TASER® Exposure and Cognitive Impairment

Implications for Valid Miranda Waivers and the Timing of Police Custodial Interrogations

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Research Summary

This study reports findings from a randomized controlled trial that examined the effects of the TASER® (a conducted energy weapon sold by TASER International, Scottsdale, Arizona) on several dimensions of cognitive functioning. The research demonstrated that in a sample of healthy human volunteer participants, TASER exposure led to significant and substantial reductions in (a) short-term auditory recall and (b) abilities to assimilate new information through auditory processes. The effects lasted up to 1 hour for most subjects, almost all of whom returned to baseline 60 minutes postexposure.

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Policy Implications

The study applies the findings of reduced cognitive functioning among healthy participants in a laboratory setting to criminal suspects in field settings and questions the abilities of “average” suspects to waive their Miranda rights knowingly, intelligently, and voluntarily within 60 minutes of a TASER exposure. The study poses the question: What would it cost police to wait 60 minutes after a TASER deployment before engaging suspects in custodial interrogations?

When the U.S. Supreme Court decided *Miranda v. Arizona* (1966), it did more than require police officers to advise suspects of their Fifth and Sixth Amendment rights prior to engaging them in custodial interrogations. It required officers to obtain a “valid waiver” before they could allow suspects to, in effect, relinquish their rights that protected them against self-incrimination and guaranteed them legal representation during interrogations. According to the Court in *Miranda v. Arizona*, such waivers could be accepted only if suspects made them knowingly, intelligently, and voluntarily. In other decisions—both before and after *Miranda v. Arizona*—the Court has treated “knowing,” “intelligent,” and “voluntary” as legal concepts to be assessed independently of one another in evaluations of suspects’ competency to waive their rights (*Dickerson v. United States*, 2000; *Escobedo v. Illinois*, 1964; *Fare v. Michael C.*, 1979; *In re Gault*, 1967; *Johnson v. Zerbst*, 1938). In general, the waiver requirement contains two components (*Moran v. Burbine*, 1986: 2260):

1. It must be “voluntary in the sense that it was the product of a free and deliberate choice.”
2. It must be “made with a full awareness of both the nature of the right being abandoned and the consequences of the decision to abandon it.”

Note that “awareness” generally refers to the *knowing* requirement, whereas the “consequences” generally refers to the *intelligent* requirement.

The *Miranda v. Arizona* (1966) decision also is notable for not requiring officers to use specific or standardized language when advising suspects of their so-called *Miranda* rights. As a result, research has identified at least 47 different versions of *Miranda* warnings in use across the United States (e.g., Greenfield, Dougherty, Jackson, Podboy, and Zimmerman, 2001; Helms, 2003), as well as more than 400 different *Miranda* components (Rogers, Harrison, Shuman, Sewell, and Hazelwood, 2007). Moreover, even though *Miranda* warnings range in complexity from first-grade to postgraduate school reading levels (Rogers, Harrison, Shuman, et al., 2007: 185), the Court has never established a bright-line lower threshold of age, intelligence, education, or mental fitness to determine, a priori, suspects’ capacities (or lack thereof) to waive their rights knowingly, intelligently, and voluntarily. Rather, through several decisions (e.g., *Colorado v. Spring*, 1987 and...
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Fare v. Michael C., (1979), the Court has applied a “totality of circumstances” standard that considers myriad situational and individual-level factors to determine valid waiver capacity (Colorado v. Connelly, 1986; Coyote v. United States, 1967; Fare v. Michael C., 1979; West v. United States, 1968; Frumkin and Garcia, 2003; Grisso, 2003; Oberlander and Goldstein, 2001).

In the years since Miranda v. Arizona (1966), policing as an occupational field has adopted multiple interrogation innovations designed to elicit both confessions and incriminating statements from suspects while operating either just at or just outside the margins of valid waiver requirements (Leo, 2008; Skolnick and Fyfe, 1993); the Supreme Court has responded by reaffirming the importance of knowing, intelligent, and voluntary with respect to police interrogation practices (e.g., Dickerson v. United States, 2000). Yet, when adopting technological innovation—particularly in the form of conductive energy weapons—policing has been less subject to judicial review, despite strong evidence that certain forms of electrical injury can lead to declines in cognitive functioning, which may impact decision-making capacity (Barrash, Kealey, and Janus, 1996; Crews, Barth, Breisford, Francis, and McArdle, 1997; Pliskin et al., 2006). For example, in their review of the literature on electrical injury (EI), Duff and McCaffrey (2001: 112) concluded that individuals who experience EI show “diffuse impairments . . . across all neuropsychological domains, including visual–motor skills, attention/concentration, memory, executive functioning, and speech and language.” As the TASER® (the most well-known and used conducted energy weapon sold by TASER International, Scottsdale, Arizona) gains ubiquity in American police departments, little remains known of the extent to which TASER exposure—designed to incapacitate a combative suspect by delivering an electrical discharge of up to 50,000 volts and 2.1 m.A amperage—can, at least in the short term, cause cognitive declines that reduce suspects’ capacities to waive their Miranda rights knowingly, intelligently, and voluntarily.

To address this knowledge gap, this article reports on a randomized controlled trial (RCT) designed to examine the effects of the TASER on cognitive functioning. Because the RCT did not explicitly focus on the Miranda implications of TASER exposure, it did not use Grisso’s (1998) original or updated (i.e., Condie, Goldstein, and Grisso, 2005) Instruments for Assessing Understanding and Appreciation of Miranda Rights, which presume to test suspects’ comprehension of Miranda warnings. Rather, the RCT focused on a more scientifically fundamental question that, to date, had been left unexamined: To what extent—if at all—might TASER exposure affect cognitive functioning in a sample of healthy human volunteers? The study thus used a series of instruments validated to assess (among other functions) auditory recall, verbal learning and memory, delayed recall, and mental flexibility. These dimensions of cognitive functioning likely better address issues of knowing, intelligent, and voluntary than do the Grisso instruments (even though they do not directly measure Miranda comprehension) because they quantify participants’ abilities to assimilate and synthesize new information (i.e., they indicate capacity).
By reporting our findings related to the effects of the TASER on cognitive functioning, we hope to initiate a public dialogue about (a) how the TASER might influence suspects’ capacity to waive their *Miranda* rights in advance of custodial interrogations and (b) the potential costs and benefits of police departments establishing a presumptive waiting period before issuing *Miranda* warnings and engaging suspects in custodial interrogations.

**Literature Review**

*Immersion of Conducted Energy Devices (CEDs) in Policing*

During the past decade, the TASER has become one of the preferred less-lethal weapons in many police departments across the United States.\(^1\) For example, more than 17,000 law enforcement agencies in the United States have issued the TASER to line personnel. Data indicate that more than 2.37 million citizens have received a TASER exposure in the field during encounters with police and that the device is employed, on average, 904 times each day (every 2 minutes; TASER International, Inc., 2015). However, several concerns have emerged regarding police use of the TASER.\(^2\) For example, there are questions related to when and under what conditions the device should (and should not) be used (e.g., against vulnerable populations or in response passive resistance; Alpert and Dunham, 2010; White and Ready, 2010). Questions also have been raised regarding the effectiveness of the device, measured most commonly as injuries to both suspects and officers (although see White and Ready’s [2007, 2010] research on reduced suspect resistance as an effectiveness measure). With a few notable exceptions (Terrill and Paoline, 2012), most research has indicated that deployment of the TASER by a police department leads to reduced prevalence of officer injuries, suspect injuries, or both (MacDonald, Kaminski, and Smith, 2009; Police Executive Research Forum, 2009).

The third and perhaps most contentious area of controversy involves the physiological effects of the TASER—specifically, whether it poses an increased risk of serious injury or death. An estimate from 2012 indicated that more than 500 people have died after being exposed to a TASER (Trimel, 2012). A large body of research has explored the effects of CEDs on human beings both in laboratory settings and in the field, focusing primarily on cardiac rhythm disturbances, breathing, metabolic effects, and stress (Bozeman et al., 2009; Ho et al., 2009; Ho, Miner, Lakireddy, Bultman, and Heegaard, 2006; National Institute of Justice, 2011; Pasquier, Carron, Vallotton, and Yersin, 2011; Vilke, Bozeman, and Chan, 2011). This research has consistently concluded that the TASER poses a low risk for healthy human adults and that deaths after exposure are caused by other factors.

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1. Although the TASER device is just one brand of CED, it is by far the most commonly used device in the United States. It is also the device that was used in the current study. As a result, we use the term “TASER” throughout this article.

2. See White and Ready (2010) for a more detailed review of these areas of concern.
including substance abuse, preexisting medical conditions, and excited delirium (National Institute of Justice, 2011). Although research has thoroughly examined the physiological effects of the TASER, virtually no studies have explored the effects of TASER exposure on the brain.

Neuropsychological Effects of Exposure to Electricity

A robust body of research has consistently documented deficits in neuropsychological functioning after exposure to electricity, particularly in the domains of memory, attention, and concentration (Barrash et al., 1996; Crews et al., 1997; Daniel, Haban, Hutcherson, Bolet, and Long 1985; Duff and McCaffrey, 2001; Fish, 2000; Hooshmand, Radfar, and Beckner, 1989; Hopewell, 1983; Miller, 1993; Varney, Ju, Shepherd, and Kealey, 1998). For example, Pliskin et al. (2006) conducted a series of studies comparing 63 EI victims with 22 non-EI control subjects. Pliskin et al. (2006) found that EI victims reported substantially higher rates of physical, cognitive, and emotional problems; nearly 50% reported some type of cognitive difficulty (most commonly concentration problems, slower thinking, and impaired memory). Pliskin et al. (2006) also noted that some of the problems persisted for years after the event and that the nature of cognitive difficulties was not related to the severity of EI injury (e.g., voltage exposure).

In their review of the existing literature on EI injuries, Duff and McCaffrey (2001) categorized study results across eight domains of cognitive functioning, and they reported that impairment was evident across all eight domains (although it was most common in memory and attention). Moreover, some research has suggested that electrical exposure may also cause the onset of psychiatric disorders such as depression and schizophrenia-like illnesses (Zia Ul Haq, Prakash, Soy, Gupta, and Ahktar, 2008), as well as posttraumatic stress disorder (Premalatha, 1994).

Given that the TASER generates a high-voltage (up to 50,000 volts), low-amperage (2.1 mA) current of electricity, the literature on electrical injuries provides an important backdrop for considering the potential neuropsychological effects on suspects who receive a TASER exposure. Only two known studies have examined the impact of the TASER on cognitive functioning, and the variation in findings across those studies sheds little light

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3. Research in this area has considered EIs and injuries from lightning strikes together, but we focus our attention on EI victims only. Although the symptoms and effects seem similar, lightning strike injuries are less relevant as background for the current study on the TASER.

4. Duff and McCaffrey (2001) suggested that variance in EI-related injuries may be explained by individual-level differences in physical health, psychosocial adjustment, gender, education, and premorbid characteristics (see also Cherington, 1995; Daniel et al., 1985).

5. The eight domains were overall neuropsychological functioning, intelligence, attention and concentration, speech/language, sensory and motor, visual motor, memory, and executive functioning. They also examined potential links between EI and personality and mental disorders (i.e., psychopathology and neurosis) and found that 70% of studies indicated a connection, most commonly for depression.
on the issue (Dawes et al., 2014; White, Ready, Kane, and Dario, 2014). Dawes et al. (2014) tested cognitive functioning among 57 law enforcement or correctional officers who engaged in five different use-of-force scenarios, including 5-second TASER exposure, 100-yard sprint, 45-second simulated fight, K-9 search and bite activity (in a protective suit), and pepper spray exposure to the face. Dawes et al. (2014) documented statistically significant declines in neurocognitive performance across all groups for up to 1 hour postintervention, and they reported no statistical differences in scores across the force scenarios (i.e., the effects of the TASER were not significantly different from the other force types). White et al. (2014) administered a battery of cognitive tests to a group of police recruits who received a TASER exposure as part of their training. The tests were administered 3 to 4 hours before exposure, within 5 minutes after exposure, and again 24 hours after exposure. White et al. (2014) documented statistically significant declines in cognitive performance immediately after exposure, although all recruits had returned to baseline by the 24-hour mark.6

Miranda Rights, Waiver, and Impairment

In *Miranda v. Arizona* (1966), the Supreme Court held that any interrogation of a suspect would be presumed involuntary (and the statements inadmissible in court) unless the police had advised the defendant of his or her constitutional rights. These *Miranda* rights consist of five components (Rogers, Harrison, Shuman, et al., 2007; Rogers, Harrison, Hazelwood, and Sewell, 2007):

1. The right to silence
2. Use of any statements against the suspect
3. The right to counsel
4. Access to counsel for indigent suspects
5. Assertion of rights (and termination of questioning) at any time

The Supreme Court affirmed the *Miranda* ruling in *Dickerson v. United States* (2000: 13–14), stating that the warnings are constitutional in origin and have “become embedded in routine police practice.” The Court has been equally clear that a waiver of *Miranda* rights must be voluntary, knowing, and intelligent (see Colorado v. Spring, 1986), and that the burden is on the State to prove that a waiver has met this standard (DeClue, 2005). The voluntariness issue centers on the waiver being a “free and deliberate choice” without coercion or intimidation (Colorado v. Spring, 1987: 573). A knowing waiver refers to the individual’s comprehension of the rights, whereas the intelligence component focuses on the
person’s consideration of the options available and the consequences of a waiver (Frumkin, 2000; Greenfield and Witt, 2005).

In determining whether a *Miranda* waiver is valid, the Court has imposed a case-by-case strategy based on the “totality of the circumstances.” No single factor automatically invalidates a waiver, and neither specific scores nor cutoffs are recognized by the courts as baselines for waiver assessment (Oberlander and Goldstein, 2001). However, in *Coyote v. United States* (1967), the court did identify a list of relevant factors to consider (e.g., intelligence and mental illness). Greenfield and Witt (2005: 476) noted that the knowing and intelligent aspects of a *Miranda* waiver can be violated when a suspect is “cognitively impaired, confused, intoxicated, or otherwise possibly not fully mentally competent” (see also Cooper and Zapf, 2008; Rogers, Harrison, Hazelwood, et al., 2007). In *Townsend v. Sain* (1963: 372), the Court ruled that statements to police are inadmissible in court unless they are “the product of a rational intellect and a free will.” The 9th Circuit Court subsequently applied this standard to cases where the suspect is mentally ill or under the influence of drugs or alcohol (*Gladden v. Unsworth*, 1968: 1).

**Summary**

Only two studies have considered the neuropsychological effects of TASER exposure. Given the methodological limitations of those studies (small convenience samples of police officers), the inconsistent findings regarding potential impact on cognitive functioning, and the widespread use of the TASER by police, the absence of research in this area is troubling (Lim and Seet, 2009). This knowledge gap raises concerns for the questioning of suspects who have received a TASER exposure, as it is unknown whether the device impairs a person's cognitive functioning and, if so, whether that impairment may be severe enough to threaten the voluntary, knowing, and intelligent requirements for a valid *Miranda* waiver. The current study represents a first step in examining this important question.

**Methods and Data**

**Overview**

The authors carried out an RCT to investigate whether TASER exposure produces deficits in cognitive functioning. Healthy human volunteers who passed rigorous screening protocols were randomly assigned to one of four experimental conditions: Control, Exertion only, TASER only, and TASER + Exertion. Exertion, which was included to mimic resistance against police, required participants to punch a heavy bag vigorously for 30 seconds. Individuals in the TASER groups received a 5-second exposure. Participants completed a battery of valid and reliable neurocognitive tests at five points in time before and after receiving their treatment: 1 hour prior to treatment (pretest), immediately after treatment (posttest), 1 hour after treatment (1 hour), 1 day after treatment (1 day), and 1 week after treatment.
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(1 week). The authors examined within- and between-group changes in cognitive test scores over time to determine whether TASER exposure caused declines in cognitive functioning.

**Screening and Recruitment**

The screening protocols for study admission were stringent in accordance with human subject protections. Nearly 800 potential participants from all four Arizona State University (ASU) campuses were recruited by the research team. Recruitment involved face-to-face meetings with potential participants, whereby a research team member would approach potential volunteers, explain the study (from an institutional review board-approved script), and ask whether they would be interested in participating. The names of all interested individuals, as well as basic demographics and contact information (e-mail and phone number), were recorded and entered into an SPSS (SPSS Corporation, Chicago, IL) database.

Once recruitment was complete, the entire volunteer pool was randomly assigned to one of the four experimental conditions of the RCT. The research team then began contacting potential participants by phone to gauge their continued interest in the study and to assess their eligibility. The phone screening consisted of 15 exclusionary questions, which were developed in collaboration with the study’s Advisory Board:

- Are you able to read and understand the English language?
- Are you between the ages of 18 and 65 years old?
- Do you weigh less than 100 pounds?
- Do you have any significant health problems?
- (If female) Are you now or could you be pregnant?
- Do you now or have you ever used drugs that were not prescribed by your doctor?
- Have you ever been diagnosed with a psychiatric problem?
- Are you currently homeless?
- Do you now or have you ever been diagnosed with any cognitive problems, like problems remembering, problems with reading, or problems with attention?
- Have you ever been diagnosed with high blood pressure?
- Have you ever had an abnormal ECG?

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7. The study was reviewed by three institutional review boards: The Western Institutional Review Board (WIRB; a for-profit, independent human subject review board), the Arizona State University Institutional Review Board, and the Institutional Review Board for the National Institute of Justice.

8. Research team members targeted areas of the ASU campuses most frequented by students, such as the student union; eateries; and on occasion, dormitories. Team members had no systematic process for selecting students to approach, although they tended to target groups of students (rather than individuals) to maximize recruitment reach.

9. The study’s Advisory Board included two physicians, two neuropsychologists, an attorney, and a police practices expert.

10. ECG is an abbreviation for electrocardiogram.

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• Have you ever had a heart attack, stroke, or transient ischemic attack (a mini-stroke that goes away in an hour or so)?
• Has your doctor told you that you should not exercise?
• Do you have chronic back pain?
• Have you ever been “tased” before (or been exposed to another kind of conducted electrical device)?
• Have you ever had an electrical injury before?

An affirmative response to any of the screening questions resulted in exclusion from the study (for the “reading English” and “age” questions, negative responses were exclusionary). If an individual “passed” the phone screening, he or she was scheduled for an in-person visit the following week. The in-person visit at ASU began with a 45-minute informed consent meeting with the study principal investigator (PI), which covered the purpose of the study, potential risks and benefits (including risks associated with TASER exposure), requirements for participation, and remuneration. If an individual consented to participate (in writing), then he or she moved on to the second stage of screening, which included several self-report mental and physical health assessments. If an individual passed the in-person mental and physical health screening (i.e., did not disclose exclusionary criteria), then they were then administered the battery of cognitive instruments for baseline testing. After the testing, they were scheduled for more rigorous screening 3 or 4 days later at Freedom Pain Hospital in Scottsdale, Arizona.

The participant’s first visit to Freedom Pain Hospital was extensive and lasted a minimum of 3 hours. The visit began with intensive screening that included confirmation of willingness to participate by the study principal investigator (PI); medical screening including alcohol Breathalyzer, urine test for illicit drugs, pregnancy test (females only), and physician examination (including review of health history, blood pressure, pulse rate, and 5-Lead Electrocardiogram [ECG]). When a participant completed these steps, the study’s PI and the Freedom Pain Hospital physician consulted and jointly determined whether the participant was eligible for formal admission to the study.

11. Regardless of group assignment, all study participants received $200 cash for their time and effort. Remuneration was given in installments based on completed visits: $50 after visit 2; $50 after visit 3 (1-day visit); and $100 after visit 4 (1-week visit).
12. Visit 2 instruments included the Neuropsychological Symptom Checklist, the State-Trait Anxiety Inventory, the World Mental Health Composite International Diagnostic Interview Screener (WMH CIDI), the Physical Activity Readiness Questionnaire (PAR-Q), and a standard self-report medical history.
13. Results from this first test administration, generally 3–5 days before treatment, have been set aside for the current article.
14. The research team, in collaboration with the physician and institutional review board, determined exclusionary ranges for blood pressure and ECG. Participants were automatically excluded for baseline pulse > 100 beats/minute, systolic blood pressure > 140 mm Hg, diastolic blood pressure < 90 mm Hg, and abnormal point-of-care ECG.
**Experimental Treatments**

Once formally admitted to the study, each participant was taken to a private room to complete the pretest administration of the neurocognitive instruments. After completion of the pretest administration and a brief waiting period, participants were then notified of their assigned study groups, and the treatment was administered (e.g., group assignment was blind until 1 minute before receiving treatment). Control group participants were taken immediately to a room for the posttest cognitive administration. Exertion and TASER exposures were carried out in a separate room. Participants in Exertion groups were required to wear protective gloves and punch a heavy bag vigorously for 30 seconds. Participants in the TASER exposure groups laid face down on a mat and the TASER was attached to their clothing using alligator clips (one at the shoulder and the other at the lower back). After a final consent query by the PI, participants received a 5-second exposure (participants in the TASER+Exertion group punched the bag first and then received a TASER exposure). TASER exposures were administered by two certified TASER instructors with the Glendale, Arizona Police Department. After the treatment condition was delivered, participants were taken immediately to a room for the posttest cognitive administration. Participants completed the battery of tests on three more occasions: 1 hour postexposure, the next day, and the next week.

**Neurocognitive Instruments**

The battery of neurocognitive tests included the Hopkins Verbal Learning Test (HVLT), Digit Span, Digit Symbol, Trail-Making Test (Versions A and B), and the Halstead Finger Tapping Test. The tests measure a range of cognitive dimensions including auditory recall, verbal learning and memory, visual search abilities, speed of processing, mental flexibility, and motor function. Each test is described briefly in the following list (for additional information on the battery of tests, see White et al., 2014):16

- Hopkins Verbal Learning Test: Measures verbal learning and memory by asking the respondent to recall a set of 12 words in three separate, consecutive trials. During trial 1, the tester reads aloud the 12 words, and once completed, asks the respondent to repeat back as many words as he or she can remember, in any order. The process is repeated two times; in the delayed recall component, the respondent is asked to recall the words approximately 20 minutes later, and in a recognition component, the tester reads a separate list of words and asks the respondent to indicate “yes or no” if he or she believes each specific word was on the original list.

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15. The PI queried all participants about their continued willingness to participate throughout the visit, including immediately after notification of group assignment and immediately before delivery of the treatment.

16. Different versions of the tests, except for the Halstead Finger Tapping and Digit Span tests, were used to attempt to minimize possible learning effects.
Digit Span Subtest: Measures short-term auditory memory and concentration by asking the respondent to repeat a list of numbers that are read aloud, both in the same order as they are read (Digit Span Forward) and in reverse (Digit Span Backward). The sequence starts out short (two numbers) and increases to nine numbers. The Digit Span Forward is completed first followed by the Digit Span Backward.

Digit Symbol Subtest: Measures processing speed that is affected by motor coordination, short-term memory, and visual perception by asking the respondent to review nine digit-symbol pairs and then to write down the symbols that correspond to a long list of digits as fast as possible for 2 minutes.

Trail Making Test A and B: Measures visual search abilities, scanning, speed of processing, mental flexibility, and executive functions by asking respondents to, as quickly as possible, connect 25 circles distributed on a piece of paper: Part A has these circles numbered 1 through 25, and Part B alternates between numbered and lettered circles.

Halstead Finger Tapping Test: Measures motor functioning by asking respondents to press down a “tapper” with their index finger as many times as possible across a 10-second time period. Respondents are asked to complete this task five times with each hand (starting with their dominant hand in a 3, 3, 2, 2 sequence).

Participants also were asked a series of subjective state questions that captured self-reported difficulties in concentration and memory, as well as levels of perceived anxiety and feeling overwhelmed. Specifically, respondents were asked to respond to the following questions:

- How would you rate your level of difficulty concentrating right now (0–10, with 0 meaning no problem and 10 meaning a severe problem)?
- How would you rate your level of memory difficulties in everyday life—for example, with things that you want to remember and things that are important to you (0–10, with 0 meaning no problem and 10 meaning a severe problem)?
- How would you rate your level of anxiety right now (0–10, with 0 meaning no anxiety or fear and 10 meaning severe anxiety or fear)?
- How would you rate your level of feeling overwhelmed right now (0–10, with 0 meaning you are in complete control and 10 meaning you feel severely overwhelmed and you are not sure what to do next)?

The objective tests and subjective state questions were selected in consultation with the neuropsychologists on the study’s Advisory Board. The complete battery of tests took approximately 25 minutes to complete during each administration. The research team attended a 3-hour training on the administration and scoring of the cognitive tests, provided by one of the neuropsychologists on the Advisory Board. Moreover, the researchers video-recorded 10–15% of the cognitive test administrations and conducted inter-rater reliability
reviews of the six different testers. The tests were administered and scored via “paper and pencil,” and the data from tests were subsequently entered manually into SPSS.

**Sample Size and Attrition**

The final sample included 142 individuals (32–38 per group). The sample size was purposely limited based on the preliminary nature of the study and the unknown risks to cognitive functioning after TASER exposure (i.e., concerns about human subject protections). Attrition was rare after formal admission to the study. Two participants withdrew after notification of group assignment, one withdrew because of an adverse event, and one never returned for the 1-week follow-up administration. Participant attrition was more common at earlier stages of the screening process. For example, 48 individuals completed the in-person visit at ASU and were given an appointment at Freedom Pain Hospital, but they failed to appear at the hospital. Ten individuals appeared at Freedom Pain Hospital but failed to pass the drug and alcohol screening (either tested positive or self-reported prior drug use). The research team conducted a comparative analysis of study participants and individuals who attrited (on demographic characteristics and on scores from the initial baseline cognitive testing during the ASU visit), and no significant differences were found.

**Analytical Procedures**

Repeated-measures analysis of variance (ANOVA) models were conducted to examine the effects of group (i.e., Control, Exertion, TASER, and TASER + Exertion), time (i.e., pretest, posttest, 1 hour, 1 day, and 1 week), and the group by time interaction on objective and subjective cognitive outcomes. To investigate significant group by time interactions, the authors used post hoc univariate analysis of covariance (ANCOVA) models to identify which groups were significantly different from each other at posttest, 1 hour, 1 day, and 1 week while controlling for pretest scores. Post hoc paired-samples $t$ tests were used to examine which time points were significantly different from each other within groups.

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17. These reviews found considerable consistency in test administration across the testers, but on a few occasions, the study PI did speak with a tester about his or her administration techniques.

18. The research team employed a double-blind data entry protocol whereby two graduate students each entered all data independently. By using a command in Stata, the graduate students then performed a cell-by-cell reliability check (there were 68,600 cells of data to be entered) under the guidance of the PI. Each time a discrepancy between the coders was identified, the students pulled the manual forms and resolved the discrepancy. Discrepancies that could not be resolved by the graduate students were reviewed by the PI. The graduate students generated a discrepancy rate of less than half of 1%.

19. The adverse event involved a participant who experienced a separated shoulder after TASER exposure. It was later determined that the participant had preexisting shoulder problems that he did not disclose during the screening process (if he had disclosed the problem, then he would have been excluded from the study). The study PI reported the adverse event to the study funder (National Institute of Justice) and the relevant institutional review boards (Western Institutional Review Board, and ASU’s Institutional Review Board).
We calculated the effect size $f$ for the ANOVA main effects and interactions by using the partial eta squared ($\eta^2$), which is defined as the ratio between the between-groups variance and the total variance (Faul, Erdfelder, Lang, and Buchner, 2007). The interpretation of effect size $f$ suggests that $f = 0.10$ is a small effect, $f = 0.25$ is a medium effect, and $f = 0.40$ is a large effect. We also calculated effect sizes by using $d_z$, which measures the magnitude of the within-group difference in means from the pretest to the posttest (Faul et al., 2007). According to Cohen’s (1988) interpretation of effect sizes, small effects range from 0.20 to 0.49, medium effects range from 0.50 to 0.79, and large effects are greater than or equal to 0.80.

Results

Table 1 shows a breakdown of participant demographics for the entire sample and by study group. Overall, nearly two thirds of participants were White (63.6%), 10.0% were Black, and 7.9% were Asian. In terms of ethnicity, 15.7% were Hispanic. Race/ethnicity varied across the study groups, but group differences did not reach statistical significance. Among the entire sample, more than three quarters was male (77.9%) and just under one quarter was female. Again, group differences were not statistically significant. The age of participants ranged from 18 to 34 years, although more than half were 18–20 years old and less than 5% of the sample was older than 25 years. Although group assignment was random, the authors were nevertheless concerned about preexisting group differences in test scores. As a result, the authors conducted one-way ANOVAs comparing group mean scores from the pretest administration. The pretest analysis revealed that there were no significant differences in cognitive functioning between groups prior to treatment exposure.
**Objective Cognitive Tests**

Table 2 shows group means on the five objective cognitive tests over time (with statistical significance indicated for within-group change pretest to posttest). The authors examined both within-group and between-group change across the five data collection points. The comparisons that most directly assess the potential for the TASER to cause deficits in cognitive functioning are the between-group and within-group changes from pretest to posttest (before and immediately after treatment). If there are group differences in cognitive functioning at posttest, then the duration of those deficits are captured by scores at the 1-hour, 1-day, and 1-week follow-up test administrations.

**Hopkins Verbal Learning Test.** The results in Table 2 show statistically significant declines in two components of the HVLT. For trials 1–3, the TASER and TASER+Exertion groups experienced statistically significant declines in the mean number of words recalled: for TASER from 26.69 to 22.89, and for TASER+Exertion from 26.68 to 22.53 (declines of approximately 4 words from pretest to posttest; a perfect score is 36). The Exertion group also experienced a statistically significant decline from 25.75 at pretest to 23.94 at posttest. Paired-samples \( t \) tests indicate that the within-group changes are statistically significant: Exertion (\( t(31) = 2.45, p = .02, 95\% \) confidence interval [CI] [0.30, 3.32], \( d_z = 0.43 \)), TASER (\( t(34) = 5.87, p = .00, 95\% \) CI [2.48, 5.12], \( d_z = 0.99 \)), and TASER+Exertion (\( t(37) = 6.20, p = .00, 95\% \) CI [2.80, 5.52], \( d_z = 1.01 \)). Post hoc contrasts from the ANOVA tests indicated that there were significant between-group differences at posttest among Control and TASER, Control and TASER+Exertion, and Exertion and TASER+Exertion, 95\% CIs [–4.31, –1.02], [–4.64, –1.41], [–3.67, –0.31], respectively. HVLT scores returned to pretest levels by the 1-hour follow-up, suggesting that the deficits in cognitive functioning are short term (Figure 1).

20. Additionally, there was a significant group by time interaction effect (\( F(12, 140) = 2.34, p = .01, f = 0.26 \)) on the Hopkins Verbal Learning Trials 1–3 (HVLT, summed total). The follow-up univariate ANCOVA results suggested that there were significant differences between groups on HVLT at posttest while controlling for pretest scores (\( F(3,141) = 5.86, p = .00, f = 0.35 \)). Univariate ANCOVAs did not reveal significant differences between groups at 1 hour (\( F(3, 141) = 0.19, p = .90 \)), 1 day (\( F(3, 141) = 1.59, p = .20 \)), and 1 week (\( F(3, 140) = 0.48, p = .70 \)) while controlling for pretest scores.

The results from the Hopkins Delayed Recall also showed declines in cognitive functioning among the TASER groups. Paired-samples \( t \) tests indicated that TASER (\( t(34) = 6.88, p = .00, 95\% \) CI [1.99, 3.66], \( d_z = 1.17 \)) and TASER+Exertion (\( t(37) = 6.65, p = .00, 95\% \) CI [1.98, 3.71], \( d_z = 1.09 \)) groups showed statistically significant within-group decreases from pretest to posttest. More specifically, both the TASER and TASER+Exertion group mean scores declined by more than 30% from pretest to posttest (9.26 to 6.43 for TASER and 9.32 to 6.47 for TASER+Exertion; a perfect score is 12). The Control and Exertion groups did not change significantly. In terms of between-group comparisons, post hoc contrasts indicated that there were significant differences between Control and
**TABLE 2**

Mean Scores on Objective Cognitive Tests Across Time by Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretest Mean (SD)</th>
<th>Posttest Mean (SD)</th>
<th>1-Hour Mean (SD)</th>
<th>1-Day Mean (SD)</th>
<th>1-Week Mean (SD)</th>
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<td>HVLT Trials 1–3</td>
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<td>Control</td>
<td>26.54 (4.38)</td>
<td>25.46 (4.15)</td>
<td>25.24 (4.42)</td>
<td>25.97 (3.67)</td>
<td>26.70 (4.15)</td>
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<tr>
<td>Exertion&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.75 (4.22)</td>
<td>23.94 (4.03)</td>
<td>24.41 (5.15)</td>
<td>26.34 (4.53)</td>
<td>27.03 (5.31)</td>
</tr>
<tr>
<td>TASER&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.69 (3.79)</td>
<td>22.89 (5.09)</td>
<td>25.23 (4.94)</td>
<td>26.09 (3.43)</td>
<td>26.79 (4.46)</td>
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<tr>
<td>TASER + Exertion&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.68 (4.54)</td>
<td>22.53 (4.21)</td>
<td>25.71 (4.84)</td>
<td>27.42 (4.22)</td>
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<td>9.32 (2.16)</td>
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<td>11.59 (2.17)</td>
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<td>11.73 (2.28)</td>
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<td>52.64 (4.61)</td>
<td>52.62 (5.42)</td>
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<td>53.31 (4.81)</td>
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<td>16.06 (3.46)</td>
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<td>TASER + Exertion&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>16.33 (3.86)</td>
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<td>42.51 (15.05)</td>
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<td>52.11 (18.02)</td>
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</table>

(Continued)
### TABLE 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretest Mean (SD)</th>
<th>Posttest Mean (SD)</th>
<th>1-Hour Mean (SD)</th>
<th>1-Day Mean (SD)</th>
<th>1-Week Mean (SD)</th>
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<td>Digit Symbol</td>
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<td>81.11 (13.26)</td>
<td>89.32 (15.68)</td>
<td>85.57 (15.23)</td>
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<td>89.32 (15.23)</td>
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<td>95.41 (12.20)</td>
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<td>TASER + Exertion</td>
<td>84.16 (10.19)</td>
<td>91.47 (13.14)</td>
<td>89.50 (11.69)</td>
<td>98.37 (12.53)</td>
<td>91.47 (13.65)</td>
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</tbody>
</table>

*Notes.* SD = standard deviation. HVLT 1–3: Higher scores reflect increased words recalled, and across the five test points, the scores ranged from 10 to 36 (of 36 possible). HVLT Delayed: Higher scores reflect increased words recalled, and across the five test points, the scores ranged from 0 to 12 (of 12 possible). Digit Forward: Higher scores reflect increased digit sequences recalled, and across the five test points, the scores ranged from 6 to 16 (of 16 possible). Digit Backward: Higher scores reflect increased digit sequences recalled (in reverse), and across the five test points, the scores ranged from 2 to 14 (of 14 possible). Halstead Average (right and left): Higher scores indicated increased tapping across a 10-second trial, and across the five test points, the scores ranged from 33.4 to 69.0 for the right hand, and 29.6 to 63.0 for the left hand. Trail-Making A and B: Lower scores indicated improved completion time of the task (in seconds), and across the five test points, the scores ranged from 7.28 to 36.31 for Trails A, and from 15.5 to 125 for Trails B. Digit Symbol: Higher scores reflect increased symbols completed (across a 2-minute time period), and across the five test points, scores ranged from 46 to 133.

Indicates statistically significant change in group mean score (within groups) from pretest to posttest ($p < .05$).

Other objective tests. No other deficits in cognitive functioning were documented among the TASER groups, suggesting that the negative effects of the TASER may be limited to verbal learning and memory. In fact, significant cognitive improvements were shown from pretest to posttest for the Exertion and TASER + Exertion groups (compared with the Control and TASER groups) on the Halstead Finger Tapping test, which measures psychomotor and dexterity functioning. Performance on the Halstead test returned to baseline by the 1-hour mark. It is unclear whether the short-term spikes in performance on

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21. The results also show a significant group by time interaction on the HVLT Delayed Recall ($F(12, 140) = 5.92, p = .04, f = 0.21$). The follow-up univariate ANCOVA results suggested that there were significant differences between groups on Delayed Recall at posttest while controlling for pretest scores ($F(3, 141) = 2.70, p = .048, f = 0.25$). Univariate ANCOVAs did not reveal significant differences between groups at 1 hour ($F(3, 141) = 1.53, p = .21$), 1 day ($F(3, 141) = 1.40, p = .24$), and 1 week ($F(3, 140) = 0.99, p = .40$) while controlling for pretest scores.

22. Paired-samples t tests revealed that there were significant differences from pretest to posttest for the Exertion ($t(31) = -4.34, p = .00, 95\% CI [-4.25, -1.53], d_i = 0.77$) and TASER + Exertion groups ($t(37) = -8.00, p = .00, 95\% CI [-4.78, -2.85], d_i = 1.28$). Post hoc contrasts indicated that there were significant between-group differences among Control and Exertion, Control and TASER + Exertion, and TASER and TASER + Exertion, 95\% CIs [0.19, 3.09], [0.96, 3.74], [0.25, 3.06], respectively. Similar findings were reported for the Halstead Finger Tapping right hand.
the Halstead test are tied to physical activity because this finding did not emerge in other
tests that measure motor coordination (Trail-making and Digit Symbol).

Additionally, several measures of cognitive functioning showed a pattern of improvement
over time for all groups, suggesting that there may be learning effects. For instance,
ANOVA model results indicated that there was a significant main effect of time on Trail-
making A ($F(4, 140) = 19.54, p = .00, f = 0.40$) and Trail-making B ($F(4, 140) = 57.19,
$p = .00, f = 0.75$). The patterns of means suggested that time to complete the Trail-making A
and Trail-making B tasks significantly decreased across five time points for all groups. Similar
findings were reported for the Digit Span (Backward and Forward) and Digit Symbol tests.\textsuperscript{23}

\textbf{Subjective State Measures}

For the subjective measures, Table 3 shows group means over time with statistical signif-
ificance indicated for within-group change, pretest to posttest. The focus is again on
group differences (within and between) from pretest to posttest. Overall, the findings in
Table 3 demonstrate that TASER exposure produces negative, short-term effects on multiple
indicators of emotional state.

\textbf{Concentration difficulty.} Paired-samples $t$ tests comparing within-group means show
significant increases in concentration difficulty from pretest to posttest for the Exertion
($t(31) = -2.55, p = .00, 95\% \text{ CI } [-1.07, -0.12], d_z = 0.45$), TASER ($t(34) = -3.79,
p = .00, 95\% \text{ CI } [-1.76, -0.53], d_z = 0.64$), and TASER+Exertion ($t(37) = -6.87,$
\textsuperscript{23} There were significant main effects of time on Digit Span Backward ($F(4, 140) = 14.04, p = .00, f = 0.31$),
Digit Span Forward ($F(4, 140) = 9.93, p = .00, f = 0.35$), and Digit Symbols ($F(4, 140) = 85.37, p = .00, f =
0.90$). These learning effects occurred even though we employed multiple test versions of the
Trail-making test (two versions of Trails A and two versions of Trails B) and Digit Symbol (five versions).
### TABLE 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretest Mean (SD)</th>
<th>Posttest Mean (SD)</th>
<th>1-Hour Mean (SD)</th>
<th>1-Day Mean (SD)</th>
<th>1-Week Mean (SD)</th>
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<td>1.19 (1.94)</td>
<td>1.03 (1.51)</td>
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<td>TASER</td>
<td>0.66 (1.19)</td>
<td>1.26 (1.62)</td>
<td>0.46 (0.85)</td>
<td>0.23 (0.49)</td>
<td>0.42 (0.94)</td>
</tr>
<tr>
<td>TASER + Exertion</td>
<td>0.42 (0.76)</td>
<td>1.71 (2.34)</td>
<td>0.76 (1.48)</td>
<td>0.37 (0.91)</td>
<td>0.39 (0.89)</td>
</tr>
<tr>
<td>Memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.03 (1.17)</td>
<td>0.73 (0.99)</td>
<td>0.76 (0.98)</td>
<td>0.89 (1.05)</td>
<td>0.81 (1.02)</td>
</tr>
<tr>
<td>Exertion</td>
<td>0.94 (1.39)</td>
<td>0.81 (1.28)</td>
<td>1.03 (1.36)</td>
<td>1.00 (1.34)</td>
<td>0.91 (1.25)</td>
</tr>
<tr>
<td>TASER</td>
<td>1.26 (1.76)</td>
<td>1.14 (1.26)</td>
<td>1.26 (1.22)</td>
<td>1.09 (1.12)</td>
<td>0.79 (1.07)</td>
</tr>
<tr>
<td>TASER + Exertion</td>
<td>0.97 (1.22)</td>
<td>1.21 (1.60)</td>
<td>1.18 (1.43)</td>
<td>0.89 (1.11)</td>
<td>0.87 (1.12)</td>
</tr>
</tbody>
</table>

Notes. SD = standard deviation. Concentration: Higher scores reflect increased concentration difficulty, and across the five test points, the scores ranged from 0 to 10. Anxiety: Higher scores reflect increased anxiety level, and across the five test points, the scores ranged from 0 to 7. Overwhelmed: Higher scores reflect increased levels of feeling overwhelmed, and across the five test points, the scores ranged from 0 to 8. Memory: Higher scores reflect increased memory difficulty, and across the five test points, the scores ranged from 0 to 9.

*Indicates statistically significant change in group mean score (within groups) from pretest to posttest (p < .05).

\[ p = .00, \text{95\% CI } [-2.69, -1.47], d_z = 1.11 \] groups. The increase in concentration difficulty was largest for the TASER + Exertion group (from 0.61 at pretest to 2.68 at posttest, scale of 0–10). For between-group comparisons, post hoc contrasts indicate statistically significant differences among Control and Exertion, Control and TASER, Control and TASER + Exertion, Exertion and TASER + Exertion, and TASER and TASER + Exertion, 95% CIs [0.27, 1.65] [0.86, 2.20], [1.68, 3.02], [0.70, 2.08], [0.15, 1.49], respectively.

Concentration difficulty decreased to pretest levels at 1-hour follow-up for Exertion and TASER groups, and at 1-day follow-up for the TASER + Exertion group.\(^\text{24}\)

\(^\text{24}\). Repeated measures ANOVA results yielded a significant group by time interaction for ratings of concentration difficulty (\(F(12, 140) = 4.51, p = .00, f = 0.63\)). The post hoc univariate ANCOVA comparing group means on difficulty concentrating at posttest revealed significant differences.

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Anxiety level. For within-group change, paired-samples \( t \) tests indicated that anxiety level significantly decreased from pretest to posttest for the Control (\( t(36) = 4.13, p = .00, 95\% \text{ CI } [0.44, 1.29], d_z = 0.68 \)) and Exertion (\( t(31) = 4.08, p = .00, 95\% \text{ CI } [0.70, 2.11], d_z = 0.72 \)) groups, but the TASER and TASER+Exertion groups did not change significantly from pretest to posttest. For between-group change, the post hoc contrasts indicated that there were significant differences at posttest between Control and TASER, Control and TASER+Exertion, Exertion and TASER, and Exertion and TASER+Exertion, 95% CIs [0.21, 1.63], [0.76, 2.15], [0.26, 1.74], [0.81, 2.26], respectively (with the TASER groups indicating significantly higher levels of anxiety). Anxiety levels for the TASER groups dropped notably at the 1-hour mark.25

Feeling overwhelmed. Paired-samples \( t \) tests examining within-group change show that mean scores for feeling overwhelmed significantly increased from pretest to posttest for the TASER+Exertion (\( t(37) = -3.85, p = .00, 95\% \text{ CI } [-1.97, -0.61], d_z = 0.62 \)) group, whereas the Exertion and TASER groups did not show significant change, and the Control group significantly decreased from pretest to posttest (\( t(36) = 2.37, p = .00, 95\% \text{ CI } [0.04, 0.50], d_z = 0.39 \)). For between-group change, the post hoc contrasts indicated that there were significant differences among Control and TASER, Control and TASER+Exertion, and Exertion and TASER+Exertion, 95% CIs [0.18, 1.60], [0.78, 2.17], [0.54, 1.99]. The mean scores of feeling overwhelmed decreased to pretest levels at the 1-day follow-up for the TASER+Exertion group.26
**Memory difficulty.** No statistically significant group differences (within and between groups) were found from pretest to posttest. In fact, memory difficulty means significantly decreased between pretest and 1-week follow-up for all groups ($f = 0.20$).27

**Discussion**

**Summary**
The current study reported findings from an RCT that investigated the effects of TASER exposure on cognitive functioning. Healthy human participants ($n = 142$) were randomly assigned to four study groups, two of which received a 5-second TASER exposure. All participants completed a battery of valid and reliable neurocognitive tests at five points in time before and after treatment exposure. The results indicate that TASER exposure caused statistically significant reductions in one of the five measures of cognitive functioning: the HVLT, which measures verbal learning and memory. The effects lasted, on average, less than 1 hour, and no deficits were documented across the other neurocognitive tests. Interestingly, the Digit Span test, like the HVLT, also measures auditory memory but no effects were documented with this test. Potential explanations for the difference in HVLT/Digit Span findings could include test–retest effects for the Digit Span (we used six versions of the HVLT and only one version of the Digit Span) and variability in the difficulty of remembering numbers versus words. The results also showed that TASER exposure caused significant negative change in several subjective state self-measures, including concentration difficulty, anxiety level, and feeling overwhelmed. The significant findings in the subjective state measures raise the possibility that emotional factors after TASER exposure are important and may affect test performance.

**Considering the Importance of Documented Deficits After TASER Exposure**

Two aspects of the HVLT findings are especially noteworthy. The first involves the severity of the deficits of TASER-exposed participants. Although TASER and TASER+Exertion group scores on the HVLT had returned to baseline by the 1-hour mark, the severity of the short-term disruption was considerable. The average HVLT score (summed total, trials 1–3) in the normal young- to middle-aged adult (i.e., <78 years old) population is 25 (SD = 2.8) (Frank and Byrne, 2000). Scores of 18–19 are considered the cut point for detecting mild cognitive impairment (Frank and Byrne, 2000), although Brandt (1991) identified the 19–20 range as indicative of mild cognitive impairment.

In the current study, the mean HVLT score for each group at pretest was 26—just above the normal range for healthy young adults. At posttest, one quarter of each TASER group scored below 20 on the HVLT (25.7% and 28.9% for TASER and TASER+ Exertion, respectively).

27. The ANOVA model for subjective ratings of memory indicated that the group by time interaction was not significant ($F(12) = 1.54, p = .11$), but there was a significant main effect of time ($F(12, 140) = 2.73, p = .03, f = 0.29$).
respectively), which represents the mean level of cognitive functioning for 79-year-old nondemented adults (Kuslansky et al., 2004) and places them within the range of mild cognitive impairment (18.8% of the Exertion only and 2.7% of the Control group scored less than 20). Additionally, at posttest, only one fifth of each TASER group scored at or above the pretest HVLT sample mean of 26 (20.0% for TASER and 18.4% of TASER+Exertion) compared with 45.9% for the Control group and 31.2% for the Exertion group. Thus, the reductions in cognitive functioning among the TASER and TASER+Exertion groups were both statistically significant and clinically important.

As noted, the larger TASER RCT did not use any *Miranda* comprehension tests, such as Grisso’s (1998, 2003) *Instruments for Assessing Understanding and Appreciation of Miranda Rights*, to indicate directly the reductions in *Miranda* comprehension that might have resulted from TASER exposure. Rather, the present study used the HVLT, which likely represents a favorable alternative—at least in an initial study—to *Miranda*-specific tests for several reasons. First, the HVLT measures auditory recall (i.e., the same type of recall assumed by *Miranda* warnings), but it does so in a way that allows researchers to consider the HVLT scores across a larger context than those of *Miranda* comprehension instruments. That is, the HVLT findings provide more information about a participant’s overall cognitive abilities than does a *Miranda* comprehension test, which allows us to compare present findings with other known cognitively impaired (or underdeveloped) groups for the purposes of drawing conclusions about participants’ cognitive health as a result of TASER exposure.

The HVLT findings demonstrated that, on average, TASER-exposed participants resembled patients with mild cognitive impairment, which suggests that not only might our participants be more likely to waive their *Miranda* rights directly after TASER exposure, but also they would be more likely to give inaccurate information to investigators. Thus, part of our findings implicates a suspect’s ability to issue a valid waiver, whereas another part implicates the accuracy of information he or she might give investigators during a custodial interrogation (e.g., false confessions or statements). For example, evidence suggests that suspects who are mildly mentally retarded, juvenile, or cognitively impaired are the most likely to waive their *Miranda* rights prior to custodial interrogation often because of their deference to authority, lack of understanding of the consequences of waiving their rights, and their suggestibility (e.g., Kassin et al., 2010; O’Connell, Garmoe, and Goldstein, 2005; Rogers, Harrison, Shuman, et al., 2007). Persuasive evidence shows that conviction of the factually innocent occurs in the U.S. court system (Garrett, 2008), and some portion of wrongful convictions are a result of false confessions (Ofshe, 1992). Moreover, at least one laboratory study has found evidence that “not-guilty” suspects may waive their rights because they “believe” their innocence will “set them free” (Kassin and Norwick, 2004); this finding is supported by Leo’s (1996) earlier study of actual interrogations.

The problem is that even innocent suspects who waive their *Miranda* rights could make incriminating statements that become difficult to explain away as they progress through the interrogation process. To the extent that TASER-exposed suspects experience
cognitive declines that inhibit their ability (at least in the short term) to process adequately the consequences of waiving their *Miranda* rights, they too may become susceptible to suggestibility or memory lapses right after hearing their rights. They may waive their *Miranda* rights and make incriminating statements to police without the benefit of counsel. Those statements might be inaccurate or untrustworthy (based on short-term memory impairment) given their declines in cognitive abilities. *Miranda* comprehension tests are not sensitive or specific to cognitive functioning, and their scores do not allow researchers (or policy makers) to draw conclusions about suspects’ overall abilities to integrate and process new information (even outside of *Miranda* warnings) directly after TASER exposure. The HVLT is designed (and validated) precisely for such assessments.

The present study’s observed declines in cognitive functioning are particularly noteworthy when considering its sample of participants: healthy college students who at baseline scored predictably higher on the HVLT than the general population of adults younger than 78 years. Indeed, it is likely, if not probable, that this group of relatively young, healthy, well-educated, frequent test takers, who were sober and drug free at the time of their TASER exposure, function on average at a much higher level of cognition than do the “typical” suspects in the field who experience TASER exposure at the hands of police officers. Thus, given the declines in cognitive functioning experienced by the present study’s participants, we would expect “typical” suspects—who may be drunk, high, or mentally ill and in crisis at the time of exposure—to experience even greater impairment to cognitive functioning as the result of TASER exposure.

This observation becomes especially salient when considering the great variability in the complexity and reading levels of police department *Miranda* warnings across the United States (e.g., Greenfield et al., 2001; Helms, 2003; Rogers, Harrison, and Shuman, et al., 2007). Recall that when the Court decided *Miranda*, although it required police officers to inform suspects of specific rights prior to engaging them in custodial interrogations, it did not articulate the specific language police officers (or police departments more generally) were required to include in their warnings. In the absence of clear direction, police departments have created at least several hundred different warnings across the country, many of which assume high-school and even college-level reading aptitude (Rogers, Harrison, Shuman, et al., 2007).

**Policy Questions Raised by Current Research**

The current research should not be construed as an indictment against the TASER or conducted energy weapons generally. Indeed, available evidence suggests that the TASER represents a reasonable *medical* alternative to physical force (National Institute of Justice, 2011) and deadly force devices (Vilke and Chan, 2007) that could even save lives under certain circumstances when police officers encounter violent resistance (Sousa, Ready, and Ault, 2010). Rather, this study suggests that, given the degree to which a sample of healthy human volunteers experienced cognitive declines immediately after a TASER exposure, there
is room for public dialogue about how best to ensure both police officer field effectiveness and the protection of *Miranda’s* waiver requirements for suspects exposed to a TASER (or other CED) by police officers.

We thus pose the following questions:

1. What would it cost the police under routine circumstances to wait 60 minutes after a successful TASER deployment before administering *Miranda* warnings and trying to obtain a waiver from suspects?
2. What might be the benefits of such a policy?

Through judicial review, the Supreme Court has already created several exceptions to *Miranda*—perhaps most notably for present purposes, the so-called public safety exception (*New York v. Quarles*, 1984; see also *Corn and Jenks*, 2013)—while continuing to reaffirm the importance of *Miranda* and the valid waiver (*Dickerson v. United States*, 2000). Hence, under “routine” circumstances in which police are not dealing with a terrorism suspect or a suspect who may have dropped a weapon during a foot pursuit, we suggest that waiting 60 minutes before issuing *Miranda* to suspects who experienced a TASER exposure would cost the police little, both in terms of time and the probability of successful case resolution. Furthermore, waiting 60 minutes would (a) preserve *Miranda’s* intent to reduce the overwhelming advantage police officers enjoy over most suspects during custodial interrogations and (b) reduce the probability that suspect statements and confessions would be excluded from evidence during suppression hearings by judges who agree with defense counsel claims that their clients could not give valid waivers as the result of TASER exposure (*Salisbury v. Itasca County*, 2011; *United States v. Mack*, 2009).

**Limitations and Implications for Future Research**

Clearly, a single RCT does not produce the evidence required to call for a national policy (or standard) requiring police to wait 60 minutes before interrogating suspects who were exposed to a TASER, in particular, because the present study (as with most research) answered several questions while raising others. For example, one of our secondary, but still noteworthy, findings involves the differences in the severity of the deficit between the Exertion only group and the TASER + Exertion group. Two prior studies have investigated the effects of the TASER on cognitive functioning, and only one of which included multiple force scenarios (Dawes et al., 2014). Dawes et al. (2014) documented statistically significant declines in neurocognitive performance across all groups for up to 1 hour postintervention, and they reported no statistical differences in scores across the force scenarios. The authors noted that their findings could be used to refute claims involving TASER-induced cognitive deficits, given that memory is “only transiently affected and, again, the effects are no different than other use of force scenarios” (Dawes et al., 2014: 16).
Our findings depart from those of Dawes et al. (2014), indicating that cognitive deficits among the TASER+Exertion group were significantly larger than the non-TASER force scenario group (i.e., Exertion; although the difference between the Exertion and TASER only groups was not statistically significant). Still, these seemingly contradictory findings (or, at least, contradictory interpretations) suggest the importance of further research that continues to clarify the effects of the TASER on cognitive functioning by using designs that allow researchers to isolate some of the potential confounding effects that may condition the relationship between the TASER and cognition.  

Conclusions
Given that American police departments have deployed the TASER more than 2 million times against suspects in the field (White et al., 2013)—and in light of the current findings that demonstrate a short-term significant and clinically important reduction in cognitive functioning as the result of TASER exposure—we suggest a public dialogue about how best to integrate the TASER into everyday lawful policing in ways that maintain officer safety while reducing potential social costs incurred by suspects exposed to a TASER discharge. We argue that such a dialogue will enhance police officers’ ability to use the TASER to overcome serious resistance effectively while adhering to the standards set by Miranda and other Supreme Court cases emphasizing the importance of obtaining a knowing, intelligent, and voluntary waiver before engaging suspects in custodial interrogations.

In the meantime, we recommend that the present study be replicated with added instruments and that different populations are used to determine the extent to which the present findings might generalize across different groups studied from different methodological perspectives. For example, future studies should include Miranda comprehension instruments in their designs to assess more accurately the direct link between TASER exposure and participants’ abilities to comprehend their Miranda rights. Moreover, subsequent research should consider introducing more variability into its samples by drawing from heterogeneous community-based populations. This strategy would likely yield samples of participants who resemble actual TASER-exposed suspects more closely than our sample of college students. In the end, we recommend a line of research that treats cognitive functioning with the same importance as physical and physiological health with respect to TASER exposure.

28. For example, participants in the current study were not notified of their group assignment until 1 minute prior to treatment. Future research could include a participant group that is notified early on that they will receive a TASER exposure, but as treatment is about to be delivered, they are informed that no exposure will occur. The addition of this group could allow for deeper exploration of the emotional and physiological (i.e., adrenaline) responses to anticipated TASER exposure.
References


**Court Cases Cited**


*Coyote v. United States*, 380 F. 2d. 305 (10th Cir. 1967).
Robert J. Kane is a professor and department head of criminology and justice studies at Drexel University. Kane’s primary research interests include police authority and accountability, communities, crime and health, and technology and justice. Kane (with his academic mentor, James J. Fyfe) completed a study of police misconduct in the New York City Police Department (NYPD): To date, it is the largest study of misconduct ever conducted in an American police agency. Since then, Kane has published numerous peer-reviewed articles on police misconduct, legitimacy, and accountability in the NYPD, culminating in his 2013 book, Jammed Up: Bad Cops, Police Misconduct, and the New York City Police Department (NYU Press, co-authored with Michael D. White). Kane is the co-editor (with Michael Reisig) of the Oxford Handbook of Police and Policing (2014, Oxford University Press). Kane’s current book project examines the 2014 Ferguson riots and protests through the lens of geo-tagged social media posts of those who participated.

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