



Online citation: Armstrong, Jennifer, Clare, Joseph, and Plecas, Darryl. 2014. "Monitoring the impact of scenario-based use-of-force simulations on police heart rate: Evaluating the Royal Canadian Mounted Police skills refresher program" *Western Criminology Review* 15(1): 51-59 (<http://wcr.sonoma.edu/v15n1/Armstrong.pdf>).

Monitoring the Impact of Scenario-based Use-of-force Simulations on Police Heart Rate: Evaluating the Royal Canadian Mounted Police Skills Refresher Program

Jennifer Armstrong
University of the Fraser Valley

Joseph Clare
University of Western Australia

Darryl Plecas
University of the Fraser Valley

Abstract: *This research aimed to establish the extent to which scenario-based use-of-force training undertaken by the Royal Canadian Mounted Police (RCMP) replicates aspects of the essential physiological characteristics of real-life, high-stress police activity. Using heart rate monitors, the physiological stress reactions of 132 officers were recorded while they completed one of four use-of-force training scenarios (including a control, where no use-of-force was required). Average heart rate information was used as a proxy measure for officer stress reactions at four time points during the scenarios: (a) 10 minute pre-scenario, (b) during the scenario when verbal contact was made, (c) during the scenario when physical contact was made, and (d) 10 minute post-scenario. Relative to pre- and post-scenario rates, heart rates were elevated during verbal and physical contact. No differences in this pattern were observed between scenarios, including the control scenario. Relative to previous use-of-force simulation evaluations, the strengths of this design are the size and quality of the sample of participants, the collection of the stress proxy measure during the scenarios, and the inclusion of a control scenario. Overall, this examination demonstrated that the RCMP's current scenario-based use-of-force skills refresher program produces heart rate patterns that are consistent with the elevated physiological stress produced by real-world policing as demonstrated in prior field research.*

Keywords: heart rate monitors, scenario-based training, police, physiological stress indicators, use of force

INTRODUCTION

Previous field research has demonstrated that on-duty Royal Canadian Mounted Police (RCMP) officers who encounter high-risk situations produce predictable physiological patterns that are consistent with elevated stress levels (e.g., Anderson, Litzenberger, and Plecas 2002, as discussed below). Given that these use-of-force situations occur infrequently, skills refresher training that police officers undergo must be relevant to ensure that police officers are optimally prepared to act under the high-stress they may encounter. Taking these factors into consideration, the purpose of this research was to examine whether RCMP scenario-based use-of-force skills

maintenance simulations replicate the physiological patterns produced by police officers when faced with use-of-force situations (as measured by heart rate). The experimental design chosen for this study improves on previous similar work because of (a) the size of the sample of participants, (b) the measurement of physiological stress throughout the scenarios, and (c) the inclusion of a control scenario. To preview the conclusions, this research demonstrates that the scenario-based use-of-force skills refresher program used by the RCMP does produce heart rate results that are consistent with the elevated stress levels found in field research monitoring real-world policing situations (e.g., Anderson et al. 2002).

THE STRESS-INDUCING NATURE OF POLICE WORK

According to Anderson et al. (2002), a stress reaction involves two basic components: one of which is hormone-based (endocrine) response and the other is a nervous system response. Given the activation of the sympathetic nervous system and the release of adrenaline, the heart responds with an elevated rate. In conjunction with other system stress responses, increased heart rate prepares a person to fight for survival (Driskell and Salas 1996; Murphy and Ross 2009; Peters et al. 1998; Violanti et al. 2007; Weinberger, Schwartz, and Davidson 1979). During a life threatening event, perceptual information is quickly processed through the thalamus and an individual's emotion or level of perceived threat is attached and routed through the amygdala, which then alarms the rest of the body of the threat (Murphy and Ross 2009). A physiological stress response may include an elevation of heart rate, and increases in perspiration, stress hormones, and muscle tension (Driskell and Salas 1996; Murphy and Ross 2009; Violanti et al. 2007).

With respect to elevated heart rates, field research by Anderson et al. (2002) provides clear indication of the physiological impact of physical and psychological stress on police officers. In their study, Anderson et al. (2002) fitted 76 police officers with heart rate monitors, which were worn prior to and during their entire shifts. These officers were accompanied by research assistants who recorded the officers' actions for every minute they were on duty. This methodology enabled the researchers to determine: (a) an average resting heart rate for police officers, (b) an average heart rate for police officers when engaged in a list of specific events associated with typical non-threatening police duties (e.g., sitting, standing, walking), and (c) an average heart rate for police officers when engaged in high threat/use-of-force police duties. The findings of this field research indicated that the average heart rate for officers throughout their shifts (81 beats per minute) was 22 beats above the average resting heart rate of 59 beats per minute. When use-of-force activities occurred, officers demonstrated physical and psychological stress through heart rate increases of an average of 40 beats per minute above resting (when they placed their hand on their weapons in the presence of a suspect) to 65 beats per minute above resting (when wrestling with suspects). Although Anderson et al. (2002) differentiated between physical and psychological sources of stress that led to heart rate increases, their findings demonstrated that both types of stressors associated with use of force produced physiological outcomes for the police officers with respect to elevated heart rates.

Given the physiological indicators of stress and the findings from Anderson et al. (2002), it has been documented that officers are regularly exposed to acute stressors that exceed those experienced by members of the

general public. From a training perspective, preparing officers to manage these stressful incidents in the optimal way, there are three major complicating factors: (a) the causes of these stressful incidents are highly unpredictable across time and space, (b) the onset of these events is often very sudden, and (c) the risk posed by these events could involve the individual officer, their colleagues, and members of the public (Anderson et al. 2002; Kureczka 1996). As a consequence, it is common practice for police forces to implement training scenarios designed to help prepare officers for these types of events, should they occur. The following section discusses some of the approaches that have been taken to determine the stress-inducing capacity of these types of training scenarios.

RELEVANT TRAINING ENVIRONMENTS FOR SKILL TRANSFER – THE UNDERLYING REASON FOR SCENARIO-BASED USE-OF-FORCE TRAINING FOR POLICE

The primary objective of scenario-based training is to provide a realistic environment that replicates what an officer would expect to encounter in a real-life situation in the course of duty. Simulation training allows for a controlled and safe environment in which officers can make errors and receive feedback on those errors, that if made in real life, could have serious consequences (Groer et al. 2010). This is particularly important for high-risk, use-of-force events, given the likelihood that they will be very infrequent, with potentially very significant safety implications for all involved in addition to possible legal (criminal and civil) implications for the officer (Groer et al. 2010; Murphy and Ross 2009). Through realistic training scenarios, officers will be able to develop appropriate cognitive schemas for response in high-risk situations that can be drawn upon automatically when confronted with those situations (Violanti and Aron 1995).

Some prior research has utilized aspects of the experimental design chosen within the current study (large sample size, measurement throughout, and control scenario) to examine the physiological relevance of use-of-force scenario-based training for police. Murphy and Ross (2009) aimed to assess the extent to which simulator systems induce measureable stressors in lethal force scenarios. A group of 150 officers went through three different scenarios: an outdoor vehicle stop with violence, a workplace scenario with violence, and a workplace scenario without violence. The stress response indicators selected in this study were four specific salivary biomarkers: immunoglobulin A (sIgA), cortisol, alpha amylase (salimetrics) and interleukin-6 (e-bioscience). The releases of these biomarkers were measured pre- and post-scenario participation. Analysis indicated that the violent scenarios resulted in an increased release of the biomarkers, relative to the control scenario without violence.

Groer et al. (2010) built on Murphy and Ross's (2009) findings, and examined salivary biomarkers in conjunction with a range of other stress-detection equipment to determine the stress increase during a lethal force simulated training exercise. The additional equipment utilized by Groer et al. included eye-tracking devices, measurement of respiratory rate, electrocardiographs, skin temperature, heart rate, and heart rate variability. Groer et al.'s evaluation involved two scenarios: one high-threat use-of-force event that occurred outdoors and one high-threat use-of-force scenario that occurred indoors. The results of this study indicated that the simulated training did result in an increase in psychological stress for participants. Groer et al. took these results as indications that virtual reality scenarios are capable of producing physiological stress responses that successfully mimic occupational stress.

The Survival Scores research project, published as a research report by the US Federal Law Enforcement Training Center (FLETC, 2004) used a high-stress law enforcement scenario (involving a range of use-of-force and noise) to compare performance on a stressful scenario-based simulation to a range of physiological and psychological measures. The experiment was conducted over a two-year period and a total of 1,268 law enforcement students were involved in the study. In addition to heart rate, this study also collected blood pressure and cortisol, with measures taken at regular intervals throughout the scenario. Consistent with the previously discussed research findings, the results of this process demonstrated that the law enforcement students' performances degraded as all of these physiological measures increased.

In an earlier study conducted by the HeartMath Research Center (1999) heart rate monitors were used to examine the stress impact of simulated scenario training for police officers. This study determined that officer heart rates responded with hormonally-based increases to the simulated scenario training and that heart rates remained elevated well above the baseline for more than an hour after the scenario ended.

Despite these previous studies, it remains to be seen the extent to which real-world stress patterns associated with specific, high-risk activity (as demonstrated by Anderson et al. 2002) are being replicated during use-of-force training scenarios. Specifically, it is important to examine how the patterns of stress induced by the simulations change throughout the scenario as a consequence of the specific activity in which the officers are involved. The purpose of this study, therefore, is to conduct a specific evaluation of an existing skills refresher program to compare it to the heart rate findings of Anderson et al. discussed previously, by combining the optimal aspects of previous research (large sample size, measurement throughout and control scenario) into a single design.

THE CONTEXT FOR TESTING THE PHYSIOLOGICAL RELEVANCE OF USE-OF-FORCE SCENARIOS

The context selected to examine this issue was the RCMP use-of-force skills refresher program. The RCMP requires all officers to complete training and requalification in use-of-force methods every three years. An exception to this is officers with special duties who are required to complete the training and qualification every year. For RCMP officers in British Columbia, this training is provided under a standardized week-long block training model. The structure and activities of this training are varied, spanning a five-day curriculum intended to re-certify specific elements of police duties including firearm safety, carotid control techniques, OC spray and baton control, emergency response training, handcuffing, and physical fitness testing.

During this training, each officer participates in a variety of simulations, all designed to allow for tactical errors, with a view to learning from the constructive criticism provided by the course instructors. This process focuses on each officer's ability to assess risk, choice of intervention options, capacity to deploy the options that they select, assessment of the option's effectiveness, and the explanation of the rationale for actions taken. In combination, this is intended to provide the officer an opportunity to practice the skill of explaining why they did what they did, and specifically, what threat assessment was made and what it meant to the individual officer. This is crucial, as it relates to the justification of an officer's actions in any given use of force situation; justifications which are driven by policy and civil litigation agendas.

Training in general is intended to provide a knowledge base of both policy and technique which can be relied upon in regular duty. The assumption that underlies this training approach is that, in order for use-of-force training to be successful, it must be focused on a judgment and scenario based environment that exposes participants to the types of situations which could occur in the line of duty. The immediate outcome expected from this training is officer re-certification, reflecting the fact that officers have received refresher-instruction on particular elements of regular duty policy. Intermediate outcomes of the training are those which address the abilities of the officers to handle events which could pose a threat to themselves, other police officers or members of the public.

AIMS AND HYPOTHESES

The primary objective of scenario-based training is to provide a training environment that is realistic, to adequately prepare the officer for real-life use-of-force events that could occur. The first objective of this research was to establish to what degree the scenario training was

generating a physiological response similar to those experienced during real-life use-of-force events. Heart rate was chosen as the measure for physiological response in this case to allow comparison with the field research data produced by Anderson et al. (2002). Keeping in mind that the benchmark heart rate data presented by Anderson et al. did not include an actual shooting, OC spray, or baton deployment, the following hypotheses were being examined here: (1) the simulated scenarios are effectively reproducing the types of physiological responses observed from officers in the field when they encountered real stressful situations, and (2) there would be no difference in physiological reactions to simulation scenarios as a

consequence of the scenario outcome, given the anticipation of pending use-of-force activity.

METHODOLOGY

Participants

One-hundred and thirty-two RCMP officers were involved in this study. The average age and years of service are displayed in Table 1, along with gender, policing specialization, past use-of force experience, and health. As indicated in the table notes, one-way ANOVA demonstrated some significant variation between participant groups with respect to age and years of service.

Table 1. Descriptive demographic statistics for the police officers who participated in the use-of-force simulations (for the total sample, and for each scenario group)

Demographic category	Total (n=132)	Outstanding warrant (n=34)	No insurance (n=28)	B&E in-progress (n=29)	Breach conditions - control (n=41)
Age (mean years)	38.0	41.8 ^a	39.5	35.2 ^b	35.8 ^b
Years of service (mean years)	11.5	15.1 ^c	12.7	10.9	8.0 ^d
Female officers (%)	19.7	8.8	17.9	20.7	29.3
Uniform officers (%)	58.3	47.1	53.6	62.1	68.3
Plain clothes officers (%)	34.1	44.1	39.3	27.6	26.8
ERT officers (%)	3.8	2.9	7.1	3.4	2.4
Administrative officers (%)	3.8	5.9	0.0	6.9	2.4
Lethal force past experience (%)	10.6	8.8	14.3	3.4	14.6
Health - good/great (%)	87.1	88.2	89.3	96.5	78.1

Note: (a) Significant Age differences between groups, $F(3,128) = 5.21, p < .01$, with Tukey post-hoc comparisons indicating significant differences between *a* and *b*, and (b) significant Years of service differences between groups, $F(3,128) = 4.18, p < .01$, with Tukey post-hoc comparisons indicating significant differences between *c* and *d*.

Non-parametric tests did not reveal any significant differences between groups for any of the other measures. All officers who completed the skills refresher course during the data collection period were given the opportunity to participate. Final participation was voluntary and no officers refused to participate.

Use-of-Force Scenarios

There were four use-of-force simulation scenarios involved in this evaluation, each of which is summarized below. This was a between-subjects design, in which all participants were only involved in a single simulated scenario. Participants completed their scenario training within small groups (approximately 5 to 8 officers per group), and each group was randomly allocated to a scenario.

Outstanding Warrant Scenario

The officers were told that they were operating a police vehicle and conducting patrols when they observed a vehicle with a burnt-out brake light. The scenario commenced when the officer had pulled over the vehicle to investigate further. The driver was alone in the vehicle and was cooperative at first. During the scenario, while writing the violation ticket, the officer processed the driver's information on CPIC, and the officer was advised there was an outstanding arrest warrant for the driver that they needed to execute. A use-of-force situation resulted when the driver resisted arrest.

No Insurance Scenario

The officers were told that they were operating a police vehicle and conducting patrols when they observed

a vehicle that appeared to have an expired insurance decal. The scenario commenced when the officers had pulled over the vehicle to investigate further. The officers were informed that they had positioned their vehicle and advised dispatch of their status. The plate, vehicle and registered owner returned no alerts when queried by the dispatch. The officers were instructed to approach the vehicle and give the driver a ticket for no insurance. A use-of-force situation resulted when the driver became aware of the impending ticket.

Break-and-Enter In-Progress Scenario

The officers were told that they had been dispatched to a call of an unsecured business in the downtown core. The officers were also informed that the caller, a passer-by, had noted an open door and thought they saw a person inside. The passer-by had proceeded to work and was no longer on the scene. Officers were told that upon their arrival, they had located a door that was ajar, but that there were no obvious signs of forced entry and the business appeared to be closed because of the absence of activity. Once inside, the officers encountered a break-and-enter (B&E) in progress and a use-of-force situation resulted.

Breach Conditions (Control) Scenario

The officers were told that they were dispatched to a residence where a female caller had stated that her son just returned from the bar and had been drinking. The son had previously been charged with assault and was currently on conditions, one of which was no alcohol. The officers were told that the mother stated that he was not violent at the time, but that she was concerned he might go out and get into more trouble. In addition, the mother wanted him arrested and removed from the residence. The officers were instructed that upon their arrival he/she was invited into the residence by the mother, and that her son did not know that she called the police. When the officers encountered the son he was sitting in the kitchen. The officers completed the arrest without incident and no use-of-force was required. This acted as a control scenario, within which the expectation of the requirement for use-of-force was equivalent to all other scenarios tested here.

There were specific objectives that the trainers were looking to assess on each of these scenarios. Consistent with normal police activity, the range of use-of-force options that were available to the police officers during the scenarios ranged from physical control to baton/OC spray, up to lethal force. In broad terms, the assessment of the performance rested on the officer's ability to legally articulate the actions that were taken, detailing how they were reasonable and necessary, based upon a proper risk assessment.

PROCEDURE

Data were collected during a four-month period in mid-2011 in conjunction with week-long block training that was being conducted. Included in the range of activities that officers were required to complete during this training were the four use-of-force training scenarios selected for the purposes of this evaluation. Prior to participating in each of these scenarios, officers were placed in a holding/briefing area where they were fitted with a heart-rate monitor. Researchers recorded the timing associated with the involvement of each officer in each scenario with respect to the start, finish and timing of critical events that occurred during the scenarios. Heart rate data were collected in five second intervals prior to, during, and after the scenarios, including the debriefing and rest periods. To manage the logistical implications of fitting heart rate monitors and also minimizing the degree to which the evaluation interfered with the broader objectives of the training, each participant was only involved in one of the four scenarios. To an extent, this logistical constraint potentially resulted in a methodological benefit for the study, as no testing effects (stemming from individuals participating in multiple simulations of the course of the research) could influence the outcome of the research. As discussed previously, there are a range of physiological stress indicators that could have been selected for the purposes of this study. Heart rate monitors were selected in this case as they are very receptive to rapid physiological changes, they could be measured within the constraints of the testing environment, and they allowed direct comparisons with the Anderson et al. (2002) field research findings.

RESULTS

The average heart rates over four key periods of time were examined for each participant. These time periods captured: (a) the 10 minutes prior to commencing the scenario, (b) the 2 minutes directly following the verbal contact with the simulated perpetrator, (c) the 2 minutes directly following the initial physical contact with the simulated perpetrator, and (d) the 10 minutes directly after the scenario was completed. The questions here are: (1) to what extent did each scenario generate an increased heart rate in the participants, reflective of heightened stress levels, and (2) was there any difference in the stress induced by the control scenario (where no use-of-force was required) relative to the other three conditions. Table 2 displays the number of participants who completed each scenario, along with the average duration (minutes), and the average heart rates produced during each of the four time periods of interest.

There was significant variation in the duration of the scenarios, $F(3,128) = 30.5, p < .001$, with post-hoc Tukey tests revealing that the *Breach Conditions (Control)* scenario was shorter than all the others, and the *B&E In-progress* was longer than the other two use-of-force scenarios. Despite this variation in scenario duration, there were no significant differences between scenarios with

respect to the average heart rates recorded during each of the time periods (with F 's ranging from 0.3 to 1.5 across these four comparisons). From a stress perspective, the potential for use-of-force as simulated by the control scenario was enough to elevate the officers' heart rates to a level that was equivalent to that experienced during a use-of-force encounter.

Table 2. Average heart rates across each time period for police officers involved in each of the four simulation scenarios

Scenario	n	Duration (Min)	10 min pre-scenario		Verbal contact		Physical contact		10 min post-scenario	
			Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Outstanding warrant	34	10.23	95.1	(17.6)	112.7	(21.9)	112.2	(21.1)	95.7	(15.2)
No insurance	28	12.04	93.5	(21.4)	116.1	(26.1)	120.8	(29.2)	92.8	(15.5)
B&E in-progress	29	14.44	94.2	(17.5)	118.1	(24.4)	120.4	(24.8)	93.4	(14.0)
Breach conditions - control	41	8.08	101.7	(18.2)	115.0	(22.6)	114.2	(21.6)	96.7	(12.4)
Total	132	10.87	96.6	(18.7)	115.3	(23.4)	116.4	(24.0)	94.9	(14.1)

Variations in the heart rates between each of the time periods were then examined. Given the non-significant differences between the average heart rates produced by participants within each scenario across the time intervals, these comparisons were undertaken using a series of paired sample t -tests collapsed across scenario groups. These tests demonstrated (a) a significant overall increase in heart rate

between the pre-scenario time period and the initiation of verbal contact, $t(131) = -12.3, p < .001$, (b) no difference between the heart rates recorded for verbal and physical contact, $t(131) = -1.30$, and (c) a significant reduction in heart rate between the point of verbal contact and the final measurement, $t(131) = 13.6, p < .001$.

Table 3. Matrix displaying t-values comparing mean heart rates by activity from Anderson et al. (2002), Table V, with the combined mean heart rates (all four across scenarios) by time period for the current study

				Combined mean heart rates by time period							
				10 min pre-scenario		Verbal contact		Physical contact		10 min post-scenario	
				Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Results from Anderson <i>et al.</i> (2002), Table V				96.6	(18.7)	115.3	(23.4)	116.4	(24.0)	94.9	(14.1)
Activity	n	Mean	(SD)	t-score	t-score	t-score	t-score				
Tussle	26	117	(25)	-4.78***	0.34	0.12	-6.30***				
Wrestling	7	124	(25)	-3.71***	0.96	0.81	-5.09***				
Handcuffing	32	104	(23)	1.92	2.46*	2.64**	-2.86**				
Hand on gun, no suspect present	17	88	(15)	1.82	4.68***	4.74***	1.89				
Hand on gun, suspect present	8	99	(9)	0.35	1.96	2.04*	0.81				
Average during full shift	66	82	(12)	5.77***	10.86***	10.97***	6.37***				

* $p < .05$, ** $p < .01$, and *** $p < .0001$.

Finally, the patterns of heart rates observed during the simulation scenarios were compared with the real-life baseline data obtained from the Anderson et al. (2002) field research with the RCMP. Given the lack of difference between groups, these comparisons with Anderson et al. were undertaken using the combined average heart rates recorded across all four scenarios. A series of independent

sample t -tests were performed, comparing the average heart rates at each of the four time intervals produced within the current evaluation with a list of use-of-force activities identified by Anderson et al (2002). The results of these comparisons are summarized in Table 3, with the numbers in each cell indicating the t -value produced by the comparison between the row and column value (with sample sizes, mean

values, and standard deviations also listed). A negative *t*-value in this table occurs when the column heart rate value is smaller than the row heart rate value. Comparisons were only performed on the activities that Anderson et al. noted when the frequency of this event was greater than 3. This analysis demonstrates two main patterns. First, the heart rates produced during all four current scenarios were consistent with those produced during physical stress situations such as tussling, wrestling, and full fights. Second, the pre- and post-scenario heart rates induced during the scenarios were elevated relative to the average rates produced by officers during their shifts.

DISCUSSION AND CONCLUSIONS

Overall, this analysis demonstrated the following: (a) the physiological stress of all scenarios was equivalent, which reflected the fact that all participants were anticipating a use-of-force situation was about to unfold; (b) elevated heart rates were observed in all conditions at all time periods relative to resting heart rates established in prior research, and (c) variations in physiological stress were observed over time, with pre- and post-incident heart rates lower than those experienced during the scenarios. The fact that these rates were elevated during the post-incident period (relative to resting heart rates for officers demonstrated in prior research) was consistent with the previous research findings of Anderson et al. (2002) and the HeartMath Research Center (1999). Although there were some observed differences for the demographic characteristics of the participants in groups within this study, these did not translate to systematic differences in heart rate responses when presented with the stress-inducing scenarios.

The objective of this research was to examine the extent to which the current use-of-force skills maintenance scenario-based training employed by the RCMP mimics the relevant heart rate patterns produced by police officers when faced with use-of-force situations, utilizing the optimal aspects of previous experimental designs (large sample size, measurement during the scenarios, and inclusion of a control scenario), within a single study. This said, there were some limitations associated with the current methodology including: (a) despite random allocation of groups of participants to each scenario, there were significant differences between conditions with respect to participant 'experience' (as captured by age and years of service), (b) there were differences in the duration taken to complete the control condition relative to the scenarios that required a use-of-force encounter, and (c) heart rate was the only measure taken to examine the impact of scenario participation. It is unclear to what extent these factors influenced the overall patterns observed here and future research could seek to examine these issues.

As discussed from the outset of this paper, previous research has demonstrated that on-duty officers who encounter high-risk situations produce predictable physiological patterns that are consistent with elevated stress levels. Given that these use-of-force situations occur infrequently, the skills refresher training that they undergo must be relevant to ensure that police officers are optimally prepared to act under the high stress they will encounter. Taking these factors into consideration, the purpose of this research was to examine whether the simulated scenarios reproduce the relevant physiological reactions (as measured by heart rate) to ensure they are appropriate and useful. Based on the patterns of findings with respect to heart rate, it appears that this is the case in this instance. This will ensure that the training the officers are undergoing is providing them with a relevant context within which to develop appropriate schemas that can be utilized during times of high-stress when the use-of-force is required.

Unlike previous research examining this issue, the heart rate activity was examined before, during, and after the simulation, and also compared to a real-life baseline. Future research into this type of scenario-based training could consider the impact of other forensically-relevant issues associated with police use-of-force. One particular focus of this type of investigation would be cognitive capacity during periods of high-stress, with a view to exploring what is 'normal' with respect to recall and recognition memory performance following use-of-force. Such research could examine: (a) the significance of individual differences between officers for accurate memory for events (as a function of factors such as age, years of service, training, and prior use-of-force experience) (e.g., Ericsson, Patel, and Kintsch 2000), (b) the speed of decay of memories encoded under highly-stressful situations (Hulse and Memon 2006) and the corresponding significance of timing of questioning (Beehr et al. 2004; Hulse and Memon 2006), and (c) the potential benefits of context reinstatement (mental and/or physical) as a memory facilitator (Fisher and Geiselman 1992). Although these issues have been explored in previous research, replication of previous methodologies within this context of demonstrated physiological comparability (with respect to heart rate) would provide a valuable platform from which to extend past work.

Acknowledgement

The authors would like to thank the officers from the Royal Canadian Mounted Police who participated in this exercise and the Royal Canadian Mounted Police management for making this work possible. Also, special thanks to research assistants Al Gray and Matt Miller. Thanks finally to the anonymous reviewers of this work for their suggestions.

References

- Anderson, Gregory S., Robin Litzenberger, and Darryl Plecas. 2002. "Physical Evidence of Police Officer Stress." *Policing: An International Journal of Police Strategies and Management* 25:399-420.
- Beehr, Terry A., Lana Ivanitskaya, Katherine Glaser, Dmitry Erofeev, and Kris Canali. 2004. "Working in a Violent Environment: The Accuracy of Police Officers' Reports about Shooting Incidents." *Journal of Occupational and Organizational Psychology* 77:217-235.
- Driskell, James E. and Eduardo Salas. 1996. *Stress and Human Performance*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Ericsson, K. Anders, Vimla Patel, and Walter Kintsch. 2000. "How Experts' Adaptations to Representative Task Demands Account for the Expertise Effect in Memory Recall: Comment on Vincete and Wang (1998)." *Psychological Review* 107:578-592.
- Federal Law Enforcement Training Center. 2004. *Survival Scores Research Project; FLETC Research Paper*. U.S. Department of Homeland Security.
- Fisher, Ronald P. and R. Edward Geiselman. 1992. *Memory-enhancing Techniques for Investigative Interviewing: The cognitive interview*. Springfield, IL: Charles C. Thomas, Publisher.
- Groer, Maureen, Randall L. Murphy, William Bunnell, Kristin Salomon, Jeanne Van Eepoel, Blake Rankin, Kristi White, and Cathy Bykowski. 2010. "Salivary Measures of Stress and Immunity in Police Officers Engaged in Simulated Critical Incident Scenarios." *Journal of Occupational and Environmental Medicine* 52:595-602.
- HeartMath Research Center. 1999. "Impact of the HeartMath Self-management Skills Program on Physiological and Psychological Stress in Police Officers." HeartMath Research Center, Boulder Creek, CA.
- Hulse, Lynn M. and Amina Memon. 2006. "Fatal Impact? The Effects of Emotional Arousal and Weapon Presence on Police Officers' Memories for a Simulated Crime." *Legal and Criminological Psychology* 11(2):313-325.
- Kureczka, Althur W. 1996. "Critical Incident Stress in Law Enforcement." *FBI Law Enforcement Bulletin* 65:10-16.
- Murphy, Randall L. and Darrell L. Ross. 2009. "Virtual Training Systems and Survival Humanistic Factors." Presented at the meeting of the *Interservice/Industry Training Simulation and Education Conference (IITSEC)*, Orlando, FL, 30 November-3 December 2009 (pp.1-10).
- Peters, Madelon L., Guido L.R. Godaert, Rudy E. Ballieux, Marja van Vliet, Jacques J. Willemsen, Fred C.G.J. Sweep, and Cobi J. Heijnen. 1998. "Cardiovascular and Endocrine Responses to Experimental Stress: Effects of Mental Effort and Controllability." *Psychoneuroendocrinology* 23:1-17.
- Violanti, John M., Michael Andrew, Cecil M. Burchfiel, Tara A. Hartley, Luenda E. Charles, and Diane B. Miller. 2007. "Post-traumatic Stress Symptoms and Cortisol Patterns among Police Officers." *Policing: An International Journal of Police Strategies and Management* 30:189-202.
- Violanti, John M. and Fred Aron. 1995. "Police Stressors: Variations in Perception among Police Personnel." *Journal of Criminal Justice* 23:287-294.
- Weinberger, Daniel A., Gary E. Schwartz, and Richard J. Davidson. 1979. "Low-anxious, High-anxious, and Repressive Coping Styles: Psychometric Patterns and Behavioral and Physiological Responses to Stress." *Journal of Abnormal Psychology* 88:369-380.

About the Authors:

Jennifer Armstrong is the Research Coordinator in the Centre for Public Safety and Criminal Justice Research, School of Criminology and Criminal Justice, University of the Fraser Valley.

Joseph Clare is an Honorary Research Fellow in the Crime Research Centre, University of Western Australia, and a member of the Institute of Canadian Urban Research Studies (ICURS), Simon Fraser University.

Darryl Plecas is the RCMP Research Chair and Director, Centre for Public Safety and Criminal Justice Research in the School of Criminology and Criminal Justice at the University of the Fraser Valley.

Contact information: Jennifer Armstrong, School of Criminology and Criminal Justice, University of the Fraser Valley, A-202, 33844 King Road, Abbotsford, BC, V2S 7M8, Canada; Phone: +1 604 854 4579; Fax: +1 604 870 5927; Email: jennifer.armstrong@ufv.ca

Joseph Clare, Crime Research Centre, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia; Phone: +61 8 6488 2830; Fax: +61 8 6488 7918; Email: joe.clare@uwa.edu.au

Darryl Plecas, School of Criminology and Criminal Justice, University of the Fraser Valley, A-202, 33844 King Road, Abbotsford, BC, V2S 7M8, Canada; Phone: +1 604 854 4579; Fax: +1 604 870 5927; Email: darryl.plecas@ufv.ca