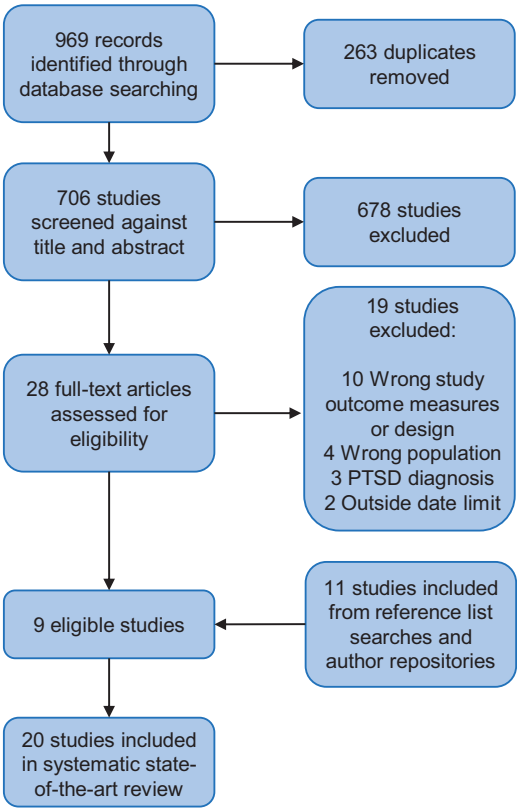

Figure 1.
PRISMA summary

Investigations on the effects of various stressors on encoding and consolidation

Physical stress: Strenuous physical exertion mimics physiological changes in response to psychological threat (Bertilsson *et al.*, 2019). When performed before a simulated critical incident, physical exertion reduced recall accuracy for scenario details, including recognition of target individuals and pre-exertion briefing information (Hope *et al.*, 2012). These findings show that physiological stress responses impair encoding of important information during an incident and consolidation of information provided before the onset of stress responses.

Occupational stress: Repeated exposures to work-related encounters that are potentially traumatic are well-documented among police and contribute to the development of mental disorder symptoms (Carleton *et al.*, 2020). Gutshall *et al.* (2017) hypothesized that non-critical, day-to-day occupational stress experienced over 10 days would result in decrements to visuospatial working memory. However, officers showed marginal improvements that may be attributed to significant study limitations, including a lack of demonstrable stress induction (i.e. non-significant self-reported stress), a lack of critical incidents during the study period, possible habituation or adaptation to the nature of calls at the agency or practice effects (i.e. recalling the same visuospatial figure three times at both baseline and follow-up assessments).

Stress-inducing scenarios: The majority of studies identified in the current review utilize stressful simulations. Decrements in performing the visuospatial task used by Gutshall *et al.*

Table 1.
Investigations of stress and memory among police, law enforcement officers (LEOs) and military personnel

Study	Sample	Memory evaluation	Stress manipulation	Results
Beehr *et al.* (2004)	Police officers, $n = 194$	Delayed recall (12 weeks), with or without rehearsal	High- (shoot) vs. low- (no-shoot) threat live and video simulations	Accuracy highest live shoot condition, those who rehearsed immediately post-exposure, and for objects closest to the threat
*Dawes *et al.* (2015)	LEOs, $n = 11$	Rehearsal	3 UOF scenarios	Verbal commands and subject behaviours corrected in post-incident reports after reviewing BWC footage, errors of omission uncorrected
Gutshall *et al.* (2017)	Police officers, $n = 25$	Visuospatial memory (1, 3, and 25-min recall periods)	10-days work cycle	Marginal improvement in performance between baseline and follow-up assessment. Self-reported stress measures not significant, findings may be attributable to practice effects
*Hartman *et al.* (2017)	Police officers, $n = 15$	Delayed recall (4–10 weeks), rehearsal	UOF scenario	Overall accuracy did not change over time, but delayed recall accuracy improved for officers that viewed their BWC footage ($n = 11$) compared to those that did not ($n = 4$)
*Hope *et al.* (2012)	Police officers, $n = 52$	Encoding pre- and post-stress induction	Physical activity before UOF scenario	Compared to controls, less accurate recall of event details, pre-exertion briefing information, and recognition of critical and incidental target individuals
*Hope *et al.* (2013)	Authorized firearms officers, $n = 300$	Rehearsal	UOF scenario	Conferring with colleagues increased confidence but not post-incident recall accuracy. Errors obtained from colleagues were not in final reports of those who wrote immediate independent reports
Hope *et al.* (2016)	Police officers, $n = 76$	Immediate recall	Active vs. observational role during UOF scenario	Active-role officers recalled significantly fewer correct details and more false memories, effect mediated by level of stress response, no between-group differences in accuracy
*Hulse and Memon (2006)	Police officers, $n = 70$	Immediate recall	High- (shoot) vs. low- (no-shoot) threat video simulation	Less information but greater accuracy for observed high-threat simulation, but physiological arousal was not significantly different between conditions
Karlsson and Christianson (2006)	Police officers, $n = 11$	Delayed recall (10mons, 5 years, 9 years)	Responders to mass casualty event	Visual and auditory memories were best retained but declined by the final timepoint

(*continued*)

Table 1.

Study	Sample	Memory evaluation	Stress manipulation	Results
Lewinski *et al.* (2016)	Police officers, $n = 24$	Immediate recall, consolidation interference	UOF scenario	Officers' recalled movement path was significantly different from actual path of travel. Distractions presented during consolidation did not impact recall
*Meyerhoff *et al.* (2004)	Police trainees, sample size not provided	Immediate recall	UOF scenario	43% of participants accurately described their shot placement, 57% could identify when the situation justified lethal force
*McClure *et al.* (2020)	LEOs, $n = 151$	Immediate and delayed (48h) recall	3 virtual UOF scenarios	Perpetrator details recalled more than event details, inconsistent findings for recall and stress biomarkers between conditions
*Morgan *et al.* (2004)	Military personnel, $n = 509$	Immediate recall	High- vs. low-threat POW exercise	Eyewitness memory of one's interrogator was poorer following high-threat exercise, but accuracy was enhanced for cued photographs
*Morgan *et al.* (2006)	Special Operations military personnel, $n = 184$	Visuospatial memory (before, during, after exercise)	High-threat POW exercise	Impaired visuospatial memory copy and recall performance during a stressful POW exercise, related to symptoms of dissociation and history of traumatic stress
Morgan *et al.* (2007)	Special Operations military personnel, $n = 53$	Delayed recall (48h)	High-threat POW exercise	Significant positive relationship between officers who made more true positive identifications on a standard facial memory task and delayed recall of their interrogator
Page *et al.* (2016)	Police cadets, $n = 63$	Immediate recall	Psychological performance training group vs controls during UOF exercise	Training group remembered more items, especially those that engaged in tactical breathing, during the exercise
Porter *et al.* (2018)	Police officers, $n = 87$	Delayed recall (48h), with or without rehearsal	UOF scenario	Improved delayed recall of peripheral details among rehearsal group. Delay did not impair recognition of threat-relevant details, and visual details were recognized better than spatial or auditory details

(*continued*)

Table 1.

Study	Sample	Memory evaluation	Stress manipulation	Results
Stanny and Johnson (2000)	*Experiment 1*: police officers, $n = 40$ *Experiment 2*: undergraduates ($n = 13$); police officers ($n = 16$)	Immediate recall	High- (shoot) vs. low- (no-shoot) threat and active vs. observational role during UOF scenario	*Experiment 1*: Police officers recalled more details from the low-threat scenario, no differences between roles *Experiment 2*: Both police officers (active-role) and citizen witnesses (observational-role) recalled more details from the low-threat scenario. Officers experienced higher levels of stress and correctly recalled slightly more event information than citizens, but no group differences in recall accuracy
*Taverniers *et al.* (2010)	Special Forces candidates, $n = 27$	Immediate visuospatial declarative memory	High-threat POW exercise	Increased post-exercise cortisol was significantly related to degraded memory performance
*Taverniers *et al.* (2013)	Special Forces candidates, $n = 24$	Immediate and delayed (24h) visuospatial declarative memory	High-threat POW exercise	Extent of increased post-exercise cortisol was related to greater degradation of immediate and delayed recall

Note(s): * Denotes that study was not yielded in systematic literature review. BWC = body-worn camera; POW = prisoner of war; UOF = use of force

(2017) have been observed during (Morgan *et al.*, 2006), immediately following (Taverniers *et al.*, 2010), and 24 h following an intense prisoner of war (POW) interrogation exercise among special forces personnel (Taverniers *et al.*, 2013). These effects were further exacerbated by dissociative symptoms (Morgan *et al.*, 2006) and the extent of stress-induced cortisol concentrations (Taverniers *et al.*, 2010, 2013). Symptoms of dissociation, especially occurring during a traumatic event, disrupt encoding and accurate recall of such events (Koopman *et al.*, 1994). Together with scientific evidence reviewed above, these findings confirm that cortisol plays an important role in disrupting memory encoding and consolidation.

Investigation of police officers' spatial memory during a simulated lethal force scenario reveal significant differences in accuracy of recalled versus actual path of travel, even when provided with visual aids (Lewinski *et al.*, 2016). Together with Meyerhoff *et al.* (2004), these findings demonstrate compromised encoding of spatial information during stressful incidents, including physical area, position, distance, as well as shot placement and when the situation justified lethal force. Hartman *et al.* (2017) found that remembering more details of a high-stress simulation was at the cost of reduced accuracy, especially for verbal information. Roughly half of the officers tested noticed the suspect's hidden hand that eventually produced a weapon and fired at them and also noticed more location details and fewer verbal details.

High- versus low-threat conditions: The detail/accuracy memory trade-off is also supported by studies examining whether an officer assumes a presumably more stressful primary active responder role or a secondary support or observational role. Hope *et al.* (2016) showed no differences in accuracy but significantly fewer correct details and more false memories in active role officers, which were mediated by the extent of stress responsivity (i.e. heart rate). Several researchers attribute these memory impairments to an attentional "filtering process" during encoding, whereby officers filter out peripheral or unimportant information to focus limited attentional resources on critical threat- or target-related situational details (Lewinski *et al.*, 2016; see also Alpert *et al.*, 2012).

High- versus low-threat conditions are commonly experimentally manipulated by exposing officers to simulations that either require ("shoot") or do not require ("no shoot") a use of lethal force. Stanny and Johnson (2000) compared memory performance between groups of active and observational role police officers (Experiment 1) and citizen witnesses (Experiment 2), as well as "shoot" and "no-shoot" conditions. No significant between-group differences were observed for recall accuracy, but both officers and citizens recalled fewer details of the more stressful "shoot" scenario. Hulse and Memon (2006) also found that police officers remembered less information but with greater accuracy for observed shoot versus no-shoot simulations, consistent with the mechanistic filtering process of attending to (and therefore encoding) fewer details during a high-stress encounter.

High- and low-stress simulation conditions have also been used to assess facial recognition accuracy among military personnel, who show consistently better performance following low-stress POW exercises (Morgan *et al.*, 2004). While high-stress events may increase guanine-cytosine (GC) levels to an extent that disrupts encoding, relatively low-stress events can induce moderate levels of arousal that can facilitate encoding. This explanation is in line with the Yerkes and Dodson (1908) model, wherein the relationship between stress and cognitive performance (including memory) follows an inverted-U shape. Accordingly, several studies in this review provide evidence for mediating or correlational effects between memory impairment and the extent of physiological stress responses (Hope *et al.*, 2016; Taverniers *et al.*, 2010, 2013; see also Yuille *et al.*, 1994). This nuanced influence of stress can also provide a physiologically-based mechanism for discrepant accounts of critical encounters, as physiological stress responses are highly individual and one officer's threshold for maladaptive stress may differ from that of their colleague.

Training-induced improvements to police memory: There is mounting evidence for improved cognitive performance, including lethal force decision-making and situational awareness, among police following training that integrates and educates about physiological stress responses at both immediate (Andersen and Gustafsberg, 2016; McCraty and Atkinson, 2012) and follow-up assessments (Andersen *et al.*, 2018; Nieuwenhuys and Oudejans, 2011). Dynamic and occupationally-relevant training scenarios induce realistic physiological stress responses (Armstrong *et al.*, 2014), facilitating encoding and consolidation of essential skills that will be robust to stress-induced retrieval interference during real-world encounters. The only study comparing post-training changes to memory performance identified by the current review was conducted by Page *et al.* (2016). Following a simulated pepper spray exercise, police cadets that had undertaken psychological performance training recalled more items placed in the exercise space compared to controls. Amount of information recalled was further improved among those who reported engaging in tactical breathing during the exercise. These findings contribute to the growing support for adaptive integration of stress into police training to improve learning outcomes, as well as broader cognitive and autonomic functioning that promote psychological resilience and wellness.

Investigations on the effects of rehearsal on consolidation and retrieval

Post-incident rehearsal can take several forms, including writing independent notes of one's account, (in)formal debriefing or reviewing footage including BWCs. Hope *et al.* (2013) found that conferring with colleagues increased confidence but not amount or accuracy of information recalled. However, false memories from colleagues were only incorporated into final reports of officers who did not complete initial independent accounts, consistent with previous evidence of encoding misinformation (Zhu *et al.*, 2012).

Three studies compared delayed recall accuracy between officers who did and did not rehearse information immediately after a simulated high-threat scenario and reveal inconsistent results. McClure *et al.* (2020) compared immediate and delayed recall accuracy within the same officers and between groups that performed three different virtual scenarios. Perpetrator details were recalled better than event details overall, but significant differences in recall accuracy following rehearsal were inconsistent across scenarios. Conversely, Porter *et al.* (2018) found improved accuracy for peripheral details at 48-h delayed recall, but no impact of rehearsal on accuracy for threat-relevant details. Beehr *et al.* (2004) found that delayed recall accuracy was highest among officers who were debriefed immediately after a live (versus video) high-threat (versus low-threat) simulation and for objects closest to the threat across conditions. Limitations of these studies include inconsistent follow-up durations, and rehearsal and simulation conditions.

Body-worn cameras: Without consideration of how stress physiology impacts each stage of memory, discrepancies between officer testimony and video evidence undoubtedly raises concerns on the officer's credibility and integrity. Only two studies yielded by the current systematic review investigated the effects of reviewing BWC footage on subsequent memory. Dawes *et al.* (2015) allowed officers to correct their post-incident notes after reviewing BWC and found that omission errors for important information including the presence of drugs, weapons or individuals were uncorrected. After BWC review, officers corrected details regarding verbal commands and subject behaviours. These *post hoc* corrections may reflect an officers' attempt to identify important details to justify a use of force that are captured in BWC footage but not necessarily perceived in-the-moment as supported by novel research tracking officers' gaze (Heusler and Sutter, 2020). Hartman *et al.* (2017) found improved accuracy of delayed recall among officers that immediately reviewed their BWC footage compared to officers that did not. However, both studies had very small samples, follow-up durations varied between 4 and 10 weeks, and changes were not statistically significant (Hartman *et al.*, 2017).

These findings emphasize the need for further empirical research to understand how rehearsal, including BWC review, influences the content and accuracy of an officer's long-term accounts of a critical incident. Given that litigation can span years, it is important that we clarify: (1) how rehearsal can preserve long-term memories; (2) the timeframe surrounding memory decay for stressful events and (2) how long-term and repeated exposure to occupational stress (and not just critical incidents) influences retrieval. Research on discrepant officer reports and BWC footage could illuminate additional perceptual distortions during critical incidents (Klinger and Brunson, 2009). Investigation of possible RIF of event details not rehearsed in reports or BWC review (i.e. obstructed/uncaptured information, internal perceptions, emotions, arousal) could reveal suppression of these memories in favour of reinforcing observable "practiced" material that better supports the narrative captured by BWCs (see Grady *et al.*, 2016).

Mechanisms that hinder and promote memory retrieval

Ability: Morgan *et al.* (2007) show a positive relationship between military officers' performance on a standardized facial recognition task and memory of their interrogator after a stressful POW exercise. Thus, inherent differences in cognitive ability including recognition memory may account for discrepant reports between officers and may be robust to the interfering effects of stress.

Consolidation period: The only study of memory for a real-life, non-simulated critical event found retention but eventual reductions in visual and auditory memories among police who responded to a mass casualty event and evaluated after 10 months, five and nine years (Karlsson and Christianson, 2006). Indeed, research provides some support for the notion that high-stress events might require longer consolidation periods, spanning several days after exposure and reinforced during deep-stage REM sleep (Labar and Phelps, 1998; Stickgold, 1999). These findings may account for discrepancies in immediate recall accuracy for high- and low-stress events (Morgan *et al.*, 2004).

Contamination: With respect to identifying an optimal time period between a stressful exposure and officer questioning, Hope (2016) suggests minimizing this duration among stressed and fatigued officers to reduce the potential for memory decay and contamination. Indeed, evidence suggests that sources of contamination have little influence on memory performance when information is recalled within hours of the initial event. Lewinski *et al.* (2016) concluded that a distractor scenario that occurred after a high-stress incident did not impact consolidation or recall accuracy of initial incident details. Yuille *et al.* (1994) conducted a relevant study that fell outside of our date restrictions, but present evidence of improved delayed (12 weeks) recall accuracy for stressful versus non-stressful simulations. The authors propose that long-term memories may be reinforced by rumination of high-stress experiences compared to more mundane ones. Thus, the impact of stress on all stages of memory processing might be further influenced by whether or not officers perceive an event as stressful, as the strength of physiological responses are proportional to the level of perceived threat (Thayer and Sternberg, 2006).

Evidence-based recommendations. Given the state-of-the-art concerning officer memory of stressful encounters, how do police agencies (and by extension courts) implement evidence-based practices surrounding post-incident evidence collection? Existing recommendations suggest collecting officer testimony after a "cooling off" period that can range from a few hours to overnight (IACP, 2005) to a minimum of 48 h (Remsberg, 2014). Support for delayed recall stems from the concept of *critical incident amnesia* (Grossman and Siddle, 1998), which stipulates that immediate recall will be less accurate and complete by induced stress responses that can persist for a day or more. However, research on eyewitness testimony suggests that delayed recall leads to poorer accuracy and fewer details (Dunning and Stern,

1992) and immediate recall improves retention of studied information over time (see Eisenkraemer *et al.*, 2013).

Based on the current review, we offer several pragmatic policy recommendations for optimal memory encoding, consolidation and retrieval. While some may already be in practice, procedures should be standardized to promote accuracy of officer accounts.

(1) Officers should immediately (or as soon as possible) record an independent account of internal (i.e. emotional, arousal) and external perceptions of what they saw, heard or did. Accounts can be detailed plain language notes or verbal recordings, and will help rehearse (i.e. consolidate) early memories for as much information as possible, including information excluded from BWC footage.

- Independent accounts should be completed prior to reviewing BWC footage, which evidence suggests could inadvertently suppress consolidation and later recall of information initially perceived but not captured and rehearsed by BWC review.

(2) Officer testimony should be obtained:

- Immediately following completion of independent accounts, which supports increased consolidation and maintained accuracy of delayed recall for "rehearsed" information. However, timing of the interview might be best scaled to the magnitude of the officer's stress response, with early recall of less stressful events (e.g. where the officer assumed a secondary observational role) and later recall of high-stress events (e.g. active role officers that applied lethal force);
- Within 24–48 h to allow recovery from severe event-related physiological stress responses among officers who experience severe post-incident physical, mental or emotional distress. This duration allows at least one night of REM sleep, optimally primes rehearsal-based memory consolidation, and access to legal, medical and/or mental health services as needed;

(3) Investigations of critical incidents involving officers can bear significant implications for the officer's employment and livelihood. Therefore, post-incident interviews are undoubtedly a stressful experience whether the officer believes themselves to be at fault or not. The conditions under which officers are interviewed or questioned must minimize stress as much as possible to preserve recall accuracy, especially for officer-involved shootings and lethal force encounters. Accordingly, individuals responsible for obtaining officer testimony should be accompanied and/or adequately trained by licenced mental health professionals, such as a psychiatrist, psychologist, counsellor or social worker (Saywitz *et al.*, 2019).

(4) To mitigate stress induced by threat to one's job security, officers should be provided with access to legal representation, including a union representative during all questioning and testimony proceedings. If policies are already in place to provide officers with these resources, officers should be made well aware of how to access these and other resources, including mental health and medical support which may not be as readily and consistently available across jurisdictions.

Conclusions

Based on the literature identified in this state-of-the-art review, it is clear that stress influences memory encoding by way of increased physiological responses and directing attention to salient, target-oriented details relative to the periphery. Conducting thorough independent

post-incident accounts prior to viewing BWC footage, including rehearsal of internal, target and peripheral details, may facilitate more accurate consolidation and long-term recall of factors that better account for officer behaviour than what is captured by BWC. More research is required to identify a precise timeframe or "critical period" for consolidation (and possible contamination) of stressful incidents among law enforcement officers. Training that adaptively induces and educates officers about implicit stress physiology can improve cognitive performance, including memory of high-stress encounters. When experienced during high-threat encounters, stress responses impair retrieval of knowledge and skills that can promote performance in the moment. Accordingly, stressful interview conditions can compromise the accuracy of officer accounts, especially for events that bear significant legal and professional consequences. Therefore, post-incident questioning should minimize officer stress by allowing sufficient time to recover from physiological stress responses and adequately training individuals responsible for obtaining officer testimony.

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