Reducing Lethal Force Errors by Modulating Police Physiology

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Objectives: The aim of this study was to test an intervention modifying officer physiology to reduce lethal force errors and improve health.

Methods: A longitudinal, within-subjects intervention study was conducted with urban front-line police officers (n = 57). The physiological intervention applied an empirically validated method of enhancing parasympathetic engagement (ie, heart rate variability biofeedback) during stressful training that required lethal force decision-making. Results: Significant post-intervention reductions in lethal force errors, and in the extent and duration of autonomic arousal, were maintained across 12 months. Results at 18 months begin to return to pre-intervention levels. Conclusion: We provide objective evidence for a physiologically focused intervention in reducing errors in lethal force decision-making, improving health and safety for both police and the public. Results provide a timeline of skill retention, suggesting annual retraining to maintain health and safety gains.

Keywords: autonomic arousal, biofeedback, heart rate, heart rate variability, intervention, lethal force, occupational stress, performance, police, recovery, shooting, training, use of force

Researchers have identified significant error rates in the application of lethal force among police in the United States. 1 Lethal force errors result in significant personal and societal suffering, underscoring the urgency for effective interventions to reduce such errors. To date, interventions attempting to change psychosocial attitudes lack empirical support to improve health or demonstrate objective reductions in lethal force errors beyond what is achieved with skill-based (eg, tactical, weapons) occupational training. 2 This study takes a novel approach to improving police health and safety outcomes by targeting physiological regulation during stress, and enhancing recovery following threatening encounters. Research has shown that excessive or prolonged responses to threat may interfere with occupational performance and raise health risks. 3–7 The intervention applied in the current study aims to reduce negative health and safety outcomes by modulating the human physiological response to threat and stress, as discussed below.

Threat appraisal is a process occurring largely outside conscious awareness in neural circuits that are also responsible for imbibing meaning and personal relevance. 3,8–10 During threat appraisal, the brain coordinates and stimulates cardiovascular physiology that supports metabolic and behavioral responses to threat, similar to meeting physical demands such as exercise. This neural coordination of rapid behavioral responses happens within milliseconds. 8,10,11 Maladaptive physiological arousal (ie, too much or too little) in response to threat may hinder subsequent cognitive processes such as decision-making and situational awareness. 12–15 Research conducted with police officers suggests that it is the modulation of cardiovascular arousal, rather than simply the reduction of arousal, that may be key in reducing lethal force decision errors. For example, researchers measured indices of autonomic arousal (heart rate (HR) and heart rate variability (HRV)) among police officers immediately before, and during, two high-intensity, realistic, and threatening encounters. 16 Officers exhibiting excessive cardiovascular arousal before the scenarios were more likely to use lethal force when it was not necessary (ie, an error of inhibitory control), and that insufficient arousal led to missed threat cues that endangered the lives of the officers (ie, an error of disinhibition; not using lethal force when necessary). 16 These findings demonstrate that autonomic arousal preceded the threat exposure, strengthening the hypothesis that maladaptive arousal plays a causative role in lethal force errors.

Responding to threat requires the engagement of the autonomic nervous system (ANS), which is comprised of sympathetic and parasympathetic branches. Good physical health and cognitive function are associated with a flexible balance between the two branches. 10 Colloquial and empirical work often highlight activation of the sympathetic branch in response to threat, popularly referred to as the “fight or flight response.” Indeed, the impact of the fight or flight response can include perceptual distortions, tunnel vision, reduced fine motor skills, and loss of situational awareness; conditions that increase the probability of decision-making errors

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Learning Objectives
- Become familiar with efforts to reduce error rates in the use of lethal force by police, including the findings of previous intervention studies.
- Summarize the new intervention seeking to modify police officers’ physiology to reduce lethal force errors and improve health.
- Discuss the findings of the new intervention study, including the effects on autonomic arousal and their persistence over follow-up.

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JPA did the conceptual framework, codevelopment of the intervention (psychophysiology), data collection, manuscript writing. PMID did the data analysis, manuscript writing. BB - data collection, data analysis, manuscript editing. EB did the data collection, data organization and analysis, manuscript preparation. HG did the codevelopment of the intervention (police tactics), data collection, manuscript editing. SP edited existing intervention materials to match the skill level of study participants, data collection, manuscript preparation. JA did the conceptual framework, intervention codevelopment (HRV-BF, cardiovascular physiology), manuscript writing.

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TABLE 1. Demographic Information for Participants at Each Time Point During the Study

|                      | Pre- and Post-intervention | 6-Month Evaluation | 12-Month Evaluation | 18-Month Evaluation |
|----------------------|----------------------------|--------------------|--------------------|--------------------|
| n (Female)           | 57 (7)                     | 39 (3)             | 28 (3)             | 29 (2)             |
| M age (SD)           | 32.8 (6.3)                 | 33.5 (6.9)         | 33.6 (6.8)         | 32.3 (6.0)         |
| M years of service (SD) | 7.2 (5.6)     | 7.7 (6.4)         | 7.7 (7.0)         | 6.9 (6.6)         |

Note that demographic data from one officer are missing.

Participants

Fifty-seven active duty frontline police officers volunteered to participate in our within-subjects longitudinal study (Table 1). Participants were volunteers from a pool of approximately 750 frontline officers employed by a large urban police agency in Ontario, Canada. Participants provided informed consent before volunteering and were told that they could withdraw at any time with no consequence. A total of 81% of participants (47/57) returned for at least one follow-up evaluation at 6, 12, or 18 months, indicating a low attrition rate over the follow-up period [41 male, five female; M age = 33.4 (SD = 6.8), range = 23 to 47; M years of service = 7.5 (SD = 5.8), range = 1 to 28.6]. Of the officers who made errors at baseline, 89% (eight of nine) returned for follow-up assessment. All procedures were approved by the University of Toronto Research Ethics Board for Social Sciences and Humanities. All data, materials, and methods can be made available upon request to the corresponding author, with agreement to protect the confidentiality of research participants.

Procedure

The present study used a longitudinal repeated-measures, within-subjects experimental design (Table 2). Officers were evaluated at five time points: pre-intervention, post-intervention (ie, on the final day of the intervention), 6-month evaluation, 12-month evaluation, and 18-month evaluation. At the beginning of each intervention and evaluation session, officers were fitted with training versions of their usual police equipment (eg, baton, conducted electrical weapon, gun, OC spray, full uniform), and a portable HR monitor that adhered to their skin under their clothing (Bodyguard 2; FirstBeat Technologies LTD, Jyväskylä, FI). On the pre-intervention evaluation day, officers completed four live-action, reality-based scenarios, one of which did not require a lethal force decision. Following the morning of pre-intervention evaluation, the intervention began with classroom-based lessons on HR and HRV-BF theory (see Table 2 for schedule). Day 2 to 3 consisted of practice sessions of HR monitoring, HRV-BF, and other training techniques (described in detail in and below) integrated during 12 scenarios. Day 4 consisted of the post-intervention evaluation that was a single extended scenario with three stages, and required three lethal force decisions. To maintain equivalency in number of decisions across time, 6-month, 12-month, and 18-month evaluations required officers to perform three scenarios with a single lethal force decision in each.

The Intervention

The components of the intervention include a classroom portion covering psychosocial material (eg, brain and
physiology, acute stress, allostatic load and the impact of stress on performance, situational awareness), and active operationally relevant scenario-based training (described below). The classroom portion also explains what HRV-BF is and how to use it to increase parasympathetic activation during occupational exposures. In line with HRV-BF protocol by Lehrer and Gevirtz, participants were provided real-time, heat-by-beat HR data while engaging in HRV-BF exercises that produced a characteristic sine-wave-like curve of peaks and valleys in HR, indicating parasympathetic system activation. During the intervention period (Table 2), opportunities to engage in HRV-BF are provided during times of rest and before and after each scenario as a tool to train (1) the use of short periods of recovery to reduce allostatic load; and (2) the reduction of sympathetic dominance during psychologically threatening situations by activating parasympathetic activity.

Reality-Based Training Scenarios
Reality-based, live-action scenarios were utilized to enhance the ecological validity of the study, as they have been shown to stimulate motor learning neural pathways and induce autonomic conditioning that is comparable and robust to the stress of real-world encounters. To enhance ecological validity, the study was conducted at an empty school to allow for indoor and outdoor scenarios (eg, vehicle stops, room/apartment, and school environments), props were used to create realistic rooms and scenes (eg, blood, simulated weapons, scene-relevant attire, and furniture), scenario actors were comprised of experienced police officers and trainers, and firearms were loaded with Safe Shot blank ammunition that mimics the sound of live fire.

To adjust for potential confounds in scenario length and presentation, all scenarios were designed by expert Use of Force Instructors with more than 10 years of experience designing operationally relevant training scenarios. The instructors were not part of the research team to avoid any research bias, and spent upwards of 3 months scripting, practicing and refining timing, movement and verbal communication in the scenarios to make sure they were challenging, but not unrealistic, in testing the fundamental police skills of situational awareness (ie, what is happening) and lethal force decision-making (shoot/no shoot).

Although all study scenarios required a lethal force decision, the content of the encounters was different to eliminate practice effects. However, inhibitory (no-shoot) and disinhibition (shoot) lethal force decisions were distributed across all evaluation time points (nine inhibitory control decisions and six disinhibition decisions in total). Given that this was a within-subjects design, with multiple (ie, three) use of force decisions made on each evaluation day, we are able to conclude that the order of lethal force decision type (inhibitory vs disinhibition) did not influence the probability that an error was made on subsequent decisions, as no participant made more than one error in a single evaluation day.

The scenarios used in the current study comprised of challenging encounters that officers are routinely exposed to. For the pre-intervention, 6-month, 12-month, and 18-month evaluations, scenarios involved responding to calls such as a break and enter, domestic disturbance, reported robbery, suicidal person, and an assault in progress. The post-intervention evaluation was an exception challenging scenario (active school shooting). This post-test was selected to significantly challenge the officers so we could observe whether the intervention improved skills under severe stress.

Manipulation Check
To ensure scenarios were sufficiently realistic and stressful, changes in HR from rest to maximum during scenarios (HR Max) were evaluated at each time point with paired samples t tests (Table 3). As with the main results analyses, HR Max was averaged across multiple lethal force decisions performed during each evaluation. All scenarios revealed significant HR responses (P < 0.05) with large effect sizes. Resting HR did not differ across time points [F (3, 55) = 1.167, P = 0.331], and thus did not confound the HR Max index analysis described in the following section.

Measures
All of the following measures were recorded for each participant during the multiple scenarios presented on each of the five evaluation days.

Use of Force Decision-Making
Each time point evaluated three lethal force decisions. Errors in lethal force were defined as (1) failing to use lethal force when appropriate situational criteria have been met (error of disinhibition); or (2) use of lethal force when appropriate situational criteria had not been met (error of inhibition). All criteria for correct or incorrect performance were defined, observed, and evaluated by qualified and experienced Use of Force Instructors who were independent from the research study team.

Heart Rate
Continuous physiological HR data were recorded at a rate of 1 Hz (1 recording/sec) using Bodyguard 2 cardiovascular monitors (FirstBeat Technologies Ltd, Jyväskylä, Finland) that have been validated for research purposes. Officers wore the monitors at each time.

| Schedule | Day 1 Evaluation | Day 2 Intervention | Day 3 Intervention | Day 4 Evaluation | 6-Month, 12-Month, and 18-Month Evaluation |
|----------|------------------|--------------------|--------------------|------------------|------------------------------------------|
| Morning  | Pre-intervention evaluation (three scenarios with one shoot/no shoot decision each) | Intervention: Reality-based training scenarios integrated with HRV-BF | Intervention: Reality-based training scenarios integrated with HRV-BF | Post-intervention evaluation: Three-stage, extended scenario with three shoot/no shoot decisions | Three scenarios with one shoot/no shoot decision each. Survey measures, equipment return |
| Afternoon| Intervention begins: Classroom psychoeducational component | Intervention: Reality-based training scenarios integrated with HRV-BF | Intervention: Reality-based training scenarios integrated with HRV-BF | Survey measures, equipment return | |

HRV-BF, heart rate variability biofeedback.

Evaluation sessions at 6, 12, and 18 months were held during morning and afternoon blocks. Officers would attend either a morning or afternoon session, based on their schedule availability, and complete all three scenarios.
Manipulation Check: Stress Responses to Critical Incident Scenarios

| Time                  | Baseline HR M (SD) | Max HR (During Scenario) M (SD) | t     | P     | Effect Size (d) |
|----------------------|--------------------|---------------------------------|-------|-------|-----------------|
| Pre-intervention (n = 57) | 76.73 (10.48)     | 115.68 (19.57)                 | -16.670 | 0.000 | 2.48            |
| Post-intervention (n = 57) | 76.73 (10.48)     | 129.52 (25.46)                 | -14.499 | 0.000 | 2.71            |
| 6-month evaluation (n = 39) | 77.38 (10.18)     | 122.53 (17.78)                 | -17.190 | 0.000 | 3.12            |
| 12-month evaluation (n = 28) | 82.31 (13.62)     | 113.63 (16.88)                 | -12.631 | 0.000 | 2.04            |
| 18-month evaluation (n = 27) | 77.44 (11.85)     | 111.31 (22.15)                 | -9.729 | 0.000 | 1.91            |

Heart rate was measured in beats per minute (bpm) and averaged across multiple lethal force decision-making opportunities at each evaluation. Mean and standard deviations for all participants are provided for each time point.

HR, heart rate.

*Average baseline HR was measured for each participant at the start of the 4-day intervention.

To determine the number of participants necessary to detect effects, we used G*Power to conduct a power analysis with the following parameters: effect size $f = 0.25$, $\alpha = 0.05$, power (1-$\beta$) = 0.8, number of groups (within-subjects) = 1, number of measurements (repeated-measures) = 4. The power analyses indicated a total sample size of 24 participants. Because our sample size at each time point exceeds this minimum, we have sufficient power to detect significant effects.

Use of force decision-making performance was operationalized by the error rate in use of lethal force at each time point. Error rates (risk ratio) were computed by dividing the total number of errors committed by all officers at each time point across all scenarios, by the total number of decision-making opportunities at each time point. Computation of error rates was chosen as an appropriate method of analysis for our within-subject shoot/no shoot data. Results report the reduction in error rates relative to the pre-intervention baseline error rate.

Analyses of repeated-measures continuous physiological data (HR_Max and HR_Recovery) were conducted using generalized linear mixed model repeated-measures analyses of variance (ANOVAs)\(^7\) to account for unequal sample sizes at each time point (Table 1). Analyses were conducted in SPSS software (Version 24; IBM Canada LTD, Ontario, Canada). The exact sample sizes used to compute significance tests are reported in the axis legends in each figure. HR_Max had missing subject data post-intervention ($n = 1$) and at 18-month evaluations ($n = 2$) due to technical failure of the HR monitor. Missing subject data for HR_Recovery pre-intervention ($n = 1$) and post-intervention ($n = 8$) were due to participants not returning to their average resting HR following critical incident scenarios and having maximum HR lower than resting ($n = 1$). Two participants did not have HR_Recovery data at 18-month evaluation due to technical failure. A two-tailed criterion value of $P$ less than 0.05 was used to establish statistical significance. Least squared difference (LSD) pairwise comparisons were conducted where applicable to probe differences in outcome measures between time points.

**RESULTS**

Impact of the Intervention on Lethal Force Decision-Making

To assess the impact of the intervention on lethal use of force decision-making (ie, performance), participant lethal force decision-making was assessed during critical incident scenarios. We calculated a risk ratio (number of errors/total number of decision-making opportunities) to assess the incidence of these high-stakes errors. The risk ratio indicated a relatively low incidence of lethal force decision errors pre-intervention, with only nine errors from a total of 171 decision-making opportunities (Fig. 1). Despite the low 'error at baseline, the intervention reduced subsequent post-intervention lethal force error rates by 67% to just three errors of a total 171 decisions. This reduction in performance error relative to pre-intervention was maintained at 6-month (84% reduction) and 12-month (77% reduction) follow-up, with only one error at each time point from a total of 117 and 84 decision-making opportunities, respectively. Although the lethal force error rate was still 35% below pre-intervention levels at 18-month evaluation (3 errors of 87 decision-making opportunities), it is an increase relative to all other post-intervention evaluation rates. All officers were exposed to the same scenarios in the same order. Scenarios were closely balanced in decisions of disinhibition\(^8\) and inhibition.\(^9\) The errors cannot be attributed to one single individual; with the exception of three instances (6 of all 17 errors in the study), all errors were made by different individuals. The majority of participants (80.7%, 46/57) returned for at least one follow-up evaluation, including those that made errors at baseline (eight of nine).

**Autonomic Arousal**

To assess the impact of the intervention on the modulation of autonomic arousal, we evaluated the average index HR_Max achieved during live action critical incident scenarios (see Methods for HR_Max Index calculation and scenario-type descriptions). A manipulation check ensured that all scenarios significantly stimulated autonomic arousal relative to officers’ individual resting HR (see Table 3). HR_Max significantly increased post-intervention ($P = 0.002$), decreased between 6 and 12 months ($P = 0.000$), and remained lower than post-intervention levels at 12-month and 18-month evaluations ($P = 0.000$) ($F(4,57) = 8.894$, $P = 0.000$) (Fig. 2). HR_Max was lower than pre-intervention levels at
12-month follow-up ($P = 0.026$) but began to increase at 18-month evaluation ($P = 0.244$).

Recovery

To assess the impact of the intervention on the ability to recover from stressful police encounters, HR_Recovery (the time it took officers to return to their own average resting HR in seconds) was measured. HR_Recovery (Fig. 3) was significantly faster at 12-month follow-up relative to pre-intervention ($P = 0.042$), immediate post-intervention ($P = 0.009$), and 6-month evaluation ($P = 0.004$). HR_Recovery was also faster at 18-month follow-up relative to pre-intervention ($P = 0.019$), and 6-month evaluation ($P = 0.030$), approaching significance relative to pre-intervention recovery time ($P = 0.075$), but was not different from 12-month recovery time ($P = 0.177$) ($F(4, 61) = 5.094, P = 0.001$). HR_Recovery is a valid measure of parasympathetic engagement when the measurement follows physical activity, as it did in the current study.10 The variability in recovery time (shown by standard error bars) also decreased over time, demonstrating that the intervention was effective in reducing the number of outliers with extremely high or low recovery times.

**DISCUSSION**

Our findings extend previous evidence supporting the efficacy of our HRV-BF intervention for enhancing police safety and health outcomes. The intervention, in conjunction with scenario-based training,25,28,33 suggests dramatically reduced objective errors in lethal force decision-making across an 18-month period (Fig. 1). Results also show significant improvements in the modulation of, not simply the reduction of, autonomic arousal appropriate to situational demands (Fig. 2). This is evident by mapping improvements in autonomic regulation relative to reductions in lethal force errors (Fig. 4). Further, significant improvement in the ability to recover from autonomic arousal after each scenario (Fig. 3) suggests that officers’ parasympathetic engagement was enhanced by practicing the intervention techniques over a 12-month follow-up period. The rise in lethal force errors and autonomic arousal at 18-month evaluation indicates that police retraining or “booster” sessions are recommended at a minimum frequency of every 12 months to maintain gains in health and safety.

**Physiological Mechanism Underlying Gains in Performance and Health**

Our findings fit well within the literature linking parasympathetic activation and scenario-based training with improved decision-making and inhibitory control during potentially threatening encounters.18,19 Autonomic arousal serves an important evolutionary advantage by promoting vigilance and attention to threat cues in the environment, while simultaneous parasympathetic activation balances the threat response by increasing perceptual accuracy. For example, researchers found that adults who were better able to regulate HR physiology in response to an acute social stressor (ie, parasympathetic engagement) displayed fewer inhibitory control errors on a rapid decision-making task.12 In relation to the current study, our results showing an increase in HR_Max during the post-intervention evaluation paired with low lethal force errors (Fig. 4)
suggest that the intervention was successful in conditioning appropriate modulation of autonomic arousal to meet situational demands (ie, an active school shooting). Further, our results demonstrate that improvements in arousal modulation and lethal force decision making are sustained over time with continued practice.

Due to the physiologically demanding nature of shift work and multiple potentially threatening call outs per day, police are at risk of poor decision-making due to fatigue and allostatic load.21,24,34 Experimental evidence suggests that HRV-BF practice enhances automaticity of parasympathetic activity, in turn mediating the physiological benefits of recovery following stress.20 Just as with other physical skills, recovery is a physiological response that can be conditioned with repeated practice over time. Utilizing HRV-BF in combination with scenario-based training, the current intervention found improved recovery time following stressful encounters with continued practice. Specifically, recovery times ranged between 7 and 10 minutes at pre-intervention, post-intervention, and 6-month evaluations, and decreased significantly to 2.5 minutes at 12-month retention, and 3.6 minutes at 18-month retention (Fig. 3). Taken together, civilian and police research to date suggests that targeting parasympathetic regulation may be a valuable intervention for the enhancement of recovery and inhibitory control in general.12 and specifically among police, inhibiting shooting when not appropriate.16 The current findings lend support to using HRV-BF as an effective and ecologically valid intervention that does not require specialized equipment or significant time commitment once learned, and can combat occupationally induced fatigue to improve health and safety (ie, lethal force decision-making) among police.

Implications and Recommendations for Frequency and Duration of Training

The scientific literature does not indicate an exact duration or frequency of repeated physical practice to develop mastery or expertise of novel skills. It has been shown that the speed and proficiency of motor learning depends on many factors, including physicality, existing skill level (ie, novice vs expert learning), and the level of arousal during initial encoding.35–37 There are indications that functional brain activity begins to be altered after learning a novel motor sequence as early as 5 days into training nonexperts,38 and after 5 to 7 weeks of training among experts.39,40 These learning-induced changes to performance and neurophysiology can persist 2 to 4 months post-intervention with no further practice41 or even longer with continued practice and performance reflecting consolidation of novel procedural skills into implicit memory.39,42 Encouraging research from cognitive psychology that examines consolidation of novel skills into implicit memory.39,42 Therefore,
if the newly acquired skills are not rehearsed and done so repeatedly under a variety of conditions, there is a greater risk that they will fade.\textsuperscript{47} Although there is no existing neurological evidence for the extent and duration of learning-induced plasticity in police officers, the current results are in line with existing research supporting physiologically mediated efficacy of scenario-based training in improving police decision-making under stress.\textsuperscript{4,5,9} In addition, the current results demonstrate learning gains in performance after only 4 days of scenario training (Fig. 1), and in managing physiological stress responses and recovery after longer post-intervention durations. On the basis of this literature and the current findings, we recommend police use of force training should incorporate (1) scenario-based approaches that prepare the learner for a wide range of possible situations and outcomes in the real world,\textsuperscript{28,50–52} and allows for concurrent training and evaluation to occur; (2) Physiologically targeted methodology, including HRV-BF to condition the modulation of, and recovery from, autonomic stress responses\textsuperscript{3,5,5} and (3) refresher or recertification training at least every 12 months to ensure retention and consolidation of skill learning.

Our results build upon a pilot randomized controlled trial (RCT) using the same intervention with law enforcement (advanced tactical officers),\textsuperscript{25} indicating that the association between parasympathetic enhancement and improved lethal force decision-making occurs even in the presence of significant sympathetic arousal. In the RCT, all officers exhibited significant increases in HR arousal (65 to 91 bpm) during lethal force decision-making scenarios. Yet, officers in the experimental group who had received the HRV-BF intervention targeting parasympathetic enhancement exhibited significantly fewer errors in lethal use of force than officers in the control group despite significant sympathetic arousal.\textsuperscript{25} The current study extends these findings by demonstrating a maintenance in gains to performance and health up to 12 months post-intervention, after which errors in lethal use of force, autonomic arousal, and autonomic recovery times plateau. Although these measures do not return to pre-intervention levels, they suggest an optimal window for police retraining to be within 12 months. The increase in error rate from 12 to 18 months is not associated with a change in the MaxHR Index. This suggests that the increase in error rate is associated with more subtle changes in stress physiology such as changes in HRV characteristic of parasympathetic withdrawal. This is an area for future investigation using a larger dataset.

**Limitations**

Given the significant challenges of conducting a longitudinal repeated-measures RCT within an ecologically valid setting, a control group was not included in this study. However, a within-subjects design allowed us to maximize power to detect effects and reveal the potential long-term maintenance of intervention gains (see Statistical Analysis section in Methods). In addition, we maintain a high level of participant retention, with 81% (46 of 57) of officers returning for at least one follow-up evaluation conducted 6, 12, and 18 months post-intervention. This level of attrition is especially impressive considering participants were active duty officers who took part in the study on a voluntary basis and did not receive extra compensation for their time and participation in the study.

**IMPLICATIONS AND CONCLUSION**

When considering the gravity of lethal force errors for public and police safety, any improvements in training lethal force decision-making can be translated into potential lives saved. Understanding the objective, physiological, and largely unconscious nature of the threat appraisal process and its associated behavioral responses sheds light on why occupational interventions that target purely cognitive pathways (eg, attitude change) or repetitive weapon practice (eg, traditional use of force training) may not result in dramatic reductions in lethal force decision errors related to threat responding. Our work addresses the broader scientific endeavor to understand the interaction between physiology and ecologically valid decision-making during high-stakes events. Simultaneously, our results reveal an empirically based approach to rapidly reducing objective errors in lethal force decisions among police, an application of significant societal concern.

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