Factoring Fatigue Into Police Deadly Force Encounters: Decision-Making and Reaction Times

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Abstract

Significant evidence exists demonstrating the negative impact of fatigue on human cognitive performance in such areas as decision making, reaction times, and memory. Law enforcement studies have shown that officers suffer from high levels of fatigue from lack of sleep, unusual shift schedules, and exorbitant hours awake; however, little empirical evidence exists directly relating the effects of fatigue to individual officer performance in police specific tasks, particularly performance in deadly force situations. The current study (N = 53) examined effects of fatigue, including total time awake (TTA), shift work, hours slept, and subjective sleep quality, on officers' decision-making and reaction times when presented with simulated shoot/don't shoot and ambiguous target paradigms. The authors of this study hypothesized that fatigue would negatively impact officers' decision-making and reaction time accuracy. The hypothesis was confirmed in that many of the fatigue measures correlated significantly with decreases in decision making in the deadly force simulations and with increased reaction time. Specifically, poor sleep quality, greater TTA, more days worked, and working night or swing shifts all decreased the accuracy of officers' decision making, especially when officers were presented with no-shoot and ambiguous scenarios. Greater TTA, more days worked, and working swing shifts also increased officers' reaction times during these deadly force simulations. Finally, the effects of fatigue also increased throughout each work day, with officers' reaction times increasing consistently from their pre-shift assessment to their post-shift assessment. These findings have significant implications for police performance in deadly force encounters, training, and scheduling.

A simple click of the mouse button while searching through hundreds of YouTube videos can provide single dimensional eyewitness views of United States law enforcement officers in a multitude of unusual and deadly situations. The most intriguing ones revolve around officers' decision making during rapidly evolving, dynamic, and highly stressful incidents. Unfortunately, some of these incidents, about 0.2%, result in an officer's most powerful and devastating decision, the decision to use deadly force (Adams et al., 1999). Also unfortunate is how society, through the media, can sometimes misjudge these encounters based on limited information (Adams et al., 1999; Johnson, 2007; Sharp & Hess, 2008).

Understanding police use of force in today's culture of unrelenting media access and personal video devices may require a paradigm shift in how society looks at those who protect and serve. As police are often held to scientifically deduced ideal human performance standards that may be unattainable in real-life encounters, they may be perceived as racist, overly aggressive, or even murderous when they fail to meet these standards (Johnson, 2007; Lewinski & Honig, 2008; Sharp & Hess, 2008). The idea of fallibility through human performance error is rarely considered or accepted when an officer uses lethal force. It could be argued that social judgment should and legal judgment must be derived from solid empirical evidence. This evidence would do well to provide a full accounting of all the human factors involved and the context within which a specific situation exists, along with close attention to the applicable written legal codes.

To begin this accounting, a basic understanding of the aspects involved in a use-of-force incident and how they pertain to the perspective of the officer must be compiled. This journey may begin in the legal realm. Miller (n.d.), Branch Chief within the Legal Division of the Federal Law Enforcement Training Center (FLETC), states that assessment of a police officer's use of force is generally based upon the 1989 Supreme Court decision, *Graham v. Connor* (1989). In brief, the decision provides that an officer's use of force in any Fourth Amendment seizure (i.e., an arrest or detention) should be judged based on an objective reasonableness standard. The Court went on to define the objective reasonableness standard as follows: "Would another similarly experienced officer in a similar situation, utilize a similar amount of force while under split second timing restrictions and operating in "tense, uncertain, and rapidly evolving circumstances?" (p. 1).

The Supreme Court in *Graham* provided the legal backdrop for a fair and balanced approach by which police use of force can be judged. However, to truly understand the event as it was experienced by the officer involved, human factors relating to subjective perspective must be introduced. Yet, significant uncertainty exists concerning the human factors that officers may have experienced, are able to testify about, or even know to exist within the situation. The aspects of rapidly evolving violent encounters from the perspective of an involved police officer are unique and have not been previously studied with the detail necessary to fully understand them. Cognitive psychology and the study of human factors in use-of-force encounters are just beginning to close the gap of understanding (Honig & Lewinski, 2009).

Recent research provided insight into how officers on the same scene might provide differing accounts of an incident, how officers vary in threat perception, and even how they might justifiably shoot a suspect in the back (Blair et al., 2011; Lewinski & Honig, 2008; Lewinski & Hudson, 2003; Lewinski & Redmann, 2009). Take for instance the case of Randall Carr, who was shot and killed after a deadly altercation with police officers. The location of the fatal wound was questioned because its placement in the buttocks meant Carr was no longer a threat when shot by officers. Ultimately, Dr. William Lewinski of the Force Science Institute was able to adequately explain the human dynamics behind the incident, and the officers were exonerated by a jury (Force Science Institute, 2005). His breakthrough research into the dynamics of police-involved shootings demonstrated the fluidity of a gunfight and provided an officer's "stop shooting" reaction times, which could result in a suspect justifiably being shot in the back (Lewinski, 2000). Without Lewinski's research into the human factors of use-of-force encounters, the officers may have been held accountable for what appeared to be an unjustifiable shooting when, in fact, they were simply operating within the confines of human performance.

One human factor that has been ignored for too long in policing is fatigue. Shift work, court appearances, special assignments, and the long hours officers usually work have been suggested as contributing factors to human error (Vila, Kenney, Morrison, & Reuland, 2000). The concept of fatigue is closely linked to sleep deprivation, and these labels are often used synonymously (Samkoff & Jacques, 1991; Sundelin et al., 2013). A depth of research exists in the area of sleep deprivation (SD) as it applies to several occupations, including policing, but its application to specific police tasks has been rather limited. Many of the other occupations impact public safety and have been mandated to have rest periods (Senjo, 2011). Policing, which appears to have some of the poorest working conditions in regard to sleep (Senjo, 2011; Vila et al., 2000), does not benefit from such mandates. In fact, little regard is given to the many sleep disturbances officers experience. SD is often deemed just "part of the job" (Vila et al., 2000).

Bonnet and Arand (1995) discussed in great detail what constitutes adequate sleep in their literature review. The first prominent point they make pertains to today's society being chronically sleep-deprived (sleep loss > 1 hour nightly). They support an 8.5 hour standard as being optimal and demonstrate that nightly sleep lengths of 7.2 to 7.4 hours are deficient. The authors stated that chronic sleep deprivation of less than 6.5 hours is potentially disastrous in regard to human performance.

A closer look should be taken at some nuances of sleep deprivation because it may have different meanings depending on the type of study involved. Following the definition supported by lead researchers (Dinges, Rogers, & Baynard, n.d.; Durmer & Dinges, 2005; Lim & Dinges, 2010), SD is simply a restriction of a subject's sleep to less than their usual amount within any 24-hour period. SD can be as minor as restricting a subject to 7 hours of sleep nightly, which is the starting point for deficiencies in cognitive performance (Dinges et al., n.d.).

The U.S. Department of Health and Human Services (DHHS) (2012) discusses the need to combat SD through maintaining regularly scheduled sleep habits of 7 to 8 hours daily for most adults. Studies show that SD leads to problems in many areas of human functioning, the most notable being deficits in decision making, problem solving, attention, reaction time (RT), and emotional control (Durmer & Dinges, 2005; Rajaratnam et al., 2011; Vila et al., 2000). Sadly, proof of the DHHS's pronouncements has been provided by the National Highway Transportation Safety Administration's (NHTSA) (1996) report of a yearly average of 56,000 traffic collisions resulting in 1,550 fatalities occurring due to driver fatigue. The NHTSA provides the main characteristics of fatigued drivers as having increased reaction times, attention deficits, and a decreased ability to process information.

Durmer and Dinges (2005) performed an extensive meta-analysis of the consequences of SD. Their review began by discussing the many vehicle-related accidents which occur as a result of fatigue. The research suggests an analogy between fatigued driver performance and that of alcohol impaired drivers. Studies have shown that drivers who are awake for 17 to 19 hours operate a motor vehicle with similar psychomotor skills to those with blood alcohol content (BAC) between 0.05 and 0.1%, with 0.08% being the typical legal definition of driving while intoxicated (NHTSA, 2006).

Bryan Vila, Director of the Simulated Hazardous Operational Task Laboratory at the Washington State University Sleep and Performance Research Center, and his colleagues (2000) have conducted studies on police SD, which showed that 53% of U.S. police officers receive less than the mean amount of sleep needed per night. Study results showed that 18% of officers experienced fatigue and a lack of motivation, and another 16% stated they had trouble simply staying awake on the job. Performance issues related to this study were noted in the areas of reduced patience, diminished decision-making capacity, decreased alertness, and slower response times.

Neylan et al. (2002) conducted a study comparing subjective sleep quality in police officers, examining the effects of trauma exposure (critical incidents) and non-police routine organizational stressors. The findings showed that although officers suffer from trauma-related nightmares, the most significant aspect affecting sleep quality was based in the routine stressors experienced within the non-trauma-related work environment.

Senjo (2011) researched 15 Western state law enforcement agencies in the U.S. The study provided self-reported sleep needs of 7 to 9 hours a night by 70% of the responding officers. However, two-thirds of the 70% reported actual completed sleep ranging between 3 and 6 hours. Issues such as shift work, overtime, secondary employment, and others were listed as reasons for officers having insufficient sleep.

Rajaratnam et al. (2011) conducted a critical study of 4,957 police officers from across the U.S. and Canada. The research involved both online surveys and onsite interviews. Results showed that 40% of those tested suffered from at least one sleep disorder. Of those suffering from a sleep disorder, 6.5% suffered from moderate to severe insomnia, and 5.4% tested positive for shift-work disorder. Results also showed that those who suffered from sleep disorders more often reported having made administrative errors, falling asleep while driving, and committing safety violations due to fatigue.

Beyond the previously discussed fatigue issues is the concept of chronic partial sleep loss, often called sleep debt, which has also been shown to affect alertness and performance (Barger, Lockley, Rajaratnam, & Landrigan, 2009). Sleep debt is often discussed in terms of its cumulative effect. Using a simple example, cumulative sleep debt is the total amount of time, typically measured in hours, over a specified period in which the required sleep was not achieved. Van Dongen, Maislin, Mullington, and Dinges (2003) conducted a study restricting the sleep of 48 participants to either 6 hours or 4 hours over 14 days. Tests such as the Psychomotor Vigilance Test (PVT; Dinges & Basner, 2011) and the Stanford Sleepiness Scale (SSS; Hoddes, Zarcone, Smythe, Phillips, & Dement, 1973) were administered. The PVT measures alertness through required sustained attention while requiring quick reactions to random stimuli; it has been deemed highly reliable with test results comparable to real-world behaviors (Dorrian, Rogers, & Dinges, n.d.). The SSS is a subjective test with demonstrated validity that can reliably determine levels of sleepiness in an individual. The results of the SSS have been found to correspond significantly with performance on tasks related to SD (Hoddes et al., 1973). Within this sleep study, significant differences existed in both the 6- and 4-hour sleep groups in comparison to the 8-hour group, indicating deficits for the 4- and 6-hour groups. Of importance for this study was the result showing that sleep restriction to 4 hours over 14 days resulted in working memory and alertness levels equivalent to those in persons who had not slept for two days. Those in the 6-hour group showed deficits comparable to one day without sleep. Thus, the empirical evidence from this study, combined with the BAC comparisons, suggest that persons who suffer from chronic cumulative sleep debt could be functionally equivalent to highly intoxicated individuals.

Another study concerning cumulative sleep debt shows that even minor restrictions, such as one hour per night, can cause performance deficiency (Belenky et al., 2003). Belenky et al. (2003) conducted a study in which 66 participants were sleep deprived at levels from 3 to 7 hours over 7 days. The study utilized the PVT and SSS to measure sleepiness and performance four times per day. Although the 7-hour group did not report having increased sleepiness (SSS), they did show significant decreases in RT performance within PVT results.

Couyoumdjian et al. (2009) discussed real-world decision making by considering the circumstantial uniqueness in which decisions often occur. Some circumstances, such as those of policing, require innovative thinking, distraction avoidance, ignoring irrelevant stimuli, and following unfolding events, all of which are negatively impacted by SD. These executive-level functions were assessed through a task switching stimulus test. The results indicated that one night of total SD negatively impacted the participants' ability to shift between two different cognitive tasks. This information is significant in that officers are often required to switch between tasks, especially in use-of-force situations.

From the available literature, there is little doubt that police officers work within a SD occupation and are ultimately exposed to SD at levels which have adverse effects on human performance (Alhola & Polo-Kantola, 2007; Antal, 1975; Barger et al., 2009; Couyoumdjian et al., 2009; Durmer & Dinges, 2005; Edwards & Waterhouse, 2009; Lewinski & Honig, 2008; NHTSA, 1996; O'Brien et al., 2012; Rajaratnam et al., 2011; Senjo, 2011; Vila et al., 2000). Nevertheless, the specificity of research into fatigue and police performance with the use of firearms (i.e., deadly force) is lacking. A few studies are suggestive, however.

Edwards and Waterhouse (2009) conducted an experiment showing the effects of SD on the ability to throw darts. This study provided intriguing results because of its simplicity and the demonstrated effects of relatively little SD. Sixty participants were deprived of four hours sleep on just one night and then asked to throw darts at a dart board. Deficiencies were noted in accuracy and reliability. These deficiencies increased as the subjects were tested over a span of several hours after awakening.

Antal (1975) conducted a study of circadian rhythm disruption and its effects upon competitive shooters. Although his data are rudimentary and provide no specific hours of SD or levels of fatigue, he shows a correlation between the interruption of natural sleep cycles and accuracy with firearms. His study reported that shooters with SD suffered from an inability to concentrate, complaints of fatigue, and a lack of vitality. Another study involving SD of 22 hours on a range of shooting skills was completed with a group of 20 military subjects. The study revolved around the effects of caffeine and performance, but it provided solid SD data in several areas. This military study concluded that SD causes deficits in RT to engagement and accuracy of shot placement (Tikuisis, Keefe, McLellan, & Kamimori, 2004).

The effect of SD on human beings operating in various environments appears clear. A stack of empirical evidence shows lack of sleep causes poor attention, errors in judgment and decision making, and a slowing of reaction times. There also exists a rather convincing amount of evidence, indicating that SD exists at significant levels within law enforcement. The last dot to connect is between the stated effects of SD and police use-of-force incidents. Bill Lewinski of the Force Science Institute has collected scientific studies and discussion papers suggesting such a link. Based on reviews, Lewinski and Honig (2008) summarize many of the human cognitive dynamics of police use-of-force encounters and point to attention, perception, decision making, pattern recognition, and action/reaction time as having much to do with officers' successfully overcoming violent encounters and making correct decisions. Importantly, these very cognitive functions are negatively affected by SD (Alhola & Polo-Kantola, 2007; Barger et al., 2009; Couyoumdjian et al., 2009; Van Dongen et al., 2003).

Thus, a confluence of research in the areas of SD, SD in policing, and use of force provides a glimpse of the potential deadly consequences created by a combination of SD-driven factors. SD is prevalent in policing, yet the very cognitive functions that are so necessary for attending to and ultimately making the correct decision in use-of-force environments are decreased by SD. The need to more carefully examine the association between use-of-force decision making and SD is therefore surely necessary. Similar research specific to other professions has revealed serious deficiencies, prompting laws and regulations governing these fields (NHTSA, 1996).

The literature review provided empirical evidence to support the following hypothesis, which is addressed in the current research investigation. To begin, police officers' job demands likely create an environment of SD through several means, most prominently the disruption of the circadian rhythm resulting from shift work, a continuously accumulating sleep deficit, and excessive total hours awake. Overall cognitive abilities in the areas of information processing, decision making, reaction time, and attention are negatively affected by SD. Thus, it is hypothesized that these effects of SD will have a negative impact on officers' decision-making capabilities during shoot/don't shoot scenarios. Specifically, reaction time has been found to be negatively impacted by SD and is expected to be affected in this study through slower reaction times to shoot/don't shoot scenarios among officers experiencing SD, with officers' ability to react quickly to perceived threats and to correctly identify a shoot target being decreased by SD.

Methods

Participants

Participants were police officers from several national police departments (N = 53): 50 men and 3 women, ages 25 to 54, M = 40 (SD = 7.8) years. Due to the specialized nature of this study, participants were all experienced police officers having completed basic police and recurring inservice training concerning police use of deadly force. Participating officers were sampled from all shifts: Day Shift, n = 17; Swing Shift, n = 21; and Night Shift, n = 15. Following other studies on SD, participants were aware of the purpose of the study as it has been determined such studies are valid under these conditions (e.g., Edwards & Waterhouse, 2009; Tikuisis et al., 2004; Williamson & Feyer, 2000).

An additional and separate sample of police officers from across the country (N = 277) completed a 10-question online Fatigue Survey. The participants were gathered from electronic posts in police-specific online groups such as the California Association of Force Instructors, Law Enforcement Professionals, and the Officer Involved Use of Force Group, which are all hosted by LinkedIn (www.linkedin.com), a professional networking website. To protect the anonymity of these officers and encourage their honesty about a potentially difficult subject—the effects of fatigue on their own police work—absolutely no descriptive information about the participants was collected.

Procedure

An online electronic platform was created based on previous studies and validated measures. The online platform was named the Thesis Computer Program (TCP) and has built-in parameters to compensate for the lack of an in-laboratory testing environment. These parameters ensured participants logged in as required, completed all prescribed tests, and completed those tests within specified limits. The TCP's design favored validity over user friendliness to provide the best outside of a laboratory results.

Prior to engaging in the study, participants were provided with an overview of the purpose of the study and introduced to its methodology. An online introduction to the TCP followed in which in-depth instructions and screen shots were provided. All information provided prior to testing remained available to participants throughout the duration of the study. Additionally, participants had continued access to the facilitator to answer questions or resolve issues.

Participants were provided a URL which allowed them access to the TCP online. Upon entering the site, participants were required to create an account using a typical password and username security combination. The registration process included a request for certain non-identifying personal information such as age, gender, shifts worked, and days in the work week. Although all areas listed were self-explanatory, the wide range of shift definitions across law enforcement required independent definitions of day, swing, and night shifts. *Day Shift* was defined as most duty hours during daylight. *Swing Shift* was defined as half duty hours in daylight and half during darkness. *Night Shift* was defined as most duty hours during darkness.

During the registration process, the consent form was displayed on the page, and participants were unable to register without selecting a “consent/register” button, allowing them to move forward. Participants received a validation e-mail to the address they provided and were required to activate their accounts through a link provided to that e-mail account. Activating the account allowed participants to have access to the task sections of the TCP.

Once registered, participants were asked to log into the TCP at the beginning of their duty week. They were required to log-in as close to the beginning and end of each individual work shift as possible. Strict adherence to the research design was required, and participants were aware of parameters invalidating any improper actions or inputs by the user. Participants understood that a failure to complete all tests on all log-ins would result in nullifying that day’s data.

The TCP itself adhered to a very strict set of guidelines which allowed users little leeway to operate outside its design. Participants were guided step by step through the online testing platform by displayed instructions as well as automated movement to the next task after the former task was completed. The TCP did not allow for log-ins outside of certain parameters, such as a mandated 8 hours between shifts or a requirement to log in for post-shift tasks within 24 hours of the pre-shift log-in. Participants were unable to log-in for post-shift task completion without having first signed in for pre-shift completion.

Sleep Diary

The first task required for each log-in to the TCP was the completion of a sleep diary. Participants completed a sleep diary for the three days prior and all four days of the testing cycle. The sleep diary required the participants to enter the time they awoke each day, the total hours of sleep prior to waking that day, and their opinion about the quality of their sleep.

Due to the subjective nature of asking participants whether or not they had a good or bad night’s sleep, the TCP defined each category. A good sleep cycle was defined as an “uninterrupted sleep cycle while awakening well rested.” A bad sleep cycle was defined as an “interrupted sleep cycle while awakening poorly rested.” These definitions appeared on each log-in to ensure consistency and validity. The TCP sleep diary task provided drop-down menus or restricted data entry points (e.g., HH:MM) for each required response, ensuring only the correct type of answer was provided.

The sleep diary information was requested for several reasons. The first is its ability to provide a static picture of changes in sleep patterns between duty days and non-duty days. Additionally, time awake, hours slept, and sleep quality are all key points of correlation to the performance tasks within the study, and they allow a determination of whether or not these factors have any effect on reaction times or decision making (Dinges et al., 1997; Lim & Dinges, 2010).

Epworth Sleepiness Scale (ESS)

Participants were asked to complete the ESS daily during both pre- and post-shift log-ins to the TCP. Johns (2000) studied various sleepiness scales and demonstrated the ESS as the most valid and reliable test available for measuring the appropriate amount of sleep. This self-administered questionnaire (ESS) provides empirical evidence of whether or not test subjects are fatigued. The instructions for the ESS are very specific, yet simple, requiring participants to subjectively rate their potential for “dozing” under a series of eight conditions. These standardized instructions were provided in two places within the TCP as well as reprinted on the TCP’s ESS data input page. Additionally, input selections were limited by drop-down menus to the standardized ESS responses. The drop-down menus were an additional method of ensuring validity in the responses provided.

Psychomotor Vigilance Task (PVT)

The PVT has been mentioned often as a prevalent and simple testing measure to determine the effects of sleep loss upon reaction speed and lapses (Alhola & Polo-Kantola, 2007; Dinges & Basner, 2012). Gartenberg and Parasuraman (2010) conducted a study testing the validity of a shortened "reaction test" using the iPhone/iPad platform, with the application titled *Mind Metrics*. The study provided evidence of validity in using this 3-minute form of the PVT. Additionally, other shorter duration PVT tests (i.e., 3 to 5 minutes) have demonstrated validity (Dinges & Basner, 2012). The TCP included a version of the 3-minute PVT due to the amount of required testing sessions and the total time required per log-in session.

Participants were required to complete the PVT daily during both the pre- and post-shift log-ins. Specific instructions were provided to participants to ensure strict adherence to the PVT methods. These instructions were provided within the computer program and had to be viewed before each test began. To ensure validity, participants were required to use their dominant hand middle finger to perform the test. The hand was required to be static, positioned just below the keyboard, helping to standardize the distance the middle finger would be from the data input device, which was the space bar. This method enhanced both within-subject and between-subject validity. In addition to the physical restrictions asked of the participants, the PVT had restrictions on acceptable reaction time results. The PVT does not accept RT scores faster than 100 ms or slower than 1,500 ms to further ensure validity of captured data. The reaction time parameters are similar to other studies measuring RT under similar circumstances (Adam, Bays, & Husain, 2011; Baumann & DeSteno, 2010; Correll et al., 2007; Dinges & Basner, 2011; Gartenberg & Parasuraman, 2010; Lewinski & Hudson, 2003).

Shoot/Don't Shoot Situations (SDS)

Correll et al. (2007) tested police use of force decision making on several occasions through the use of SDS computer analysis. The studies used a computer-based simulation displaying photographs of armed or unarmed subjects in various settings. The photographs remained on the screen for a short period of time, between 500 and 850 ms, and were intended to elicit SDS decisions from the subjects. Points were added and subtracted based upon the decisions made by the subjects.

Using similar methodology, a SDS process was incorporated into the TCP. The process, similar to Correll et al. (2007), records data from SDS displays and participant inputs regarding reaction time and decision making in response to the stimulus photo. Due to the different nature of measurements within this project, a minor change in the SDS platform from Correll et al. (2007) was required as follows. Police officers spend a sizable portion of their day involved in low stress tasks, but when necessary, they are required to switch to aroused status in reaction to threatening stimuli (e.g., from report writing to a radio call of an in-progress crime). Likewise, police shooting situations are often unexpected and occur in confluence with any number of other low to highly arousing daily duties. To replicate a realistic switch between arousal states, or at least provide for a realistic cognitive distraction, the TCP displayed a simple math equation between SDS stimuli. The math questions required the participants to respond by striking the spacebar for correct answers. The math problem remained on the screen for 2 to 10 seconds prior to the display of each new SDS stimulus. This intervening math event was not present in Correll et al. (2007).

Per log-in, participants in the current study viewed 12 of 62 randomized and encoded SDS photographs upon a computer screen: six shoot, three no-shoot, and three ambiguous scenarios. SDS decisions were made through standard keyboard input used for gaming: A = shoot, L = don't shoot. Prior to inclusion, the photographs in this study were reviewed by a panel of tenured police use-of-force instructors. Photographs which received anything other than full agreement by the panel were deemed ambiguous. Thus, all SDS photographs used have 100% inter-rater reliability by tenured police use-of-force instructors, representing definitive SDS situations or ambiguous situations.

Participants were required to complete the TCP daily during both pre- and post-shift log ins. To avoid practice effects that could degrade the validity of the testing process, two procedural actions were put in place. The first was a randomization of the SDS photographs as to where each appeared during each session. The randomization of the SDS scenarios should ensure a lack of familiarity with each stimulus. The second method of avoiding practice effects is the sheer number of scenario photographs, which were greater than 60. A random viewing of 12 of 62 photographs over just four days should ensure a lack of familiarity with each photograph as no photograph was likely to appear several times for each officer across the testing days.

Specific instructions were provided to participants to ensure strict adherence to the TCP's parameters. These instructions were provided within the computer program and had to be viewed before each test began. Participants were required to place both hands below the keyboard in a specific manner while having their "point" fingers hovering above the A and L keys. In addition to the physical restrictions asked of the participants, the TCP contained restrictions on acceptable reaction time results. The reaction time parameters selected were similar to those used in other studies measuring RT under similar circumstances (Adam et al., 2011; Baumann & DeSteno, 2010; Correll et al., 2007; Dinges & Basner, 2011; Gartenberg & Parasuraman, 2010; Lewinski & Hudson, 2003).

Fatigue Survey

A survey created on the SurveyMonkey website contained 10 questions. Table 1 lists the questions, all based on self-report, related to sleep, performance, and agency oversight. The answers were limited to "Yes" or "No." The purpose was to assess a separate sample of police officers, untainted by their experiences completing the TCP, and obtain their personal experiences with and views of the effects of fatigue on their police performance.

Data Handling and Statistical Treatment

Participants were directed to the TCP website to complete their assessments. The TCP options were set properly to ensure none of the participants' names, police agency names, and IP addresses were collected. All results were presented in aggregate form to further protect subjects' identities and confidentiality of information. Data were only accessible through the online TCP system using a strong password known only to the researcher.

Once the data collection was completed, data were downloaded into Microsoft *Excel* and then *SPSS*, stored only on the researcher and advisor's laptop computers, and deleted from the online survey system. The *SPSS* database used for data analysis was accessible only by using a strong password known only to the researcher and thesis advisor. Neither dataset contained any coded identifiers and, as such, both are completely anonymous.

The thesis chair and the student researcher had access to the downloaded *SPSS* data. The data were stored on the two computers owned by these individuals. The data resided in separate Windows folders on each computer, segregated from unrelated files. The two computers were locked by strong Windows passwords known only to the computer owners.

Table 1. Fatigue Survey Results

	Measure	% Yes
1.	I believe shift work interferes with my ability to achieve a reasonably good night of rest.	73.5
2.	I have different sleep habits when I am not working as opposed to during my work cycle.	82.2
3.	I sleep much better on my days off as opposed to during my work cycle.	67.9
4.	I believe lack of sleep has been the cause of a mistake or error I have made while working.	68.5
5.	I believe I perform better with more sleep.	92.7
6.	I require about 8 hours of sleep to perform my best.	55.7
7.	I believe I can perform adequately when required regardless of how many hours I am awake.	41.4
8.	I believe police departments should formally explore the impact of sleep deprivation on officer performance.	94.5
9.	I don't want to explore aspects of sleep deprivation in police work because I am concerned about a change in schedule or limitations on overtime.	12.0
10.	I believe the law enforcement career field (in general) does not adequately concern itself with safety issues concerning sleep deprivation.	91.6

The data were retained on these computer systems for the duration of the research, and, following completion of the research, they were retained on the researcher's computer for a minimum of five years along with related files in case questions arise about the analyses. The dataset and related files will be transferred to any future computer owned by the researcher until the five years have expired. Throughout the study and subsequent five years, the researcher will implement a weekly backup plan wherein the dataset and related files are backed up using a secure online data backup system. After the five years, the researcher will destroy the *SPSS* data file using then-current Department of Defense data destruction standards. An affordable technique, such as encryption, will likely be chosen.

The various measures were scored according to published norms. Then, the several independent variables, which were measures of fatigue, were correlated with the outcomes of the SDS scenarios—scenario by scenario and in the aggregate. Patterns of correlations were detected by extracting significant correlations from the correlation matrix and presenting such in tabular format. Because the direction of each correlation was predicted by the hypotheses in the study, alpha levels were one-tailed, set at $p < 0.10$ for significance.

Results

In response to requests for participants printed in the *Police One Magazine* and the *Force Science Institute Newsletter*, 53 subjects completed the study. It is not possible to know how many subjects actually saw the research announcement in these two venues; as such, a response rate cannot be calculated for this study. To protect subjects' anonymity, minimal sociodemographic data were collected; it appears in Table 2. The mean subject age was 40; most subjects were men. Table 2 also reveals that subjects were fairly evenly distributed among the three typical shifts worked in policing: Days, n = 17; Swings, n = 21; Nights, n = 15. As expected, participants slept more hours on off-duty days than on-duty days: M = 6.8 hours vs. 6.4 hours. Participants were awake between 15 and 17 hours at the completion of each duty day (see Table 2 for details).

Table 2. Background Characteristics of Participants (N = 53)

Measure	Response
Shift	17 Day shift
	21 Swing shift
	15 Night shift
Age	
Mean	40 (7.83)
Gender	
Male	50
Female	3
Mean sleep hours per night	
Off-duty	6.8 (1.76) hours
On-duty	6.4 (1.49) hours
Mean total time awake at posttest	
Day 1	17 hours
Day 2	16 hours
Day 3	16 hours
Day 4	15 hours

Instrument Validity

Correlations for Day 1 were computed to determine instrument validity. A sizable number of significant correlations occurred in the predicted direction (see Table 3). Those correlations were moderate for SQ and ESS, moderate to strong for PVT and SDS RTs, and strong for ESS and SDS RTs. Aggregate means for the ESS and PVT over the course of the study also showed movement in the predicted direction. Table 3 demonstrates that subjective reporting of fatigue increased from pre-shift to post-shift: ESS pre-shift, M = 6 (4.83), and post-shift, M = 11 (6.27). Likewise, RT increased from pre-shift to post-shift: PVT pre-shift, M = 414 (63) ms, and post-shift, M = 461 (87) ms. Table 3 includes data showing daily increases in PVT RT on all but one (Day 4 post-shift) for both pre- and post-shift. These results suggest good predictive validity for the TCP instrument.

Decision Making (DM)

Table 4 displays the coefficients of all significant DM (i.e., shoot, don't shoot, or ambiguous) correlations and the number of significant correlations occurring in the predicted direction for each independent variable and the several DM outcome variables. Subjective reports of sleep quality (SQ) yielded 20 significant correlations in the direction of prediction over the course of four days. Days 1 and 4 provided the strongest correlations (> 0.41), with Days 2 and 3 providing moderate correlations (0.26 to 0.40). Total time awake (TTA) yielded 14 significant correlations in the direction of prediction on Days 3 and 4, with Day 3 providing the strongest significant correlations (e.g., 0.727).

Table 5 displays the type of significant DM correlations (i.e., shoot, don't shoot, or ambiguous). TTA and SQ produced six significant results in the shoot scenarios. TTA and SQ produced 19 significant no shoot results. TTA and SQ produced 12 significant results among the ambiguous scenarios.

Reaction Times (RT)

Table 6 displays the coefficients of all significant RT correlations and the number of significant correlations occurring in the direction of prediction. TTA in relation to RT yielded nine significant correlations in the direction of

Table 3. Correlations Suggesting Instrument Validity

Measure	Day 1
SQ & ESS	
Pre-shift	0.363
Post-shift	0.369
SQ & Shoot Response (Aggregate day 1)	
Pre1NoShoot	0.311
Post1NoShoot	0.408
PVT & SDS RT Times	
PrePVT/PreRT6	0.338
PrePVT/PreRT12	0.436
PostPVT/PostRT2	0.397
PostPVT/PostRT3	0.361
ESS & SDS RT Times	
PreESS/PreRT4	-0.318
PreESS/PreRT8	-0.282
PostESS/PostRT9	0.424
Mean Psychomotor Vigilance Task (PVT)	
Pre-shift	
Day 1	411 ms
Day 2	410 ms
Day 3	436 ms
Day 4	434 ms
Post-shift	
Day 1	437 ms
Day 2	484 ms
Day 3	486 ms
Day 4	467 ms
Pre-shift (aggregate)	414 (63) ms
Post-shift (aggregate)	461 (87) ms
Mean Epworth Sleepiness Scale (ESS)	
Pre-shift (aggregate)	6 (4.83)
Post-shift (aggregate)	11 (6.27)

Table 4. Correlations of Participants' Reaction Times with Independent Variables

Measure	Day 1	Day 2	Day 3	Day 4
Total time awake	-0.039	0.449	0.009	0.643
# Significant correlations in predicted direction	0	5	1	3
Shift	-0.169	--	-0.034	0.602
	0		1	2
Days worked	0.063	0.010	--	0.557
		1		1

Table 5. Participants' Significant Decision-Making Types

Measure	Significant Correlations
TTA & Shoot response	3
SQ & Shoot response	3
Total	6
TTA & No shoot response	6
SQ & No shoot response	13
Total	19
TTA & Ambiguous response	8
SQ & Ambiguous response	4
Total	12

Table 6. Correlations of Participants' Decision Making with Independent Variables

Measure	Day 1	Day 2	Day 3	Day 4
Sleep quality/Mean correlation	0.440	0.383	0.276	0.697
# Significant correlations in predicted direction	5	3	4	8
Total time awake/Mean correlation	-0.846	-0.067	0.727	0.342
# Significant correlations in predicted direction	1	2	7	7

Table 7. Aggregate Mean SDS Reaction Times

Measure	Day 1	Day 2	Day 3	Day 4
Pre-shift SDS RT	719 ms	726 ms	705 ms	683 ms
SD	29.04	21.15	27.50	30.47
Post-shift SDS RT	767 ms	738 ms	746 ms	729 ms
SD	29.68	32.79	37.48	37.86
Total combined SDS RT		Mean		
Pre-shift		709 ms		
SD		19.93		
Post-shift		745 ms		
SD		16.22		

prediction. Days 2 and 4 produced strong correlations (> 0.41), but Day 3 produced weak correlations (< 0.20). The work shift assigned showed strong correlations on Day 4, with three significant correlations occurring in the direction of prediction. The total days worked also had one significant correlation moving in the predicted direction on Day 4. Both work shift and days worked correlations were strong (> 0.41).

Table 7 displays the mean RT for the SDS with all RTs moving in the direction of prediction. SDS RT increased from pre- to post-shift on Day 1: for SDS pre-shift, M = 719 (29) ms, and post-shift, M = 767 (30) ms. SDS RT increased from pre- to post-shift on Day 2: for SDS pre-shift, M = 726 (21) ms, and post-shift, M = 738 (33) ms. SDS RT increased from pre- to post-shift on Day 3: for SDS pre-shift, M = 705 (28) ms, and post-shift, M = 746 (37) ms. SDS RT increased from pre- to post-shift on Day 4: for SDS pre-shift, M = 683 (20) ms, and post-shift, M = 729 (38) ms. Aggregate mean RT for the SDS from Day 1 to Day 4 increased between pre- and post-shift:

for aggregate pre-shift, M = 709 (20) ms, and post-shift, M = 745 (16) ms.

Fatigue Survey

Table 1 presents the results of the fatigue survey. Most of the respondents (74%) believed that shift work interferes with their ability to achieve a good night's rest. Most said they had different sleep habits on and off duty (82%), with 68% stating they slept better on their days off. The vast majority said they perform better with more sleep (93%), and 69% of respondents pointed to lack of sleep as a causal factor in one or more mistakes or errors which they had made while working. About half of the respondents said they require 8 hours of sleep for optimal performance, with a minority, 41%, believing they can perform adequately regardless of how many hours they are awake. Almost all believed that the law enforcement career field does not adequately concern itself with safety issues arising from sleep deprivation (92%). Likewise, 95% of respondents stated that police departments need to formally explore the impact of sleep deprivation on officer performance. A mere 12% of respondents did not want to explore sleep deprivation research within law enforcement due to concerns about changes in scheduling or limitations on overtime.

Discussion

The authors of this study hypothesized that SD would negatively impact officers' accuracy of decision making during SDS scenarios as well as their reaction times in such scenarios. This hypothesis appears to be amply confirmed by the results of the present study because many of the measures of fatigue correlated strongly with decreases in decision making in the deadly force simulations and with increases in reaction time. Specifically, poor sleep quality, greater TTA, more days worked, and working night or swing shifts all decreased the accuracy of officers' decision making, especially when officers were presented with no-shoot and ambiguous scenarios. Greater TTA, more days worked, and working night or swing shifts also increased officers' reaction times during these deadly force simulations. Finally, the effects of fatigue also increased throughout each work day, with officers' reaction times increasing consistently from their pre-shift assessment to their post-shift assessment.

The body of scientific literature regarding standard sleep requirements, sleep deprivation, and cumulative sleep debt, along with the effects of these factors on performance, is large and continues to grow. Time and again, the primary finding within the literature was the statistically significant relationship between sleep deprivation and performance in that sleep deficiency leads to performance deficiency. The law enforcement field is aware of the deficits from sleep deprivation, but never before to the knowledge of this researcher has a sleep-related study been so directed to law enforcement's most crucial element—the application of deadly force.

The starting point of the discussion revolves around the amount of sleep deprivation experienced by the participants in this study. Participants were not requested to change sleep patterns or restrict sleep as is often the case in sleep-related studies. The current study simply looked at the police officers' real life data and compared their reported experiences and assessment results to findings from the existing literature. Therein lay empirical evidence for a general determination of fatigue's impact on, and even expectation of, poorer performance during crisis situations, which could potentially involve deadly force.

The total hours slept data included days off-duty as well as days on-duty to determine what, if any, change occurred. The results showed that participants had a negative mean change of 20 minutes between off-duty and on-duty sleep. In this light, it is important to note that the literature review provided scientific evidence that even minor sleep loss can cause deficiencies in performance (Belenky et al., 2003; Bonnet & Arand, 1995). That appears to have been the case with the participants in the present study.

Those same scientific articles point to both sleep deprivation and cumulative sleep debt as indicators of fatigue and performance deficiencies. The current participants not only received less sleep than recommended, but they also experienced a rather severe cumulative sleep debt over seven days: 1.5 hours daily x 7 days = 10.5 hours cumulative sleep debt. Here again, the literature review noted the negative effects of cumulative sleep debt on performance (Barger et al., 2009; Couyoumdjian et al., 2009; Hoddes et al., 1973; Van Dongen et al., 2003), which was evident in the present study in that fatigue measures correlated with poor performance and increased reaction times more during the later days of the officers' work weeks.

The TTA of the participants must also be looked at to determine whether or not fatigue is likely to be present. Study participants reported TTA on the cusp of the hours scientifically shown to provide performance deficiencies, equivalent to a 0.05% blood alcohol content (NHTSA, 2006; Senjo & Heward, 2007), with TTA, $M = 16$ hours. Based on these results, it is empirically evident that the current subjects did suffer some level of fatigue.

The present study used two additional scientific measures to assess fatigue and provide additional validation of the evidence of fatigue discussed thus far. The first method is the well-validated ESS on which our participants self-reported post-shift mean results indicating excessive daytime sleepiness: $M = 11$ (Rajaratnam et al., 2011). This reported level of daytime sleepiness concurs with the participants' reported TTA, hours slept, and sleep debt. It should be noted that the most significant change in ESS scores occurred between Day 1 pre-shift and Day 3 post-shift: Day 1 pre-shift ESS, $M = 6.5$, but Day 3 post-shift ESS, $M = 12.75$.

The well-validated PVT was also utilized, providing RT results for all days of the study at the beginning and end of each duty day. The results indicate that RT increased in the direction of prediction over the duration of the study: pre-shift PVT, $M = 414$ ms, but post-shift PVT, $M = 461$ ms, an 11% increase in RT. This is further empirical evidence of increased fatigue and a coinciding performance decrease measured by RT. Coinciding with the ESS and providing validation to the present method, this PVT increase from Day 1 pre-shift to Day 3 post-shift was the most significant change in the direction of prediction. Deficiencies remained on Day 4 for both validated tests but leveled off as expected, with no increased sleep restriction, similar to what others have documented (Banks & Dinges, 2007).

Deadly Force and Reaction Times

Based on the results from the PVT, it is clear that RT was affected by increasing levels of fatigue. However, a corollary question is whether or not those RT deficiencies translated to the SDS task. Many significant correlations emerged in the predicted direction regarding TTA and SDS RT scores. The shift and the number of days worked also negatively affected SDS RT scores. The correlations between SDS RT and TTA, days worked, and shift worked strongly suggest that fatigue directly increases an officer's reaction time to deadly force decisions, at least in the simulated environment of the present study.

Deadly Force and Decision Making

The data clearly show that subjective SQ and TTA had a great impact on the officers' ability to decide correctly between the three SDS possibilities. It should be noted that the ambiguous responses were coded so that only a total lack of action impacted the participants' results negatively. Although not directly related to the hypothesis of this study, it is important to point out that decision making on the SDS in fatigue-related performance changes were associated overwhelmingly with the no shoot and ambiguous targets. Likely, the reason for this is due to the no shoot and ambiguous situations requiring more cognitive processing power than clear shoot situations, using a rule-based decision-making model (Harrison & Horne, 2000; Maddox et al., 2009).

This is the first time a use-of-force decision-making sleep study has been conducted in this manner. Specifically, participants were not asked to sleep less or stay awake longer as is often the practice in sleep-related studies. Rather, participants simply worked the shifts and hours required by their respective agencies. The data supported the hypothesis by showing that fatigue does appear to affect both deadly force reaction times and decision making.

One different outcome of the present study is that it did not suggest the extreme effects of fatigue that have been reported in much larger studies. For example, Rajaratnam et al. (2011) conducted a large study of police officers (N = 4,957) in which 40% screened positive for a sleep disorder and about 18% later reported making serious administrative errors. Senjo and Heward (2007) found officers were working significantly longer hours (66 to 75 hours weekly) and receiving much less sleep (3 to 6 hours per night) than was found in the present study. Vila et al. (2000) conducted a very large study involving several law enforcement agencies and found that 59% of officers did not sleep an average of 7 or more hours per night, while 16% self-reported trouble staying awake while driving. In light of the effects of fatigue on the deadly force decisions discussed in the present study, if these more extreme sleep deficits are occurring in some police agencies, these greater amounts would raise a serious concern about police decision making in deadly force situations.

Fatigue Survey

The survey provided troubling results demonstrating that a very large portion of police officers believe that the law enforcement industry needs to study the impact of sleep deprivation on officer performance. Respondents also reported that the law enforcement industry is not sufficiently concerned with the impact of fatigue on police performance and errors. These results support the literature review about the negative effects of shift work, changes in sleep patterns, and the relationship between fatigue, errors, and general job performance, suggesting that most officers are aware of these issues, contend with them regularly, and would like to see solutions to prevent deteriorated job performance and errors. The survey also supports the TCP results in areas such as changes in sleep patterns on and off duty, shift work and fatigue, SDS errors and slowed RT related to fatigue, and slowed PVT RT based on fatigue, suggesting that police in general have an awareness of these factors, are doing their best to compensate for them, and are requesting assistance in remedying the causes of fatigue.

Validity

Validity concerns in this study were always within the researcher's purview. The SDS, although a new measurement device, was based on a similar computer-based shoot/don't shoot program used in other studies (Correll et al., 2007). The ESS/PVT results complemented those of the SDS, providing solid evidence of concurrent validity for the SDS. In addition, both subjective reporting of fatigue and reaction times increased from pre- to post-shift testing, suggesting that the SDS has predictive validity as well.

Limitations

This study entails several limitations. The first limitation is the method of assessment delivery. The TCP was administered online and outside of tightly controlled laboratory conditions, allowing for the possibility of minor differences in how tasks were completed. To compensate, the TCP included photographs and clear instructions, but these do not compete with the controls available within a laboratory environment. Additionally, due to technical issues with the TCP, we lost an overwhelming amount of data. A total of 215 participants logged into the program, but only a subset (n = 53) was actually able to complete the assessment. Most of the technical issues revolved around compatibility and could have been remedied within a laboratory environment. These issues have left this investigation with a relatively small sample size. To protect the anonymity of police officers who volunteered to be in this study, minimal sociodemographic data were collected. Yet, there may be relationships between some sociodemographic variables and performance. For instance, most participants within this study were men. In addition, because a portion of the subjects were unknown to the researcher, although unlikely, it is possible that not all subjects were in fact police officers; some subjects' professional credentials were not possible to verify.

Follow Up

This study applied the findings from previous investigations to the never before tested area of officer fatigue and decision-making/reaction time during deadly force encounters. The study found, not surprisingly, that even minor amounts of sleep deprivation, decreased sleep quality, and shift work all have a negative effect upon officers' speed and ability to make appropriate decisions in deadly force situations. What may stand out to law enforcement administrators and policymakers are the relatively low levels of sleep deprivation among the subjects in this study, which nevertheless were sufficient to cause performance deficits. Several national studies with larger sample sizes have suggested that officers are typically much more sleep deprived than the present subjects. As such, the probable impact of fatigue on the outcomes of deadly force encounters may be a serious concern in the law enforcement community.

Clearly, much larger samples are needed to provide a more detailed investigation of officers' sleep habits on and off duty over a longer period of time and the effects of fatigue on performance. Tracking for the nature of the sleep disturbances (e.g., court appearances, overtime, and other work assignments) should be included. A single day's sleep disturbance could greatly increase total hours awake and cumulative sleep debt, which both evidenced powerful effects on decision making and reaction times within the present SDS task. A between-subjects comparison comparing sleep deprived and non-sleep deprived officers' performance could also be very productive.

Former Police Chief and current sleep researcher Bryan Vila has been studying police officer fatigue for decades. He has established the necessity for changes in the police community regarding sleep. Vila and Kenney (2002) provided a list of what some of those changes should be: (1) Police executives should be concerned with the total number of employee work hours; (2) Police executive should provide employees a voice in their shift and work hours; (3) Police executives should assess levels of employee fatigue; and (4) Police executives should provide employees with sleep- and fatigue-related training to ensure good habits.

The results of the present study suggest that law enforcement executives, risk managers, and their legal representatives may need to come to terms with the necessity for change within law enforcement to reduce the adverse effects of fatigue, particularly on the outcome of deadly force encounters. Ignoring the risks of excessive overtime, randomized shift schedules, and unforgiving court appearance schedules would appear to be unwise in light of the data. Empirical evidence published prior to the present study has already shown the negative effects of sleep deprivation on performance and resulted in legislation and policy changes for some industries involved in ensuring public safety such as truck drivers, commercial airline pilots, medical residents, and air traffic controllers (Arora, 2010; Halsey, 2012; Lockridge, 2014; Trejos, 2014). It may be time for law enforcement to address this long-standing issue.

The current study demonstrates agreement with previous sleep deprivation studies in regard to performance, and it builds on these previous investigations by suggesting that sleep deprivation adversely impacts law enforcement officers' most difficult decision at the moment officers are faced with deadly force encounters. Just as no law enforcement executive would place an intoxicated officer on the street, they may come to understand the dangers of placing a fatigued officer in the line of duty. Tired cops make inferior decisions and react more slowly, placing themselves and the public they serve at unnecessary risk.

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