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TASING THE CONSTITUTION: CONDUCTED ELECTRICAL WEAPONS, OTHER FORCEFUL ARREST MEANS, AND THE VALIDITY OF SUBSEQUENT CONSTITUTIONAL RIGHTS WAIVERS

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ABSTRACT

Conducted electrical weapons (CEWs)—the most famous and widely used of which are offered under the TASER brand—are ubiquitous tools of law enforcement, carried by the vast majority of law enforcement officers and routinely deployed. These devices subdue targets by coursing electric current through their bodies, thereby causing individuals to collapse as their muscles involuntarily contract. Yet this method of operation has raised concerns—voiced by researchers, advocates, and criminal defendants alike—that CEWs influence cognitive capacity in addition to muscle function as electric current potentially transits through the brain via the central nervous system. In the context of an arrest, this implicates criminal suspects' ability to understand *Miranda* warnings given by officers and to competently waive their constitutional rights against self-incrimination and to counsel. Some have gone so far as to recommend a mandated delay between when suspects are tased and when officers may administer *Miranda* warnings in order to protect individuals' rights. Intimate understandings of the law of *Miranda v. Arizona* and the true effects of CEWs on cognitive capacity are critical for determining the prudence of this recommendation, and have broader implications for the criminal justice system.

This Article is the first to conduct a thorough survey and analysis of the law of *Miranda* with regard to how courts determine whether individuals' waivers of their constitutional rights following *Miranda* warnings are knowing, intelligent, and voluntary. Ultimately, cognitive capacity is an important factor, but, in examining this faculty, courts generally rely most heavily on subjective indicia of mental acuity

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manifested at the time *Miranda* warnings were administered—e.g., reasoning ability, tone, bodily movements, and temperament. Objective indicia of mental acuity—i.e., those shown through empirical research to signal cognitive ability, such as age, education, intelligence, and blood alcohol content—are routinely treated as less valuable than subjective indicia, particularly when the two are in opposition. This presents a high bar for empirical research on the cognitive effects of CEWs to scale in order to meaningfully influence court determinations of the legitimacy of rights waivers.

This Article is also the first to conduct a comprehensive survey and examination of the literature addressing the cognitive effects of CEWs and compare these effects to those of other forceful arrest methods. Studies reveal that, rather than having a unique effect on cognition through some interaction between electric current and the brain, CEWs actually appear to impact mental faculties through a general stress effect, which other forceful methods of arrest have as well—e.g., physical altercation, police dog attack, and pepper spray. Therefore, an exceptional rule requiring a delay in administering *Miranda* warnings to suspects subject to CEWs does not seem appropriate. Nevertheless, the literature does show forceful arrest methods meaningfully affecting individual mental acuity. While more research is necessary to more finely deduce the extent of these impacts, they appear to be such that courts should consider a forceful arrest close enough in time to the administration of a *Miranda* warning to be a negative factor in assessing defendants' competence to waive their rights, similar to evidence indicating low intelligence or intoxication at the time of waiver.

INTRODUCTION

In ancient mythology, Zeus, the Greek king of the gods, employed electricity to devastating effect, hurling lightning bolts to vanquish his enemies and punish those who transgressed against him.[1] His manipulation of this powerful natural force is, of course, fantastical, but in the late 1700s, the Zeus of the animal kingdom was discovered in the form of a fish—more specifically, an eel.[2] While humans have been aware for thousands of years that certain fish deliver painful shocks, the mechanism by which they do so was not accurately contemplated until naturalists connected this action with nascent electricity research.[3] Eels use electrical current in a highly controlled fashion: they emit short bursts to locate prey by inducing muscle twitches and movement in nearby organisms, then discharge a longer and more intense burst to immobilize targets for consumption.[4] They also engage their electrical faculties for defense against intruding animals and objects.[5]

It took a few centuries after the aforementioned discovery, but humans finally also developed the capability to deploy electrical current in a controlled manner to incapacitate others.[6] In 1969, John Cover conceived the first conducted electrical weapon (CEW), which he called a "TASER" (a near-accurate acronym for the early twentieth century novel *Thomas Swift and His Electric Rifle*).[7] In essence, the TASER operates by firing two darts into an individual, each tethered to the device's main handheld body by a wire, and emitting an electrical current that flows through the target and causes his muscles to contract involuntarily.[8] Over the ensuing decades, these weapons worked their way into the armories of the vast majority of law enforcement agencies and onto the duty belts of officers as a non-lethal, ranged means of subduing individuals.[9] Like the mighty Zeus and slightly less mighty eel,

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[1] JOHN S. FRIEDMAN, OUT OF THE BLUE: A HISTORY OF LIGHTNING: SCIENCE, SUPERSTITION, AND AMAZING STORIES OF SURVIVAL 27–28 (2008).

[2] Carl Zimmer, *The Surprising Power of an Electric Eel's Shock*, N.Y. TIMES (Dec. 4, 2014), https://www.nytimes.com/2014/12/04/science/the-surprising-power-of-an-electric-eels-shock.html?_r=0 [https://nyti.ms/1yWwGMH].

[3] *Id.*; *see* Peter Kellaway, *The Part Played by Electric Fish in the Early History of Bioelectricity and Electrotherapy*, 20 BULL. HIST. MED. 112, 117–24 (1946) (describing ancient attempts to understand the mechanism behind the shocks of electric fish).

[4] Kenneth Catania, *The Shocking Predatory Strike of the Electric Eel*, 346 SCI. 1231, 1231–34 (2014).

[5] James Gorman, *Like a Slimy Taser, Electric Eels Can Leap Out and Zap Their Prey*, N.Y. TIMES (June 6, 2016), https://www.nytimes.com/2016/06/07/science/like-a-slimy-taser-electric-eels-can-leap-out-and-zap-their-prey.html [https://nyti.ms/1TS7UF6].

[6] *See infra* notes 190–91 and accompanying text.

[7] *See infra* notes 190–93 and accompanying text. *See generally* VICTOR APPLETON, TOM SWIFT AND HIS ELECTRIC RIFLE (1911).

[8] *See infra* Section II.B.2.

[9] *See infra* notes 194–255 and accompanying text; *see also* Natalie Todak et al., *Overcoming the Challenges of Experimental Research: Lessons from a Criminal Justice Case Study Involving*

authorities now deploy electrical current hundreds of thousands of times annually against suspected criminals.[10]

But along with the physically damaging and incapacitating effects of electrical current, humans have also been aware of this force's effects on cognition for some time.[11] Beginning in the eighteenth century, researchers made concerted efforts to explore the potential positive and negative psychological effects of administering electrical current to the human body.[12] "The power of electric shocks to the head was demonstrated by accounts of memory loss and sometimes of mental stimulation or improvement," and scientists and medical practitioners experimented extensively with different methods and intensities of electrical stimulation.[13] Over the decades, electrotherapy for psychological and neurological purposes steadily proliferated in research and medical practice.[14] Today, procedures such as the relatively mild and targeted transcranial direct-current stimulation and the relatively intense electroconvulsive therapy are widely employed, and, understood to meaningfully impact cognitive capacity, both positively and negatively, as primary and secondary effects.[15] In addition, an extensive body of literature exists documenting cognitive declines in individuals who suffer electrical injuries from contact with domestic and commercial power sources.[16]

Given that CEWs course electrical current through the human body, it is a small wonder that their potential diminishing of mental acuity emerged as both a scientific and legal issue. Criminal defendants appear to be the first actors to meaningfully focus on this matter beginning in the mid-2000s.[17] They argued that, as a result of being subdued and arrested through the use of CEWs, they did not adequately comprehend subsequent *Miranda* warnings administered to them and did not knowingly, intelligently, or voluntarily waive their Fifth and Sixth Amendment rights to silence and

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TASER Exposure, 42 EVALUATION REV. 358, 363 (2018) ("[CEWs] such as the TASER have become a fundamental part of the police arsenal.").

[10] *See infra* notes 265–68 and accompanying text.

[11] Paul Elliott, *Electricity and the Brain: An Historical Evaluation*, *in* THE STIMULATED BRAIN: COGNITIVE ENHANCEMENT USING NON-INVASIVE BRAIN STIMULATION 3–6 (Roi Cohen Kadosh ed., 2014).

[12] *Id.*

[13] *Id.* at 8–9.

[14] *Id.* at 7–28.

[15] *See, e.g.*, Ingrid Moreno-Duarte et al., *Transcranial Electrical Stimulation: Transcranial Direct Current Stimulation (tDCS), Transcranial Alternating Current Stimulation (tACS), Transcranial Pulsed Current Stimulation (tPCS), and Transcranial Random Noise Stimulation (tRNS)*, *in* THE STIMULATED BRAIN: COGNITIVE ENHANCEMENT USING NON-INVASIVE BRAIN STIMULATION, *supra* note 11, at 37–47; Kate E. Hoy & Paul B. Fitzgerald, *Brain Stimulation in Psychiatry and Its Effects on Cognition*, 6 NATURE REVS. NEUROLOGY 267, 267–68 (2010); Harold A. Sackeim et al., *The Cognitive Effects of Electroconvulsive Therapy in Community Settings*, 32 NEUROPSYCHOPHARMACOLOGY 244, 244–45, 252–53 (2007).

[16] *See infra* Section II.C.1.

[17] *See infra* Section I.E.

counsel, respectively.[18] Accordingly, any statements made to police following their allegedly invalid waivers were argued to require suppression.[19]

Aside from one doctoral dissertation,[20] researchers did not turn their attention to the potential cognitive effects of CEW strikes until defendants shined a spotlight on it. Since then, however, a number of studies have been published examining the issue.[21] Most notably, the authors of one such work put forth that CEWs do in fact meaningfully compromise individual mental ability, and do so to the point that special legal safeguards should be put in place to protect the constitutional rights of suspects subjected to these devices.[22] Specifically, they contend that a sixty-minute waiting period should be required before officers can administer *Miranda* warnings to suspects exposed to CEWs and they can be deemed competent to waive their rights.[23] Media outlets reported heavily on these findings and recommendations,[24] publishing pieces with such provocative titles as, "Tasers [sic] Are Bad For Your Brain,"[25] and, "Tasing Temporarily Affects Brain Function, Comparable to Dementia."[26] But while one study has dominated public discourse on the issue, its findings do not represent a consensus among researchers. Rather, there exists a stark divide between those who interpret relevant study results to reveal a significant CEW effect on cognition[27]

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[18] *See infra* Section I.E.

[19] *See infra* Section I.E.

[20] Amy Bagley, The Neuropsychological Effects Associated with Taser Administrations (May 15, 2008) (unpublished PhD dissertation, Rosalind Franklin University of Medicine and Science) (on file with ProQuest Dissertations & Theses Global).

[21] *See infra* Section II.C.2.

[22] Robert J. Kane & Michael D. White, *TASER Exposure and Cognitive Impairment: Implications for Valid* Miranda *Waivers and the Timing of Police Custodial Interrogations*, 15 CRIMINOLOGY & PUB. POL'Y 79, 101 (2015).

[23] *Id.*

[24] *See, e.g.*, Nathan Collins, *Don't Tase My Brain, Bro*, PAC. STANDARD (Feb. 8, 2016), https://psmag.com/news/dont-tase-my-brain-bro [https://perma.cc/9EGH-U9RE]; Brooks Hays, *Taser's Effect on Cognition May Undermine Police Questioning*, UNITED PRESS INT'L (Feb. 4, 2016), https://www.upi.com/Science_News/2016/02/04/Tasers-effect-on-cognition-may-undermine-police-questioning/1751454607351/ [https://perma.cc/HDB4-88C6]; David Kravets, *Study: Suspects Shocked by Taser "More Likely" to Waive* Miranda *Rights*, ARS TECHNICA (Feb. 5, 2016, 1:45 PM), https://arstechnica.com/tech-policy/2016/02/study-suspects-shocked-by-taser-more-likely-to-waive-miranda-rights/ [https://perma.cc/NLW5-ZCUT]; Tim Stelloh, *What Does 50,000 Volts from a Taser Do to Your Brain?*, NBC NEWS (Feb. 8, 2016, 8:06 PM), https://www.nbcnews.com/news/us-news/what-does-50-000-volts-taser-do-your-brain-n514191 [https://perma.cc/MA44-76TD].

[25] Anthony L. Fisher, *Tasers Are Bad for Your Brain, Especially when Being Interrogated by Police*, REASON (Feb. 10, 2016), http://reason.com/blog/2016/02/10/tasers-are-bad-for-your-brain-miranda [https://perma.cc/KZW6-JSVN].

[26] Elisa Lala, *Study: Tasing Temporarily Affects Brain Function, Comparable to Dementia*, PHILLYVOICE (Feb. 4, 2016), http://www.phillyvoice.com/study-tasing-temporarily-affects-brain-function-comparable-dementia/ [https://perma.cc/M22M-P687].

[27] *See, e.g.*, Henry F. Fradella, *Neuroscience and the Potential Need for a New Bright-Line*

and those who interpret such results to reveal only a modest effect unworthy of distinctive legal treatment.[28]

So do CEWs actually meaningfully impact cognition? And if so, is it to a degree that the weapons compromise individuals' capacities to exercise their constitutional rights unless exceptional safeguards are put in place? Given the nearly complete permeation of CEWs through law enforcement entities and their frequent use to subdue and arrest criminal suspects, answering these questions is material to ensuring individuals are not denied their constitutional rights and the criminal legal system functions in a just fashion.

This Article engages the implications of the potential cognitive effects of CEWs and the validity of subsequent in-custody waivers of Fifth and Sixth Amendment rights in three parts. Part I analyzes the legal standard for a valid waiver of one's rights first established in *Miranda v. Arizona* in 1966,[29] and since extensively developed by both federal and state courts.[30] Critical to whether the law should uniquely account for CEW strikes is how this standard incorporates defendant mental ability at the time of waiver and how courts determine this characteristic. This section offers a novel analysis of *Miranda* and its progeny in this regard. It is shown that cognitive capacity is a critical factor in all three prongs of the requirement that waivers be knowing, intelligent, and voluntary.[31] However, courts show a marked preference for relying on subjective assessments of defendant behavior at the time of waiver over more objective and detached indicators of mental competence like age, education, and intelligence (as measured by intelligence quotient (IQ) tests and scores).[32] Seeing as how any findings of cognitive deficits precipitated by CEWs fall under the latter category, this means that substantial impairment must be shown for this evidence to have meaningful singular influence on court waiver determinations, particularly to the point that specific, per se CEW legal safeguards should be instituted. A case survey is then conducted of published court orders and opinions addressing CEWs and waivers of constitutional rights.[33]

Part II is the most substantial portion of the Article, delving into the history, functioning, and cognitive effects of CEWs. Significant attention is paid to the

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Rule Concerning Miranda *Waivers After CED Exposure*, 15 CRIMINOLOGY & PUB. POL'Y 117, 126 (2015); Kane & White, *supra* note 22.

[28] *See, e.g.*, Donald M. Dawes et al., *The Neurocognitive Effects of a Conducted Electrical Weapon Compared to High Intensity Interval Training and Alcohol Intoxication: Implications for* Miranda *and Consent*, 53 J. FORENSIC & LEGAL MED. 51, 55 (2018) [hereinafter Dawes et al., *Conducted Electrical Weapon*]; Donald M. Dawes et al., *The Neurocognitive Effects of Simulated Use-of-Force Scenarios*, 10 FORENSIC SCI., MED. & PATHOLOGY 9, 16 (2014) [hereinafter Dawes et al., *Use-of-Force Scenarios*].

[29] 384 U.S. 436, 444 (1966).

[30] *See infra* Sections I.A–D.

[31] *See infra* Sections I.B–C.

[32] *See infra* Section I.D.

[33] *See infra* Section I.E.

science of CEWs so as to provide the most beneficial resource for scholars and practitioners who must confront the legal implications of these devices, and to most effectively influence the positive advancement of law. The section begins by providing a detailed background of the invention of CEWs and how they came to be near ubiquitous in law enforcement.[34] This presentation underscores the importance of engaging the issue of whether the devices impact cognition and defendants' competence to waive their constitutional rights. The section then examines the science behind CEWs, beginning with the basic importance of electrical current to bodily function and how the devices exploit this fact to incapacitate targets.[35] The lack of understanding of the exact mechanism by which the weapons influence areas of the body remote from where they impact is noted, as is the dominant theory that electrical current is conducted through the spinal cord to these regions and how such current might thereby reach the brain and affect mental faculties.[36] Next, the literature revealing cognitive deficits resulting from electrical injuries is reviewed, these works having helped inspire studies of CEWs and cognition.[37] A comprehensive and in-depth analysis is then conducted of all studies examining the potential causal link between CEW administration and mental impairment.[38] The parameters, substantial findings, and limitations of these works are presented. Given that an academic review in this area does not exist, this Article provides such a review. It therefore gives legal scholars and practitioners a detailed overview of available expert material on the potential link between CEWs and cognitive deficits, and reveals to researchers the most fruitful methods and avenues for further investigation. This review concludes that CEWs appear to affect cognition, but to a non-specific degree in line with other forceful arrest methods (e.g., direct physical subjugation, canine attack, and pepper spray administration). Accordingly, given current research, CEW use during arrest should be lumped in with other forceful arrest methods as a negative influence on a defendant's comprehension of his constitutional rights at the time of waiver, depending on the waiver's temporal proximity to the arrest.

Finally, Part III explores a void in court opinions and research addressing the factors that influence a defendant's ability to knowingly, intelligently, and voluntarily waive his constitutional rights. As noted above, courts tend to rely on subjective assessments of defendant behavior at the time of waiver, giving less regard to objective indicia of mental incompetence.[39] In terms of the influence of forceful arrest circumstances on this characteristic, courts rely entirely on witness descriptions of defendant conduct following these confrontations and their own interpretations of whether the circumstances had any cognitive effects.[40] The fact that the scientific

[34] *See infra* Section II.A.
[35] *See infra* Section II.B.
[36] *See infra* Section II.B.2.
[37] *See infra* Section II.C.1.
[38] *See infra* Section II.C.2.
[39] *See infra* Section I.D and Part III.
[40] *See infra* Part III.

literature reveals such arrest situations to negatively impact individual psychological faculties is never mentioned. Rather, and unfortunately, these occurrences are viewed as having no effect or detrimental effect depending solely on visceral assessments. But it is not just courts that ignore the science behind forceful arrest methods and cognitive ability.[41] Judicial treatments reflect an anemic literature on the subject. Research on the factors that influence one's ability to comprehend his constitutional rights and competently waive them overwhelmingly focuses on more static individual characteristics such as age, education, mental health, and intelligence (as measured by IQ tests).[42] Aside from the CEW research examined in Part II, no studies have investigated the potential influence of forceful arrest conditions on rights warning comprehension. This Article expressly links research on the cognitive effects of these circumstances with *Miranda* warning and rights comprehension research, arguing that a forceful arrest recent in time prior to a rights waiver should be an objectively negative factor in court determinations of whether a defendant knowingly, intelligently, and voluntarily waived his constitutional rights.

I. KNOWING, INTELLIGENT, AND VOLUNTARY

Whether and to what degree CEWs affect cognition are only constitutionally relevant to the validity of a suspect's in-custody waiver of his Fifth and Sixth Amendment rights if the applicable legal standard allows them to be. This section therefore dissects that standard's allowance for the influence of an individual's mental faculties on determinations of his waiver's legal legitimacy. It then examines the implications for CEWs and how courts have thus far treated these devices when invoked to challenge waiver validity.

A. Forming the Standard

In 1966, the Supreme Court held in the seminal *Miranda v. Arizona* that, prior to in-custody interrogation, a suspect must be advised of his Fifth and Sixth Amendment rights, "that he has a right to remain silent, that any statement he does make may be used as evidence against him, and that he has a right to the presence of an attorney, either retained or appointed."[43] These rights may, however, be waived, "provided the waiver is made voluntarily, knowingly[,] and intelligently."[44]

On its face, the terminology of the waiver standard implicates suspects' cognitive abilities. But these abilities are not expressly offered as relevant in *Miranda*, which is almost entirely concerned with law enforcement. A substantial portion of

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[41] *See infra* Part III.

[42] *See infra* Part III.

[43] Miranda v. Arizona, 384 U.S. 436, 444 (1966). The Court does, however, allow for "other fully effective means" to apprise a suspect of his rights and the consequences of waiving them. *Id.*

[44] *Id.*

the opinion's length is devoted to describing the coercive nature of in-custody interrogation and how it compels suspects to incriminate themselves.[45] While instances of "physical brutality" and threats of such conduct are provided as overt examples of officers' potent tactics, the Court notes that, as a result of its precedent condemning these practices, they "are undoubtedly the exception now."[46] Rather, "the modern practice of in-custody interrogation is psychologically rather than physically oriented,"[47] and it had already been legally recognized for some time that unlawful "coercion can be mental as well as physical."[48] But the Court goes farther than simply reiterating that psychological interrogation techniques *can* abridge constitutional rights, finding that they are so consistently employed and effective that "the very fact of custodial interrogation exacts a heavy toll on individual liberty and trades on the weakness of individuals."[49] Accordingly, regardless of suspects' individual mental capacity, such methods *always* abridge constitutional rights unless effective procedural safeguards are mandated and deployed.[50]

The Court then proceeds to outline the safeguard to be utilized: the advisement of one's Fifth and Sixth Amendment rights and the consequences of waiving them noted above that must precede in-custody interrogation, now called a "*Miranda* warning."[51] And "[a]fter such warnings have been given, and such opportunity afforded him, the individual may knowingly and intelligently waive these rights and agree to answer questions or make a statement."[52] Such a waiver must be explicit, and "will not be presumed simply from . . . silence" or the fact that a suspect converses to some extent prior to invoking his rights.[53] A waiver can, however, still be deemed invalid as involuntary should it be found to have been elicited by unlawful compulsion.[54]

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[45] *See id.* at 456 ("In the cases before us today, . . . we concern ourselves primarily with th[e] interrogation atmosphere and the evils it can bring.").

[46] *Id.* at 446–47. For an illustration of Supreme Court precedent rebuking physical interrogation methods, see, for example, Malinski v. New York, 324 U.S. 401, 406 (1945); White v. Texas, 310 U.S. 530, 532 (1940); Brown v. Mississippi, 297 U.S. 278, 287 (1936). For a sampling of the "exceptions" that the Court notes, see, for example, Wakat v. Harlib, 253 F.2d 59, 59 (7th Cir. 1958); Kier v. State, 132 A.2d 494, 497–99 (Md. 1957); People v. Portelli, 205 N.E.2d 857, 858 (N.Y. 1965).

[47] *Miranda*, 384 U.S. at 448.

[48] Blackburn v. Alabama, 361 U.S. 199, 206 (1960) (citing Chambers v. Florida, 309 U.S. 227 (1940)).

[49] *Miranda*, 384 U.S. at 455.

[50] *Id.* at 457–58.

[51] *See, e.g.*, Bryan Taylor, *You Have the Right to Be Confused! Understanding* Miranda *After 50 Years*, 36 PACE L. REV. 160, 171 (2015) (stating that, in *Miranda*, "the [Supreme] Court set forth what would come to be known as *Miranda* warnings").

[52] *Miranda*, 384 U.S. at 479.

[53] *Id.* at 475.

[54] *Id.* at 476.

The only points at which the Court brings up suspect cognitive capacity are where it expressly disavows the relevance of such factors in determining whether *Miranda* warnings are required.[55] They must always be administered because "[i]t is not just the subnormal or woefully ignorant" who are vulnerable to law enforcement interrogation stratagems.[56] Moreover, "[a]ssessments of the knowledge the defendant possessed, based on information as to his age, education, intelligence, or prior contact with authorities, can never be more than speculation; a warning is a clearcut fact."[57]

Overall, a waiver is presented as knowing, intelligent, and voluntary if it (1) follows a proper rights advisement and (2) is not the product of coercion. Both of these factors are dependent on the conduct of authorities. With regard to knowledge and intelligence, a suspect's actual knowledge and intelligence in relation to his rights are not clearly implicated. The advisement of rights and consequences is put forth as a singular proxy for the presence of these requirements. However, *Miranda* extensively cites precedent outlining the condition that waivers of the right to counsel must be "intelligent and competent" to be valid, and that this "depend[s], in each case, upon the particular facts and circumstances surrounding that case, including the background, experience, and conduct of the accused."[58]

In terms of the voluntariness of a waiver, the Court does not mention a suspect's susceptibility to law enforcement coercion.[59] But a more expansive reading of this prong is warranted for a similar reason as that for the first two: the opinion's consistent invocation of precedent pertaining to the voluntariness of confessions indicating that suspects' individual vulnerability can be a factor. In these cases, "a totality of the circumstances" is considered[60] as to whether official conduct unlawfully "engender[s] either hope or fear" in a suspect that induces a confession,[61] including "the confessor's strength or weakness, whether he was educated or illiterate, intelligent or moronic, well or ill."[62]

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[55] *Id.* at 457, 468–69.

[56] *Id.* at 468.

[57] *Id.* at 468–69 (internal citation omitted).

[58] Johnson v. Zerbst, 304 U.S. 458, 464 (1938); *see* Moore v. Michigan, 355 U.S. 155, 164 (1957) (considering the defendant's age, education, intelligence, and mental health in assessing the intelligence of his waiver of his right to counsel); Von Moltke v. Gillies, 332 U.S. 708, 724 (1948) ("To be valid[,] [a] waiver [of the right to counsel] must be made with an apprehension of the nature of the charges, the statutory offenses included within them, the range of allowable punishments thereunder, possible defenses to the charges and circumstances in mitigation thereof, and all other facts essential to a broad understanding of the whole matter. A judge can make certain that an accused's professed waiver of counsel is understandingly and wisely made only from a penetrating and comprehensive examination of all the circumstances under which such a plea is tendered.").

[59] *Miranda*, 384 U.S. at 444–45.

[60] Haynes v. Washington, 373 U.S. 503, 514 (1963).

[61] Bram v. United States, 168 U.S. 532, 557–58 (1897).

[62] Ashcraft v. Tennessee, 322 U.S. 143, 162 (1944) (Jackson, J., dissenting); *see* Spano

Thus, as originally expressed, the knowing, intelligent, and voluntary standard for a valid in-custody waiver of one's Fifth and Sixth Amendment rights leaves no apparent role for suspect cognitive capacity at the time of waiver. But a more in-depth reading of *Miranda* illuminates the Court's unenunciated incorporation of this factor—the importance of which has been substantially expounded upon as courts continue to interpret and apply this law.

B. Knowing and Intelligent

The first two prongs of the knowing, intelligent, and voluntary standard pronounced in *Miranda* are rarely addressed separately.[63] It therefore makes sense to analyze them together.

As it stands, a waiver is "knowing" if the defendant was aware of the nature of the rights being waived at the time of waiver.[64] And it is "intelligent" if he was aware of the consequences of waiving his rights at that moment.[65] However, an understanding of "every possible consequence of a waiver" is not necessary.[66] The Supreme Court of Illinois, in *People v. Bernasco*, provides a helpful summary of these requirements:

> If intelligent knowledge in the *Miranda* context means anything, it means the ability to understand the very words used in the warnings. It need not mean the ability to understand far-reaching legal and strategic effects of waiving one's rights, or to appreciate how widely or deeply an interrogation may probe, or to withstand the influence of stress or fancy; but to waive rights intelligently and knowingly, one must at least understand basically what those rights encompass and minimally what their waiver will entail.[67]

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v. New York, 360 U.S. 315, 321–22, 322 n.3 (1959) (considering the defendant's education, mental health, and intelligence in assessing the voluntariness of his confession); Chambers v. Florida, 309 U.S. 227, 238–39 (1940) (considering the defendants' "ignoran[ce]" in assessing the voluntariness of their confessions).

[63] *See, e.g.*, Woodley v. Bradshaw, 451 F. App'x 529, 540 (6th Cir. 2011); United States v. Cristobal, 293 F.3d 134, 142–43 (4th Cir. 2002); People v. Knedler, 329 P.3d 242, 245–47 (Colo. 2014); People v. Daoud, 614 N.W.2d 152, 159–63 (Mich. 2000); Commonwealth v. Barry, 454 A.2d 985, 988–89 (Pa. 1982).

[64] Moran v. Burbine, 475 U.S. 412, 421 (1986).

[65] *Id.*

[66] Colorado v. Spring, 479 U.S. 564, 574 (1987).

[67] 562 N.E.2d 958, 964 (Ill. 1990); *see also* State v. Knight, 785 S.E.2d 324, 336 (N.C. Ct. App. 2016) ("[A] factual understanding of the rights at issue must come together with an appreciation of the relevance of those rights in the context of an unfolding interrogation. The Constitution does not require that a suspect understand the full import of custodial interrogation, but before a waiver of rights can be intelligently made, one must understand both the basic privilege guaranteed by the Fifth Amendment and the consequences of speaking freely to law enforcement officials.").

Courts must therefore deduce the presence of a "requisite level of comprehension" within the defendant at the time of waiver from "the totality of the circumstances surrounding the interrogation" in order to deem it valid.[68] Such deductions have come to involve court assessments of myriad factors used to intuit a defendant's cognizance and mental capacity at the time of waiver.[69] In line with the focus of this Article, this subsection focuses on those facets related to a defendant's cognitive ability and knowledge, although additional aspects of a case relating to law enforcement conduct are certainly relevant (e.g., the improper administration of a *Miranda* warning).[70]

A threshold matter for whether a waiver was knowledgeable and intelligent is an individual's ability to understand the form in which a *Miranda* warning is given.[71] The language skills of a defendant are material in this regard: he cannot be aware of the nature of his rights or the consequences of waiving them if this information is not presented in a language he understands.[72] A defendant's hearing and reading abilities are similarly important, requiring that rights be advised in a comprehendible manner.[73]

But even if a rights advisement is fundamentally intelligible, courts accept that its contents can be forgotten over time.[74] Waivers provided during interrogations conducted too long after a warning can be found invalid for lack of defendant knowledge and intelligence.[75] In addition, "[p]rior experience with the criminal justice system is an important factor in determining whether the defendant made a knowing and

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[68] *Moran*, 475 U.S. at 421 (internal quotations omitted) (quoting Fare v. Michael C., 442 U.S. 707, 725 (1979)).

[69] *See infra* notes 70–79 and accompanying text.

[70] *See, e.g.*, United States v. Beale, 921 F.2d 1412, 1434–35 (11th Cir. 1991); United States v. Dohm, 618 F.2d 1169, 1174–75 (5th Cir. 1980); People v. Braeseke, 602 P.2d 384, 390–91 (Cal. 1979), *vacated and remanded by* California v. Braeseke, 446 U.S. 932 (1980), *reaffirmed by* People v. Braeseke, 618 P.2d 149 (Cal. 1980); Lee v. State, 12 A.3d 1238, 1247–51 (Md. 2011).

[71] *See* United States v. Garibay, 143 F.3d 534, 537 (9th Cir. 1998) ("In determining whether a defendant knowingly and intelligently waived his *Miranda* rights, we consider, as one factor, any language difficulties encountered by the defendant during custodial interrogation.").

[72] *E.g.*, United States v. Botello-Rosales, 728 F.3d 865, 867–68 (9th Cir. 2013); People v. Aguilar-Ramos, 86 P.3d 397, 401–02 (Colo. 2004); People v. Mejia-Mendoza, 965 P.2d 777, 780–82 (Colo. 1998); State v. Santiago, 542 N.W.2d 466, 471–73 (Wis. 1995).

[73] *E.g.*, Garner v. Mitchell, 557 F.3d 257, 273 (6th Cir. 2009) (Moore, J., dissenting); United States v. McForbes, 110 F. Supp. 3d 332, 337–38 (D. Mass. 2015); United States v. Robles-Ramirez, 93 F. Supp. 2d 762, 764 (W.D. Tex. 2000); People v. Adames, 994 N.Y.S.2d 334, 338–39 (N.Y. App. Div. 2014); People v. Ripic, 587 N.Y.S.2d 776, 783 (N.Y. App. Div. 1992); State v. Hindsley, 614 N.W.2d 48, 56 (Wis. 2000).

[74] *See, e.g.*, Stumes v. Solem, 752 F.2d 317, 320 (8th Cir. 1985); *Ex parte* Landrum, 57 So. 3d 77, 82–83 (Ala. 2010); *In re* Miah S., 861 N.W.2d 406, 412–15 (Neb. 2015).

[75] *E.g.*, United States v. Jones, 147 F. Supp. 2d 752, 761–62 (E.D. Mich. 2001); People v. Quirk, 129 Cal. App. 3d 618, 626–32 (Cal. Ct. App. 1982); Franklin v. State, 252 A.2d 487, 490–91 (Md. Ct. Spec. App. 1969); People v. Sanchez, 391 N.Y.S.2d 513, 517–18 (N.Y. Trial Term 1977).

intelligent waiver."[76] Courts view such experience as an indication that a defendant already possessed some familiarity with his rights and the potential ramifications of waiving them, and the absence of this background can signify the opposite.[77]

Finally, and most pertinent for this Article, "[a] defendant's mental capacity directly bears upon the question whether he understood the meaning of his Miranda rights and the significance of waiving his constitutional rights."[78] In this vein, to deduce a defendant's cognitive ability to appreciate the warning, courts consider a litany of individual characteristics, including: age, maturity, education, intelligence, mental health, intoxication when warnings and waivers are given, and physical and mental conditions when warnings and waivers are given.[79] The proximity of warnings and waivers to a violent arrest or other stressful event can also serve as a marker of a defendant's compromised physical and mental abilities at the time of waiver.[80]

C. Voluntary

A waiver is "voluntary" if "it was the product of a free and deliberate choice rather than intimidation, coercion, or deception."[81] Such freedom and deliberation "depend[s] on the absence of police overreaching, not on 'free choice' in any broader sense of the word."[82] Thus, a prerequisite for a finding of "involuntary" is proof of measures, physical or psychological, employed by law enforcement "calculated to break [a defendant's] will."[83] Focus can then shift to whether his "'will [was] overborne and his capacity for self-determination critically impaired' because of coercive police

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[76] State v. Brown, 436 S.E.2d 163, 167 (N.C. Ct. App. 1993) (citing State v. Fincher, 305 S.E.2d 685, 697 (N.C. 1983); State v. Jackson, 304 S.E.2d 134, 151–53 (N.C. 1983)).

[77] *E.g.*, Smith v. Mullin, 379 F.3d 919, 934 (10th Cir. 2004); People v. Ferguson, 227 P.3d 510, 515 (Colo. 2010); Hawkins v. United States, 304 A.2d 279, 281 (D.C. 1973); State v. Green, 655 So. 2d 272, 284 (La. 1995).

[78] United States v. Garibay, 143 F.3d 534, 538 (9th Cir. 1998).

[79] *See, e.g.*, Fare v. Michael C., 442 U.S. 707, 725 (1979); Moore v. Ballone, 658 F.2d 218, 229 (4th Cir. 1981); Sample v. Eyman, 469 F.2d 819, 821 (9th Cir. 1972); United States v. Gonzalez, 719 F. Supp. 2d 167, 173 (D. Mass. 2010); United States v. Yunis, 681 F. Supp. 909, 922–26 (D.D.C. 1988), *reversed by* United States v. Yunis, 859 F.2d 953 (D.C. Cir. 1988); People v. Whitson, 949 P.2d 18, 29–30 (Cal. 1998); People v. Knedler, 329 P.3d 242, 245–46 (Colo. 2014); State v. Camacho, 561 N.W.2d 160, 168 (Minn. 1997).

[80] *E.g.*, United States. v. Bennett, 604 F. App'x 11, 14 (2d Cir. 2015); *Gonzalez*, 719 F. Supp. 2d at 181; *Whitson*, 949 P.2d at 29.

[81] Moran v. Burbine, 475 U.S. 412, 421 (1986).

[82] Colorado v. Connelly, 479 U.S. 157, 170 (1986); *see also* United States v. Sauseda, No. MO-Q9-CR-252, 2011 WL 13137820, at *2 (W.D. Tex. Aug. 9, 2011) ("Without a finding of law enforcement coercion, intimidation, or deception, a court cannot conclude that a waiver of *Miranda* rights was involuntary because of a deficient mental condition or for any other reason." (citing *Connelly*, 479 U.S. at 167; United States v. Raymer, 876 F.2d 383, 386–87 (5th Cir. 1989))).

[83] Colorado v. Spring, 479 U.S. 564, 574 (1987) (quoting Oregon v. Elstad, 470 U.S. 298, 312 (1985)) (internal quotations omitted).

conduct."[84] Just as with determinations of knowledge and intelligence, "the totality of the circumstances" must be evaluated.[85]

Plainly, the methods authorities utilize to elicit a waiver are of critical initial import for determining whether said waiver was voluntary.[86] But since the "voluntary" prong "primarily concerns the *effect* of police conduct"[87] on a defendant's "will" and "capacity for self-determination,"[88] mental competence can also be relevant, as it pertains to an individual's susceptibility to pressure.[89]

However, there exists disagreement among courts on this matter. A meaningful cohort does not heed the Supreme Court's language referencing suspects' "will" and individual "capacity" in waiver voluntariness assessments.[90] The Ninth Circuit's interpretation in *Cox v. Del Papa* concisely articulates the reasoning behind this position:

> The distinction between a claim that a *Miranda* waiver was not voluntary, and a claim that such waiver was not knowing and intelligent, is important. "The voluntariness of a waiver . . . has always depended on the absence of police overreaching." In other words, the voluntariness component turns upon external factors, whereas the cognitive component depends upon mental

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[84] *Id.* (alteration in original) (quoting Culombe v. Connecticut, 367 U.S. 568, 602 (1961)). It should be noted that by quoting *Culombe*, a pre-*Miranda* case, the Court appears to explicitly integrate the standard for a voluntary confession, implicitly invoked in *Miranda*, with that for a voluntary waiver of one's constitutional rights. *See* Derrick v. Peterson, 924 F.2d 813, 820 (9th Cir. 1990) ("*Connelly* clearly holds that the 'voluntariness' inquiry in the *Miranda* waiver context is equivalent to the voluntariness inquiry under the fourteenth amendment . . . ."), *overruled by* United States v. Preston, 751 F.3d 1008, 1019 (9th Cir. 2014); *see also* Commonwealth v. Jackson, 731 N.E.2d 1066, 1070 (Mass. 2000) ("The voluntariness of a Miranda [sic] waiver and the voluntariness of a statement are separate and distinct inquiries, but the 'totality of the circumstances' test under each analysis is the same." (citing Commonwealth v. Edwards, 651 N.E.2d 398, 401 (Mass. 1995))).

[85] *Moran*, 475 U.S. at 421 (internal quotation marks and citations omitted); Fare v. Michael C., 442 U.S. 707, 725 (1979).

[86] *Spring*, 479 U.S. at 574; *Connelly*, 479 U.S. at 170.

[87] People v. May, 859 P.2d 879, 883 (Colo. 1993) (emphasis added).

[88] *Spring*, 479 U.S. at 574 (quoting *Connelly*, 479 U.S. at 163–64) (internal quotations omitted).

[89] *E.g.*, State v. Hajtic, 724 N.W.2d 449, 454 (Iowa 2006); State v. Mattox, 390 P.3d 514, 534 (Kan. 2017); Commonwealth v. Mandile, 492 N.E.2d 74, 76 (Mass. 1986); *see also* United States v. Jensen, No. CR-08-50031, 2010 WL 11537913, at *22 (D.S.D. Feb. 12, 2010) ("[T]he defendant's mental state and ability to resist psychological pressure, as it relates to police coercion, is relevant to the voluntariness inquiry.").

[90] *See, e.g.*, Cox v. Del Papa, 542 F.3d 669, 675 (9th Cir. 2008); Edwards v. State, 842 P.2d 1281, 1285 (Alaska Ct. App. 1992); People v. Humphrey, 132 P.3d 352, 357–59 (Colo. 2006); Wagner v. Commonwealth, No. 2003-SC-0770-MR, 2005 WL 1199050, at *2–3 (Ky. 2005) (citing Mills v. Commonwealth, 996 S.W.2d 473, 482 (Ky. 1999)).

> capacity. Although courts often merge the two-pronged analysis, the components should not be conflated.[91]

Yet a greater number of courts take defendant mental ability into account, appraising it using the same factors for ascertaining knowledge and intelligence.[92] And, identical to the knowing and intelligent inquiry, courts also consider the temporal distance between warnings and waivers and a violent arrest or other stressful event when determining defendant physical and mental capacity at the time of waiver.[93]

D. Discerning Cognitive Capacity

Cognitive capacity is relevant to all three prongs of whether an in-custody waiver of one's Fifth and Sixth Amendment rights is knowing, intelligent, and voluntary. To deduce this characteristic, courts consider a number of variables of varying accuracy.[94] How they compare, balance, and rely on these factors has important implications for the potential impact of research examining CEWs and cognition on waiver assessments.

The evidence courts turn to can be divided into two categories. First, there is evidence divorced from a defendant's behavior at the time of waiver, or *objective indicia* of mental acuity. Some of the main facts under this classification include age and education—generally straightforward attributes that do not involve extensive inquiry or approximating on the part of courts.[95] Measurements of intoxication and intelligence test results are also included. The former can be based on calculations of blood alcohol content at or sufficiently near the time of waiver or a description of the amount of intoxicant consumed prior to it.[96] This subcategory arguably includes medication that

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[91] 542 F.3d at 675 (internal citation omitted).

[92] That is, the factors they consider include: age, maturity, education, intelligence, mental health, intoxication, when warnings and waivers are given, and physical and mental conditions when warnings and waivers are given. *See In re* M.W., 731 N.E.2d 358, 361 (Ill. App. Ct. 2000) ("Although 'voluntariness' in the constitutional sense is distinct from the issue of whether a waiver is knowing and intelligent, the review of each issue includes many of the same factors . . . ." (citing People v. Higgins, 607 N.E.2d 337, 345 (Ill. App. Ct. 1993))).

[93] *See, e.g.*, United States v. Anderson, 695 F.3d 390, 395 (6th Cir. 2012); United States v. Annis, 446 F.3d 852, 854, 856 (8th Cir. 2006).

[94] *See infra* notes 94–110 and accompanying text.

[95] *See, e.g.*, Fare v. Michael C., 442 U.S. 707, 726 (1979); United States v. Sarsevicius, No. 3:15-CR-00091-TBR, 2016 WL 2993217, at *6 (W.D. Ky. May 23, 2016); Williamson v. Hobbs, No. 5:14CV00240JLH-HDY, 2015 WL 925898, at *4–5 (E.D. Ark. Mar. 3, 2015); *In re* S.B., 614 P.2d 786, 789 n.6 (Alaska 1980); State v. Jones, 566 N.W.2d 317, 325 (Minn. 1997).

[96] *See, e.g.*, United States v. Thompson, No. 14-302(DWF/LIB), 2015 WL 144882, at *4 (D. Minn. Jan. 12, 2015); United States v. Vanzile, No. 2:11-cr-21, 2012 WL 1537420, at *1 (W.D. Mich. Apr. 5, 2012); People v. Knedler, 329 P.3d 242, 244 (Colo. 2014); Commonwealth v. Ward, 688 N.E.2d 227, 231 (Mass. 1997); Stevens v. State, 458 So. 2d 726, 727–29 (Miss. 1984).

a defendant imbibed close in time to a waiver, which can impact cognition.[97] With regard to intelligence testing, defendants can take intelligence quotient (IQ) tests and have their abilities represented by a score measured against a standard quantitative scale of mental competence.[98] Stressful events that a defendant experienced prior to waiver that might have influenced his mental functioning can also affect an intelligence analysis. Courts tend to examine the magnitude of any experience and its temporal proximity to the waiver, as well as the severity of any injuries suffered by the defendant that were present during interactions with law enforcement.[99] And the results of mental health evaluations conducted by professionals, though generally more complex and subject to challenge than the facts previously noted, fall within this grouping as well, with diagnoses, insights, and implications for defendant cognition presented to courts.[100]

A defendant's history of interactions with law enforcement is also considered objective evidence. Such facts do not relate to cognitive capacity per se, but instead are used by courts to indicate increased awareness of one's rights and the consequences of waiving them due to repeated exposure to *Miranda* warnings and the workings of the criminal justice system.[101] Even so, courts often weigh such a history against facts that show a defendant possessing deficient mental acuity.[102]

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[97] *See, e.g.*, United States v. Casellas, 149 F. Supp. 3d 222, 245 (D.N.H. 2016); United States v. Keys, No. S-13-0082 KJM, 2014 WL 1232234, at *13 (E.D. Cal. Mar. 24, 2014); United States v. Bogan, No. CR-10-00505-PHX-NVW, 2011 WL 855670, at *1, *3, *5 (D. Ariz. Mar. 10, 2011); Kalisz v. State, 124 So. 3d 185, 203–05 (Fla. 2013); Pruitt v. State, 834 N.E.2d 90, 115–17 (Ind. 2005).

[98] *See, e.g.*, Shields v. United States, 698 F. App'x 807, 811–12 (6th Cir. 2017); Bone v. Polk, No. 1:04CV1074, 2010 WL 2733333, at *5 (M.D.N.C. July 9, 2010); United States v. Goicochea-Perez, No. 4:05-CR-57-06-HLM-WEJ, 2007 WL 9672632, at *5 (N.D. Ga. May 23, 2007); Fairchild v. Lockhart, 744 F. Supp. 1429, 1431 (E.D. Ark. 1989); Rankin v. State, 1 S.W.3d 14, 19 (Ark. 1999).

[99] *See, e.g.*, United States v. Havlik, 710 F.3d 818, 822–23 (8th Cir. 2013); United States v. Anderson, 695 F.3d 390, 395 (6th Cir. 2012); United States v. Annis, 446 F.3d 852, 854, 856 (8th Cir. 2006); United States v. Gonzalez, 719 F. Supp. 2d 167, 180–83 (D. Mass. 2010).

[100] *See, e.g.*, Garner v. Mitchell, 557 F.3d 257, 263–71 (6th Cir. 2009); United States v. Granado, No. 09-471-6, 2012 WL 12888670, at *7–8 (E.D. Pa. Feb. 9, 2012); Lynch v. Hudson, No. 2:07-cv-948, 2011 WL 4537890, at *61–67 (S.D. Ohio Sept. 28, 2011); Wacker v. State, No. 96-3126-DES, 1999 WL 138901, at *3 (D. Kan. Jan. 25, 1999); People v. Cheatham, 551 N.W.2d 355, 359, 365 (Mich. 1996).

[101] *See* Lawrence S. Leiken, *Police Interrogation in Colorado: The Implementation of* Miranda, 47 DENV. L.J. 1, 20 (1970) ("A . . . background factor which has been used by judges to impute knowledge to a suspect is his number of previous arrests and felony convictions. The assumption here [is] that if the suspect has had a substantial number of previous experiences with the criminal process, he will be more knowledgeable about his rights and more willing to assert them."). The study cited in this footnote finds that "those with fewer than eight arrests made about the same number of statements as those with more, but those with less than eight arrests had a slightly greater tendency to confess than those with more arrests," and "those with fewer previous felony convictions had a slightly greater tendency to make statements and confessions than those with more previous felony convictions." *Id.*

[102] *See, e.g.*, State v. Tothill, 586 P.2d 655, 657–58 (Ariz. Ct. App. 1978); People v.

The aforementioned evidence aimed at cognitive capacity is generally objectively indicative of this quality. For example, a study found that participants whose IQ test scores categorized them as intellectually disabled were unable to understand *Miranda* warnings.[103] Moreover, some whose scores slightly exceed that which typically demarks intellectual disability were also unable to understand the warnings.[104] Such research has been conducted with regard to a number of other factors as well.[105] Another study found that psychiatric patients performed only slightly better than those who were intellectually disabled in terms of understanding *Miranda* warnings.[106] And a third found that, "as a class, juveniles younger than fifteen do not understand at least some of their *Miranda* rights."[107]

Nevertheless, these types of facts are often discounted by courts in waiver determinations in favor of a second category of evidence: direct observations of defendant appearance and behavior at the time of waiver,[108] or *subjective indicia* of mental acuity. Courts routinely base appraisals of defendants' cognitive abilities on the individuals' conduct when they waived their rights, paying attention to such things as temperament, tone, manifestations of confusion, comments indicating understanding, and apparent reasoning ability.[109] In so doing, courts may rely on

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Thames, 344 P.3d 891, 896–97, 897 n.6 (Colo. 2015); People v. Pond, 629 N.Y.S.2d 111, 112–13 (N.Y. App. Div. 1995). It has even been argued that "prior criminal experience can be a valid proxy for the knowledge and intelligence necessary to waive one's Fifth Amendment rights to silence and counsel." Thomas P. Windom, Note, *The Writing on the Wall:* Miranda*'s "Prior Criminal Experience" Exception*, 92 VA. L. REV. 327, 331 (2006).

[103] Morgan Cloud et al., *Words Without Meaning: The Constitution, Confessions, and Mentally Retarded Suspects*, 69 U. CHI. L. REV. 495, 501 (2002).

[104] *Id.*

[105] *See* Charles D. Weisselberg, *Mourning* Miranda, 96 CALIF. L. REV. 1519, 1564–74 (2008) (providing a summary of research on the effects of certain factors on *Miranda* warning comprehension, such as age, education, reading ability, and mental health).

[106] Virginia G. Cooper & Patricia A. Zapf, *Psychiatric Patients' Comprehension of* Miranda *Rights*, 32 L. & HUM. BEHAV. 390, 400–01 (2008).

[107] Thomas Grisso, *Juveniles' Capacities to Waive* Miranda *Rights: An Empirical Analysis*, 68 CALIF. L. REV. 1134, 1160 (1980).

[108] *See, e.g.*, Smith v. Duckworth, 824 F.3d 1233, 1247–48 (10th Cir. 2016); Bone v. Polk, 441 F. App'x 193, 197–98 (4th Cir. 2011); United States v. Turner, 157 F.3d 552, 555–56 (8th Cir. 1998); Moore v. Dugger, 856 F.2d 129, 134–35 (11th Cir. 1988); Byrd v. State, 78 So.3d 445, 454 (Ala. Crim. App. 2009); People v. Clayton, 207 P.3d 831, 836, 838 (Colo. 2009); *see also* United States v. Spencer, 995 F.2d 10, 11 (2d Cir. 1993) ("Whether a waiver is 'knowing and voluntary' is a question directed to a defendant's state of mind, *which can be inferred from his actions and statements*." (emphasis added)); Cloud et al., *supra* note 103, at 527–31 (observing patterns in the factors that courts utilize to determine waiver validity, including the consistent discounting of intelligence (as revealed by IQ testing), age, and education).

[109] *See supra* note 108 and accompanying text; *see also* People v. Bernasco, 562 N.E.2d 958, 966 (Ill. 1990) ("The trial court here reached its conclusion after hearing police, parental, and psychological testimony and—*what is very significant—making its own observations of defendant while he was testifying*." (emphasis added)).

recordings, transcripts, or the testimony of authorities present at the time.[110] Courts give substantial weight to this category of evidence, and are rarely moved by objective indicia unless they clearly evince a defendant with severely compromised cognitive faculties.[111]

The current landscape of court assessments of mental capacity and the influence of this factor on findings of waiver validity presents a high bar for studies of CEWs and cognitive capacity to scale in order to meaningfully impact waiver determinations, let alone motivate a per se rule shielding those struck by these devices from law enforcement questioning for a set amount of time post-strike. The small number of published court orders and opinions addressing CEWs in waiver assessments help illuminate this predicament.[112]

E. Conducted Electrical Weapons Cases

The argument that being struck by a CEW might compromise an individual's mental processes—and thereby her ability to issue a knowing, intelligent, and voluntary waiver of her constitutional rights—appears only relatively recently in published court rulings. This is somewhat surprising given the common knowledge that brain function is electrically modulated and that CEWs incapacitate individuals by way of electrical current.[113] This subsection presents the small stable of published court orders and opinions in which this argument is broached.[114]

To begin with, in *State v. Sudduth*, the defendant was involved in a high-speed chase following a robbery.[115] When his vehicle was finally stopped, he attempted to flee on foot, but was tackled by a police officer.[116] Sudduth continued resisting so

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[110] *See, e.g.*, *Duckworth*, 824 F.3d at 1248; *Bernasco*, 562 N.E.2d at 968.

[111] *See, e.g.*, United States v. Garibay, 143 F.3d 534, 537–39 (9th Cir. 1998); Cooper v. Griffin, 455 F.2d 1142, 1144–46 (5th Cir. 1972); Brown v. Crosby, 249 F. Supp. 2d 1285, 1308–09 (S.D. Fla. 2003); United States v. Robles-Ramirez, 93 F. Supp. 2d 762, 766–68 (W.D. Texas 2000); T.S.D. v. State, 741 So.2d 1142, 1143–44 (Fla. Dist. Ct. App. 1999).

[112] *See infra* Section I.E.

[113] The devices and their effects are frequently addressed with regard to law enforcement use of excessive force and the Fourth Amendment, and have been for some time. *See, e.g.*, Cockrell v. City of Cincinnati, 468 F. App'x 491, 491 (6th Cir. 2012); Brown v. City of Golden Valley, 574 F.3d 491, 495, 500 (8th Cir. 2009); McKenzie v. City of Milpitas, 738 F. Supp. 1293, 1296 (N.D. Cal. 1990). *See generally, e.g.*,Bailey Jennifer Woolfstead, *Don't Tase Me Bro: A Lack of Jurisdictional Consensus Across Circuit Lines*, 29 T.M. COOLEY L. REV. 285 (2013); Aaron Sussman, Comment, *Shocking the Conscience: What Police TASERs and Weapon Technology Reveal About Excessive Force Law*, 59 UCLA L. REV. 1342 (2012).

[114] Defendants have also raised the argument that CEW strikes prevented them from making voluntary statements and confessions. *See, e.g.*, United States v. Stoner, 466 F. App'x 720, 725–29 (10th Cir. 2012); United States v. Bohanon, 629 F. Supp. 2d 802, 824 (E.D. Tenn. 2009); United States v. Irons, 646 F. Supp. 2d 927, 964–65 (E.D. Tenn. 2009).

[115] No. 93,633, 2006 WL 90102, at *1 (Kan. Ct. App. Jan. 13, 2006).

[116] *Id.*

officers struck him twice with a TASER.[117] On the drive to a police station, he made unprompted incriminating statements.[118] Once at the station, officers administered a *Miranda* warning and the defendant waived his rights and confessed.[119] At a suppression hearing, arguing that he did not knowingly, intelligently, or voluntarily waive his constitutional rights, Sudduth "testified that on the day of the robbery he had not eaten since 9 a.m., had consumed a half pint of vodka and smoked a 'wet' cigarette (a cigarette dipped in PCP and embalming fluid), and was thinking slower than normal because of the multiple Taser [sic] stuns."[120] The trial court, however, dismissed these claims, finding that the defendant testified "that he understood his rights and that he had waived them," and that his behavior when he waived his rights indicated knowledge and intelligence.[121] The court also concluded that the conditions of the interrogation and the defendant's apparent cognitive abilities showed that his waiver was voluntary.[122] The waiver was therefore validated, and the appellate court affirmed the ruling.[123]

In *United States v. Chancellor*, the defendant was seen by a police officer selling narcotics.[124] When the officer moved to arrest him, he pushed the officer's arm away and attempted to flee.[125] The officer gave chase and "deployed his Taser [sic], which stuck Chancellor in his back and shoulder. Chancellor fell to the ground, ending up on his back. When the five second [sic] electric current concluded, the officer directed Chancellor not to move, and Chancellor complied."[126]

The TASER was deployed at 12:39 p.m.[127] After going to a hospital where a doctor removed the TASER's darts from the defendant's body, he was brought to a police station and placed in a holding cell at 4:39 p.m., where he was administered a *Miranda* warning, waived his rights, and confessed.[128] At a suppression hearing, Chancellor argued that his waiver was neither knowing nor intelligent "because of his extremely low IQ, and because at the time he was read those rights he was very intoxicated by drugs and alcohol, sleep-deprived and suffering from the effects of having been Tasered [sic]."[129] In detail, the court explains its sympathy for the low IQ score and intoxication contentions,[130] and then addresses that involving the TASER strike:

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117 *Id.*
118 *Id.*
119 *Id.*
120 *Id.*
121 *Id.* at *2.
122 *Id.*
123 *Id.* at *3.
124 No. 07-20578-CR, 2008 WL 622937, at *1 (S.D. Fla. Feb. 8, 2008).
125 *Id.*
126 *Id.* (internal citation omitted).
127 *Id.*
128 *Id.* at *2–3.
129 *Id.* at *10.
130 *Id.* at *11–13.

> Chancellor also argues that the Tasering [sic] further compromised his ability to knowingly and intelligently waive his *Miranda* rights, and relies upon Dr. Seely's opinion that "I think the electrical shock through the brain further compromised his already compromised state." Dr. Seely acknowledged that he has not researched the effect of Tasers [sic] on cognitive function. Further, it is undisputed that the Defendant was not questioned until four hours after he was Tasered [sic]. While Dr. Seely's opinion on this point could have basis in fact, on this record, this Court gives it very little weight.[131]

Nevertheless, based on the defendant's other arguments, the court found that the defendant's waiver was not valid and suppressed his statements.[132]

In *United States v. Mack*, the defendant was pulled over on a highway under suspicion of trafficking narcotics.[133] When one of the two officers present, after receiving permission from Mack, looked in the defendant's trunk and found cocaine and a firearm, he proceeded to place Mack under arrest.[134] The defendant, however, fled on foot, and the second officer pursued.[135] After several hundred feet, Mack fell to the ground, at which point the pursuing officer repeatedly ordered him to remain there.[136] But the defendant refused, so the officer deployed his TASER.[137] At this point, the court's recitation of the facts is a bit odd. It states that Mack was hit "in the arm with one of [the TASER's two] probes."[138] But in order for the device to introduce an electrical current into a subject, both darts must embed.[139] It is therefore unclear if Mack experienced a true TASER strike or was simply struck by one of the device's darts. Continuing, the court describes the defendant ending up on the ground again as a result of this strike.[140] He continued resisting, however, and the officer administered the TASER two more times, but in "drive stun" mode.[141] In this mode, the device is placed directly against someone and elicits pain, but does not introduce electrical current into the body.[142] The court, however, appears to treat all three applications of the TASER identically, stating, "Each burst from a taser [sic] lasts five seconds, unless the officer keeps his finger on the trigger. [The officer]'s

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131 *Id.* at *14 (internal citations omitted).
132 *Id.*
133 No. 07-238, 2009 WL 580430, at *1 (M.D. La. Mar. 6, 2009).
134 *Id.*
135 *Id.*
136 *Id.*
137 *Id.*
138 *Id.*
139 *See infra* Section II.B.2.
140 *Mack*, 2009 WL 580430, at *1.
141 *Id.*
142 *See infra* notes 215–20 and accompanying text.

taser [sic] administered two five second [sic] electrical bursts, each burst carrying between .0021 and .0036 amps. The third burst lasted six seconds."[143]

But these specifications only apply to ranged TASER strikes in which a device's darts shoot out, lodge in a suspect, and conduct electrical current through him.[144] There was apparently only one TASER administration of this sort: the first.[145] The next two did not involve electrical current flowing through the defendant, so the fact that the third lasted six seconds is only relevant in so far as it describes how long Mack experienced pain from being exposed to the device in drive stun mode.[146] The court's lack of understanding aside, the officer that subdued Mack administered a *Miranda* warning as they returned to the parked cars, after which the defendant confessed.[147] At a suppression hearing, Mack argued that the TASER strikes "rendered him incapable of understanding his rights under *Miranda* or of effectively waiving those rights" and "created a coercive environment such that his subsequent confession was not free and voluntary."[148] The court, however, heeded the testimony of two officers, including the one who subdued Mack, who put forth:

> [D]uring training in the use of the taser [sic], officers, including themselves, experienced pain while the taser [sic] was used against them. They also testified, however, that after the bursts of electricity from the taser [sic] discharged into their bodies stopped, the pain they experienced during those discharges ended immediately, and they were able to function normally.[149]

The court also notes, "Mr. Mack does not submit supporting case law or evidence indicating that administration of a taser [sic] renders the recipient incompetent for any amount of time."[150] It therefore found that "the bursts of electricity were short and sufficient enough to enable the defendant to understand and comply with commands."[151] Based on this finding and two more (that Mack did not behave abnormally when he waived his rights and that the amount of force used was

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143 *Mack*, 2009 WL 580430, at *1.

144 *See infra* Section II.B.2.

145 *Mack*, 2009 WL 580430, at *1.

146 *See* Brooks v. City of Seattle, 599 F.3d 1018, 1027 (9th Cir. 2010) (recognizing that, in "dart mode," a TASER discharges from a distance and "embed[s] . . . barbed electrical probe[s]" in the target, and a "powerful electrical pulse [is] delivered" causing her "to lose . . . muscular control," whereas "[t]he use of the [TASER] in drive-stun mode is painful, certainly, but also temporary and localized, without incapacitating muscle contractions"); *see also infra* notes 215–20 and accompanying text.

147 *Mack*, 2009 WL 580430, at *1.

148 *Id.* at *3.

149 *Id.* at n.11.

150 *Id.* at n.9.

151 *Id.* at *3.

appropriate), the court concluded that the defendant's waiver was knowing, intelligent, and voluntary.[152]

In *United States v. Patterson*, the defendant was approached by a police officer after the latter observed what he believed to be the defendant dropping a firearm into a car's open window upon noticing the officer.[153] When the defendant continued hurriedly walking away after repeated entreaties to halt, the officer "deployed his Taser [sic] weapon, striking Defendant in the upper left shoulder and middle to lower right side of his back. Upon receiving the single, five second [sic] blast of electricity from the Taser [sic], Defendant fell to the ground" and was arrested.[154] Emergency medical personnel were called to attend to Patterson, and the officer procured the firearm from the car while they arrived and did this.[155] Once the paramedics left, the officer administered a *Miranda* warning and asked if the defendant would speak to him without an attorney present.[156] Patterson agreed and, shortly thereafter, confessed to owning the firearm and that it was procured illegally.[157] At a suppression hearing, the defendant argued that he did not make a knowing, intelligent, or voluntary waiver "because the effects of the Taser [sic] discharge on his person and his asserted state of intoxication."[158] The court clarifies, "Defendant appears to argue the Taser [sic] discharge and his alleged intoxication interfered with his mental capacity to appreciate the consequences of waiving his rights."[159] However, based on Patterson's behavior at the time he waived and his prior experience with the criminal justice system, it found this assertion unpersuasive,[160] noting with regard to the TASER strike:

> [Jacksonville Sheriff's Office] training specialist Larry Monts, who himself has been tased on more than one occasion and has discharged the Taser [sic] on other officers in training approximately 1200 times, testified that electrical charge generated from the Taser [sic] affects the muscle tissue, but it does not affect the brain. Mr. Monts further stated that no one he has tased has ever lost cognitive function, or the ability to speak and otherwise communicate rationally. In his opinion, even if a person had been drinking alcohol the Taser [sic] would not have a different effect on the person tased. Mr. Monts testified he had read the

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[152] *Id.*
[153] No. 3:09-cr-7(S1)-J-32TEM, 2009 WL 10670083, at *1 (M.D. Fla. June 22, 2009).
[154] *Id.* at *1–2 (internal citation omitted).
[155] *Id.* at *2.
[156] *Id.*
[157] *Id.* at *2–3.
[158] *Id.* at *4.
[159] *Id.* at *6.
[160] *Id.* at *7.

> available research literature from Taser [sic] International and those studies report these same findings.[161]

Based on his behavior at the time of waiver, the court ultimately found that the defendant knowingly, intelligently, and voluntarily waived his rights.[162]

Finally, in *United States v. Jackson*, the defendant was seen by police officers striking a woman in a car.[163] When he refused to stop after being ordered to, an officer "deployed his taser [sic], striking the man. The man fell out of the [vehicle] and was placed under arrest."[164] Marijuana and ecstasy were found in the defendant's pockets.[165] After being brought to a police station, a *Miranda* warning was given to Jackson, who waived his rights and then confessed.[166] At a suppression hearing, the defendant argued that "after having been subjected to a 50,000-volt taser [sic], [he] was in no condition to voluntarily waive anything."[167] (It should be noted that TASERs actually subject targets to electrical currents with voltages far less than 50,000 volts.)[168] But one of the arresting officers

> testified concerning the effects of a taser [sic]. [He] stated that the taser [sic] application is painful during the five seconds that it is on, but that after the five seconds there is no pain to the taser [sic] recipient. [He] had been tased at his own request. He reported, "As soon as the tasing, the actual shock stops, you feel a moment of relief. But the pain doesn't continue, no, sir."[169]

As a result of this testimony and the defendant's actions when he waived his rights and after, "[t]he court finds that there is no evidence that the defendant's will was overborne, either by his experience with the taser [sic] or from alcohol that he may have consumed."[170]

The cases above largely see courts following the path presented in the previous subsection: valuing evidence of a defendant's appearance and behavior at the time of waiver over metrics divorced from the interaction in question. In the one case where this did not occur, *Chancellor*, the fact that the defendant experienced a TASER strike prior to his invalidated waiver had almost no influence on the court's determination.[171]

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[161] *Id.* at *6 (internal citations omitted).
[162] *Id.* at *8.
[163] No. 1:08CR00076SNLJ, 2010 WL 254927, at *1 (E.D. Mo. Jan. 19, 2010).
[164] *Id.*
[165] *Id.*
[166] *Id.* at *1–2.
[167] *Id.* at *3.
[168] *See infra* Section II.B.2.
[169] *Jackson*, 2010 WL 254927, at *3.
[170] *Id.* at *5.
[171] United States v. Chancellor, 2008 WL 622937, at *1–14 (S.D. Fla. Feb. 8, 2008).

This shows that research on CEWs and cognition must clearly reveal substantial impairment if it is to meaningfully influence courts, and length of impairment matters greatly given the wide disparities in the times between CEW strikes and waivers.

However, along with demonstrating encumbrances that studies of CEWs and cognition face in influencing courts, the cases above make apparent the need for a better understanding of CEWs in the legal community and in legal contexts. A number of decisions evince glaring knowledge failings when it comes to CEW technology. *Mack* displays a lack of appreciation for the differences between the dart and drive-stun modes of TASERs, which matter immensely in terms of whether electrical current is introduced into the body (it is with the former and is not with the latter) and what an individual experiences.[172] And *Jackson* presents TASERs as subjecting targets to 50,000-volt electrical currents, a figure significantly above the actual voltage emitted.[173]

There are also issues with who testifies as an expert when it comes to CEWs. In *Chancellor*, a psychiatrist with no special knowledge of CEWs stated, "I think the electrical shock through the brain further compromised his already compromised state."[174] To its credit, the court gives "very little weight" to this testimony.[175] But in *Mack*, *Patterson*, and *Jackson*, police officers who have been tased as part of their training, tased others during training, or "read the available research literature" from the company that makes TASERs offered testimony on the effects of these devices that appears to have been accorded great weight.[176] While hearing about CEW impacts from those who have experienced them is helpful, the perspectives of these individuals should be at least somewhat discounted for several reasons: the officers were tased in controlled, nonconfrontational settings after which they were more than likely not required to engage in complex mental or physical tasks; they have not conducted peer-reviewed research on the effects of CEWs, nor did they base their opinions on any such works; they have no specialized knowledge of the actual mechanism by which CEWs incapacitate subjects or whether it might have additional effects; and they are biased information sources.

Despite these issues, the fact that the cases above cluster between 2006 and 2010 may lead some to argue that research examining whether CEWs meaningfully impact mental acuity, and therefore the ability to knowingly, intelligently, and voluntarily waive his Fifth and Sixth Amendment rights, is not overly necessary. But most court evidentiary rulings are not published or catalogued by legal research

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[172] *See infra* notes 217–22 and accompanying text; *see also infra* Section II.B.2.

[173] *See infra* Section II.B.2.

[174] 2008 WL 622937, at *14 (internal quotations omitted).

[175] *Id.*

[176] United States v. Patterson, No. 3:09-cr-7(S1)-J-32 TEM, 2009 WL 10670083, at *6 (M.D. Fla. June 22, 2009); United States v. Mack, No. 07-238, 2009 WL 580430, at * 3 (M.D. La. Mar. 6, 2009); United States v. Jackson, No. 1:08CR00076SNLJ, 2010 WL 254927, at *3 (E.D. Mo. Jan. 19, 2010).

services. Moreover, the ubiquity of CEWs and CEW use in law enforcement tells a different story. These devices are carried by most police officers in America (ninety percent by one estimate)[177] and are frequently discharged against suspects (perhaps 300,000 times per year).[178] CEWs touch scores of lives annually, and effort should be expended to ensure that these individuals are able to exercise their constitutional rights and the criminal legal system is functioning in a just manner.

In addition, as expounded upon below, researchers examining CEWs and cognition present findings that they claim militate towards per se legal rules shielding suspects who have been tased from questioning for a set amount of time.[179] And this work is beginning to be cited by courts.[180] Given the widespread use of CEWs in law enforcement, it is more than likely that enterprising defense counsel will begin to frequently turn to this research. Providing practitioners with the tools to accurately present and appraise this work is therefore a valuable endeavor.

II. CONDUCTED ELECTRICAL WEAPONS

CEWs administer electrical current to the bodies of targets. Since the brain mediates the mind and the function of the brain is mediated by electrical forces,[181] it is intuitive to think that CEWs might have some influence on cognition. And given the widespread diffusion of these devices throughout law enforcement, this potential influence may impact a significant number of individuals' ability to knowingly, intelligently, and voluntarily waive their Fifth and Sixth Amendment rights. This section seeks to add clarity to the aforementioned conjecture by presenting the history of CEWs, how they work, and an in-depth examination of the state of research on these devices and cognition and its legal implications.

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[177] Matt Stroud, *One Company Supplies Tasers to Virtually Every Police Department in the U.S.*, CITYLAB (Dec. 14, 2015), https://www.citylab.com/equity/2015/12/one-company-supplies-tasers-to-virtually-every-police-department-in-the-us/420369/ [https://perma.cc/57E8-RU5V].

[178] Sarah Kaufman, *Law Enforcement Agencies Use Tasers over 300,000 Times a Year*, VOCATIV (June 1, 2015, 9:15 AM), http://www.vocativ.com/197340/law-enforcement-agencies-use-tasers-over-300000-times-a-year/index.html [https://perma.cc/CG3P-5MGA].

[179] Kane & White, *supra* note 22, at 100–01.

[180] *See* Morris v. State, 554 S.W.3d 98, 106–07 (Tex. Ct. App. 2018) (citing such recent research on CEWs and cognition favorably when describing potential harms in a case where a trial judge forced a defendant to wear a "shock belt" during trial and activated it to electrically shock him to maintain court decorum).

[181] *See, e.g.*, JOSEPH LEDOUX, SYNAPTIC SELF: HOW OUR BRAINS BECOME WHO WE ARE 47 (2002) (describing the electrical aspects of neuronal activity and communication); STEVEN PINKER, THE BLANK SLATE: THE MODERN DENIAL OF HUMAN NATURE 41 (2002) ("One can say that information-processing activity of the brain *causes* the mind, or one can say that it *is* the mind, but in either case the evidence is overwhelming that every aspect of our mental lives depends entirely on physiological events in the tissues of the brain.").

A. A Brief History

The first electrical devices deployed as weapons by American law enforcement were electric cattle prods, used by officers against civil rights demonstrators in the 1960s.[182] Around since the late 1890s,[183] these simple devices, consisting of two prongs at the end of a long barrel, deliver an electric shock to the target.[184] They do not incapacitate a subject, but rather induce movement or compliance through the elicitation of pain at a localized area of the body, and they cannot accurately be described as *conducted* electrical weapons because electricity is not conducted through the target.[185]

In the mid-twentieth century, police officers' use of electric cattle prods, called "shock batons," and other "non-lethal" means of crowd control such as water cannons stoked public outrage and led to calls for the employment of less brutal methods.[186] Addressing public safety and law enforcement methods, President Lyndon Johnson's Commission on Law Enforcement and Administration of Justice, in its seminal 1967 report, *The Challenge of Crime in a Free Society*, called for non-lethal weapons suitable for deployment in situations that might otherwise call for the use of a gun.[187] Such a "weapon should be immediately available and ready for instant use" and "must incapacitate its victim at least as fast as a gun."[188] In addition, it should have "little risk of permanent injury to the individual who is the target."[189]

The report reached an enterprising National Aeronautics and Space Administration physicist named John Cover, who, a few days later, read a newspaper article reporting on "a man who had inadvertently walked into an electrified fence and survived, though he was temporarily immobilized."[190] Inspired by these works, Cover conceived a device in 1969 that uses electricity to attain the results sought by the

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[182] *E.g.*, DARIUS REJALI, TORTURE AND DEMOCRACY 227–29 (2007); Melissa Mann, *Police History: How a NASA Scientist Invented the TASER*, POLICE ONE (Mar. 21, 2016), https://www.policeone.com/police-products/less-lethal/TASER/articles/164475006-Police-History-How-a-NASA-scientist-invented-the-TASER/ [https://perma.cc/34AF-48W2].

[183] *See* U.S. Patent No. 427,549, at [26–29, 39] (filed Mar. 18, 1890) (patenting an "electric prod-pole" for the purpose of "excit[ing] cattle to cause them to move forward" by way of an "electric shock").

[184] REJALI, *supra* note 182, at 229; Sarah Stone, *Who Invented the TASER?*, TODAY I FOUND OUT (Oct. 7, 2014, 8:00 AM), https://www.todayifoundout.com/index.php/2014/10/invented-taser/ [https://perma.cc/YSL7-6BV9].

[185] REJALI, *supra* note 182, at 229; Stone, *supra* note 184.

[186] SEANTEL ANAÏS, DISARMING INTERVENTION: A CRITICAL HISTORY OF NON-LETHALITY 127 (2015); Mann, *supra* note 182.

[187] PRESIDENT'S COMM'N ON LAW ENF'T & ADMIN. OF JUSTICE, THE CHALLENGE OF CRIME IN A FREE SOCIETY 265 (1967), https://www.ncjrs.gov/pdffiles1/nij/42.pdf [https://perma.cc/QB6W-M7W8].

[188] *Id.*

[189] *Id.*

[190] Bruce Weber, *Jack Cover, 88, Physicist Who Invented the Taser Stun Gun, Dies*, N.Y. TIMES (Feb. 16, 2009), http://www.nytimes.com/2009/02/16/us/16cover.html?_r=0 [https://perma.cc/G7ZV-QSQ3]; *see* REJALI, *supra* note 182, at 231–32.

Johnson Administration: a weapon that fires two barbed darts into a subject, each connected to a handheld portion by two wires through which an electric current is delivered to the target.[191] In honor of the novel *Tom Swift and His Electric Rifle*, in which the protagonist invents an electric rifle that shoots bolts of electricity, Cover named the device the "Thomas Swift Electric Rifle," and initially referred to it as the "T.S.E.R."[192] This, however, became cumbersome, so he added an "A" and it became the "TASER."[193]

With a viable prototype in hand by 1970, Cover formed a company called TASER Systems and reached out extensively to law enforcement, military, and civilian actors building awareness and interest, ultimately catching the receptive ear of the airline industry in 1971.[194] Airplane hijacking experienced its heyday in the 1960s and 1970s due to global political tumult and lax passenger screening,[195] but potential protective measures recommended at the time, such as placing more law enforcement officers on flights and arming airline employees, were limited by the fact that projectile weapons (e.g., guns) are an extremely unsafe security tool onboard an aircraft.[196] Tethered darts that administer electricity, however, pose far less risk to innocents and the integrity of the plane itself.[197] But one important detail still caused trepidation on the part of airlines and investors: TASERs of the time used explosive propellant, like guns, to launch their darts, possibly subjecting them to stringent government firearms regulations that would severely limit their marketing and potential use on airplanes.[198] Cover therefore approached the Treasury Department—one of the relevant federal offices—on this matter and convinced officials not to classify TASERs as firearms (it was classified as a gun, but not a firearm).[199]

Despite Cover's initial success with regulators, other events precipitated the quick evaporation of airline interest in his product.[200] In 1973, the Nixon Administration

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[191] REJALI, *supra* note 182, at 231–32; *see also* U.S. Patent No. 4,253,132 (filed Dec. 29, 1977); U.S. Patent No. 3,803,463 (filed July 10, 1972). Interestingly, patent examiners initially deemed Cover's invention anticipated by a patent from the early 1850s covering an "Electric Whaling Apparatus," which is essentially a CEW for use on whales that delivers electrical current through a modified harpoon. Robert A. Stratbucker, *The Scientific History*, *in* TASER CONDUCTED ELECTRICAL WEAPONS: PHYSIOLOGY, PATHOLOGY, AND LAW 19 (Mark W. Kroll & Jeffrey D. Ho eds., 2009); *see* U.S. Patent No. 8,843 (filed Sept. 26, 1851).

[192] Weber, *supra* note 190. *See generally* APPLETON, *supra* note 7.

[193] Weber, *supra* note 190.

[194] REJALI, *supra* note 182, at 233.

[195] JEFFREY C. PRICE & JEFFREY S. FORREST, PRACTICAL AVIATION SECURITY: PREDICTING AND PREVENTING FUTURE THREATS 53–55 (3d ed. 2016).

[196] Greg Meyer, *Conducted Electrical Weapons: A User's Perspective*, *in* TASER CONDUCTED ELECTRICAL WEAPONS: PHYSIOLOGY, PATHOLOGY, AND LAW, *supra* note 191, at 2; REJALI, *supra* note 182, at 233.

[197] Meyer, *supra* note 196.

[198] REJALI, *supra* note 182, at 233.

[199] JOHN MURRAY & BARNET RESNICK, A GUIDE TO TASER TECHNOLOGY: STUNGUNS, LIES AND VIDEOTAPE 26 (1997).

[200] *Id.* at 32–33.

mandated new, more effective passenger screening procedures, including the use of electronic search equipment.[201] This development ended the scourge of plane hijackings, obviating airline need for the TASER.[202] Over the next few years, however, Cover successfully pivoted to selling to individuals, private security firms, and police.[203] But outside forces again worked against his success, this time more directly. By 1975, criminal use of TASERs prompted police to raise their voices in opposition to the relatively unregulated sale of these devices, with the gun industry and National Rifle Association joining the chorus.[204] The same year, California and New Jersey classified the weapon as a firearm, requiring that each one sold be registered and purchasers be licensed.[205] And by the end of the year, the Consumer Product Safety Commission (CPSC) halted all sales in order to conduct further safety testing.[206]

Yet by early 1976, the CPSC was satisfied with the safety of the TASER and rescinded its ban.[207] Nevertheless, the Treasury Department changed course and classified the weapon as a firearm, not just a gun as before, and the Bureau of Alcohol, Tobacco, and Firearms followed suit.[208] This subjected TASERs to stringent regulations: they could only be sold at gun shops, the Department of State had to approve all overseas sales, and foreign clients needed their government's approval for purchases.[209] Cover's prearranged deals were killed and the foreign market dissipated.[210] With police departments still uninterested in the product, TASER Systems hemorrhaged investors and was steadily collapsing in the late 1970s.[211]

The decline would halt with the extension of a lifeline in 1979.[212] As a result of widespread accusations of police brutality, related soaring litigation costs, and individual incidents of officer violence that commanded national media attention, the Los Angeles Police Department (LAPD) took another look at the TASER (having previously rejected it twice).[213] The Department ultimately adopted the weapon in 1981, but device issues revealed through extensive real world use demanded substantial design and production alterations that ultimately led Cover's TASER

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[201] Fred Ferretti, *Zap!*, N.Y. TIMES, Jan. 4, 1976, at 13, https://www.nytimes.com/1976/01/04/archives/zap.html.

[202] REJALI, *supra* note 182, at 234.

[203] *Id.*

[204] *Id.*; Ferretti, *supra* note 201, at 13.

[205] REJALI, *supra* note 182, at 234; Ferretti, *supra* note 201, at 13.

[206] REJALI, *supra* note 182, at 234; Stratbucker, *supra* note 191, at 19–20.

[207] REJALI, *supra* note 182, at 234; Stratbucker, *supra* note 191, at 19–20.

[208] REJALI, *supra* note 182, at 234–35; *see also* 27 C.F.R. § 178.11 (1976).

[209] MURRAY & RESNICK, *supra* note 199, at 31.

[210] REJALI, *supra* note 182, at 235.

[211] MURRAY & RESNICK, *supra* note 199, at 32; REJALI, *supra* note 182, at 235.

[212] REJALI, *supra* note 182, at 235–36.

[213] *Id.*; Meyer, *supra* note 196, at 3; Elaine Woo, *Jack Cover Dies at 88; Scientist Invented the Taser Stun Gun*, L.A. TIMES (Feb. 13, 2009, 12:00 AM), http://www.latimes.com/local/obituaries/la-me-jack-cover13-2009feb13-story.html [https://perma.cc/KJ8V-XWLC].

Systems to declare bankruptcy in the mid-1980s.[214] It sold all of its interests to investors, who continued operating the company as Tasertron beginning in 1986.[215] Tasertron exclusively supplied police, security, and military agencies, including continuing to supply the LAPD.[216]

As a quick aside to clarify technology and terminology, around the time of TASER Systems' demise, companies marketing commercial "stun guns" appeared.[217] Akin to the electric cattle prods mentioned above,[218] such devices are not range weapons and must be physically pressed against targets, inducing compliance through the elicitation of pain rather than incapacitation.[219] Stun gun companies benefitted from the awareness of electrical weapons that Cover cultivated, and both directly and indirectly used the well-known TASER brand to market their products despite critical differences.[220] In addition, stun guns are far less complicated and therefore less expensive than TASERs, and, despite their name, are not regulated as guns since they do not fire projectiles, thereby avoiding the strict sales limitations that applied to TASERs of the time.[221] The aforementioned tactics and advantages helped stun gun companies find success selling to both police and the broader public.[222]

Turning back to CEWs, Tasertron was the predominant provider of these weapons for a number of years following its formation from the ashes of TASER Systems.[223] But troubles plagued its products, severely limiting demand.[224] The devices suffered many technical and design problems and often failed to operate correctly in the field, not to mention extensive officer misuse and abuse.[225] In addition, contrary to expectations, Tasertron's most important customer, the LAPD, experienced increased civil liability claims and payments, increased personnel complaints, and a diminished public image.[226] The most famous incident occurred in 1991 and involved LAPD officers deploying a Tasertron TASER twice against an African-American man named Rodney King.[227] When this failed to subdue him, it was assumed King was on the drug Phencyclidine (PCP), thought to make users especially tenacious and

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[214] NEIL DAVISON, 'NON-LETHAL' WEAPONS 34 (2009); REJALI, *supra* note 182, at 236–37.

[215] DAVISON, *supra* note 214, at 34.

[216] *Id.*

[217] REJALI, *supra* note 182, at 242–44; Paul C. Nystrom, *The Conducted Electrical Weapon: Historical Overview of the Technology*, *in* ATLAS OF CONDUCTED ELECTRICAL WEAPON WOUNDS AND FORENSIC ANALYSIS 1–6 (Jeffrey D. Ho et al. eds., 2012).

[218] *See supra* notes 182–86 and accompanying text.

[219] REJALI, *supra* note 182, at 243; Nystrom, *supra* note 217, at 1–6.

[220] REJALI, *supra* note 182, at 243.

[221] *Id.* at 243–44.

[222] DAVISON, *supra* note 214, at 34; REJALI, *supra* note 182, at 243–44.

[223] DAVISON, *supra* note 214, at 34; REJALI, *supra* note 182, at 247.

[224] REJALI, *supra* note 182, at 236–37.

[225] *Id.*

[226] *Id.* at 246.

[227] *Id.* at 245–46.

less responsive to CEWs.[228] The officers then proceeded to beat King with metal batons, particularly severely since they thought he possessed the added strength of someone on PCP.[229] This assumption proved false,[230] and it turned out that the TASER model utilized was actually less powerful than previous incarnations, producing numerous failures to incapacitate suspects in the field.[231] Police officers lost confidence in TASERs and the number of departments and agencies using the devices plummeted throughout the 1990s.[232]

As Tasertron's fortunes diminished, those of another CEW company rose.[233] In 1993, two brothers, Tom and Rick Smith, contacted Cover in the hopes of producing a CEW that could be more easily marketed to the general public.[234] Cover conveyed that the key was avoiding the onerous federal regulations applied to firearms.[235] Working out of Cover's garage, and funded by family members, the brothers quickly produced a prototype the same year that utilized compressed nitrogen to fire its darts, as opposed to gunpowder.[236] This change did the trick, and, in November 1993, regulators confirmed that the new product, also called a TASER, was not a firearm and not subject to corresponding stringent marketing limitations.[237] The brothers, along with their father, founded Air TASER and proceeded to market their new device.[238]

But public demand for Air TASER products failed to materialize.[239] Moreover, Air TASER was barred from marketing to domestic law enforcement and military agencies as a result of a legal run-in with Tasertron.[240] Tasertron, possessing the

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[228] Lou Cannon, *The King Incident: More than Met the Eye on Videotape*, WASH. POST (Jan. 25, 1998), https://www.washingtonpost.com/archive/politics/1998/01/25/the-king-incident-more-than-met-the-eye-on-videotape/2248e35e-178b-47e9-a8db-0734f88b46e0/?utm_term=.2ff770b52d82 [https://perma.cc/6LGB-2LB5].

[229] REJALI, *supra* note 182, at 246.

[230] *Id.*

[231] Meyer, *supra* note 196, at 4.

[232] REJALI, *supra* note 182, at 246; Meyer, *supra* note 196, at 4.

[233] Woo, *supra* note 213.

[234] *Id.*

[235] Lisa Girion, *The Garage Science Behind the Stun Gun that Changed Policing*, REUTERS (Sept. 20, 2017, 7:29 AM), https://www.reuters.com/investigates/special-report/usa-taser-science/ [https://perma.cc/9ZGZ-GJYT].

[236] *Id.*

[237] *Id.*

[238] Michael Joseph Gross, *Shock and Ow!*, GQ (July 6, 2010), https://www.gq.com/story/shock-ow-taser-protector-axon-company-profile [https://perma.cc/V6LK-5BNA]; Ed Taylor, *Scottsdale's Taser Turns a Police Tool into a Profit-Making Machine*, EAST VALLEY TRIB. (Apr. 11, 2004), https://www.eastvalleytribune.com/money/scottsdale-s-taser-turns-a-police-tool-into-a-profit/article_f95f04f5-1c5d-5463-b9db-d0e6486f4dc8.html [https://perma.cc/ZMS2-YEXN].

[239] Taylor, *supra* note 238; *see also* Susan K. Williams et al., *TASER International, Inc.—Grappling with Growth*, 2 CASE J. 25, 35–36 (2006).

[240] Williams et al., *supra* note 239, at 32.

rights to Cover's patents, quickly sued Air TASER for infringement.[241] Without the resources to engage in a protracted legal dispute, Air TASER settled, agreeing not to sell to U.S. law enforcement and military entities until 1998, when the relevant patent expired.[242] Air TASER could still market to such groups overseas, but failed to stimulate interest.[243]

As the years went by during which Air TASER's non-compete agreement with Tasertron was in effect, the company amassed significant debt.[244] However, it spent this time redesigning its signature product, creating a more effective CEW.[245] In 2000, two years after the non-compete agreement expired and having rebranded itself as TASER International, the company launched the TASER M26 and aggressively targeted U.S. law enforcement and military agencies.[246] Learning from Tasertron's mistakes, TASER International made the M26 powerful enough such that targets were guaranteed to be subdued; officers could rely on them.[247] In addition, TASER International employed a sales approach that leaned heavily on the participation of actual law enforcement officers, who were paid per-session fees to train other officers to use TASERs.[248] As put by Nick Bernardini, the director of a documentary on TASER International, "These turn into police-conducted sales pitches . . . . Law enforcement officers had more authority than salespeople with no police experience. It created a trust factor that its competitors couldn't match."[249] TASER International quickly dominated the market, to the point that it acquired Tasertron for a mere $1 million in 2003.[250] The company had net sales of roughly $24.5 million in 2003, when it released the more compact TASER X26.[251] The next year, net sales almost tripled to $68 million, and they nearly tripled again by 2015.[252] The number of police departments using TASERs jumped from 125 in 2001 to roughly 4,300 in 2004.[253] More broadly, from 2000 to 2013, the number of law enforcement agencies using TASERs globally increased from 500 to approximately

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[241] Taylor, *supra* note 238; Williams et al., *supra* note 239, at 32.

[242] Taylor, *supra* note 238; Williams et al., *supra* note 239, at 32.

[243] Taylor, *supra* note 238.

[244] Stroud, *supra* note 177.

[245] Girion, *supra* note 235; Taylor, *supra* note 238.

[246] Stroud, *supra* note 177; Taylor, *supra* note 238.

[247] Stroud, *supra* note 177.

[248] *Id.*

[249] *Id.*

[250] Teresa Riordan, *TECHNOLOGY; New Taser Finds Unexpected Home in Hands of Police*, N.Y. TIMES (Nov. 17, 2003), http://www.nytimes.com/2003/11/17/business/technology-new-taser-finds-unexpected-home-in-hands-of-police.html [https://perma.cc/2V3R-AKYW].

[251] Stroud, *supra* note 177.

[252] *Id.*

[253] Nick Budnick, *Is the Portland Police Bureau Going TASER CRAZY?*, WILLAMETTE WEEK (Feb. 3, 2004), http://www.wweek.com/portland/article-2909-is-the-portland-police-bureau-going-taser-crazy.html [https://perma.cc/VPS2-EM5S].

17,000 across 107 countries, and TASER International is the sole supplier.[254] By 2009, TASERs were used by law enforcement and military entities in 45 countries and 180,000 units had been sold to private citizens.[255]

But TASER International's success and the permeation of CEWs throughout U.S. law enforcement engendered controversy.[256] Beginning with the deployment of the powerful TASER M26, concerns emerged regarding the safety of CEWs, specifically with regard to their potential effects on the heart and relationship to "excited delirium," a condition "characterized by an acute onset of bizarre and violent behavior" that is correlated with sudden in-custody deaths of suspects.[257] In 2017, Reuters published the results of an in-depth investigation of TASER safety.[258] Its findings include the following:

> Reuters documented 1,005 incidents in the United States in which people died after police stunned them with Tasers [sic], nearly all since the early 2000s . . . . Reuters obtained autopsy findings for 712 of the 1,005 deaths it documented. In 153 of those cases, or more than a fifth, the Taser [sic] was cited as a cause or contributing factor in the death, typically as one of several elements triggering the fatality.[259]

In addition, Amnesty International tabulates 540 deaths following TASER strikes by police in the United States between 2001 and 2013.[260] As far as scientific studies addressing TASER safety, a litany have been conducted and published, with some finding connections between CEWs and the negative outcomes noted above (cardiac problems and excited delirium) and others finding no such connections.[261] Some in

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[254] Stone, *supra* note 184; Todak et al., *supra* note 9, at 363. Competitors have attempted to challenge TASER International's dominance, but failed. *See, e.g.*, Matt Stroud, *Why Taser's Only Rival Gave Up Electroshock for Lemonade,* VERGE (Jan. 31, 2014, 10:31 AM), https://www.theverge.com/2014/1/31/5363546/how-taser-defeated-its-last-electroshock-rival [https://perma.cc/V8HE-CK5C].

[255] Woo, *supra* note 213.

[256] MURRAY & RESNICK, *supra* note 199, at 33; REJALI, *supra* note 182, at 247–48.

[257] HOWARD E. WILLIAMS, TASER ELECTRONIC CONTROL DEVICES AND SUDDEN IN-CUSTODY DEATH: SEPARATING EVIDENCE FROM CONJECTURE 6 (2008).

[258] *Shock Tactics*, REUTERS, https://www.reuters.com/investigates/section/usa-taser/ (last visited Apr. 14, 2020).

[259] Peter Eisler et al., *A 911 Plea for Help, a Taser Shot, a Death—and the Mounting Toll of Stun Guns*, REUTERS (Aug. 22, 2017, 11:48 AM), https://www.reuters.com/investigates/special-report/usa-taser-911/ [https://perma.cc/JV7R-5ZB2].

[260] *Annual Report: United States of America 2013*, AMNESTY INT'L (last visited Apr. 14, 2020), https://www.amnestyusa.org/reports/annual-report-united-states-of-america-2013/ [https://perma.cc/L5KC-39FP].

[261] *See, e.g.*, WILLIAMS, *supra* note 257, at 6 (concluding that excited delirium often associated with sudden in-custody deaths); Dawes et al., *Conducted Electrical Weapon*, *supra*

the latter group claim that the oft-compromised states of suspects are to blame (e.g., mental conditions, obesity, intoxication), not the weapons.[262]

TASERs and TASER International also face a number of other controversies. For example, Reuters reports that the company inserts itself into investigations of uses of its products, funds studies on its devices' safety (TASER International–funded studies are markedly more likely to find no significant safety concerns), and maintains its position and defends TASER safety by forging close ties with police, medical examiners, and consultants.[263] Reports also show the weapons used with disturbing frequency as methods of corporal punishment or torture on individuals in jails and prisons.[264]

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note 28, at 54 (finding that the X26 did not capture myocardium in human subjects); Colin Feeney et al., *Acute Agitated Delirious State Associated with Taser Exposure*, 102 J. NAT'L MED. ASS'N 1254, 1256 (2010) (determining that Taser exposure "may cause or contribute to acute or delirious states"); Saul D. Levine et al., *Cardiac Monitoring of Human Subjects Exposed to the TASER*, 33 J. EMERGENCY MED. 113, 116 (2007) (finding human subjects experienced an increased heart rate after TASER exposure, but no other significant cardiac disturbances); Christian M. Sloane et al., *Serum Troponin I Measurement of Subjects Exposed to the TASER X-26*, 35 J. EMERGENCY MED. 29, 31–32 (2008) (determining that healthy human subjects do not suffer cardiac injury from TASER exposure); Jared Strote et al., *Conducted Electrical Weapon Use by Law Enforcement: An Evaluation of Safety and Injury*, 68 J. TRAUMA INJ., INFECTION, & CRITICAL CARE 1239, 1245 (2010) (finding no direct cardiac effects from TASER use in laboratory settings); Jared Strote & H. Range Hutson, *Taser Use in Restraint-Related Deaths*, 10 PREHOSPITAL EMERGENCY CARE 447, 449 (2006) (concluding that drug use and preexisting disease may factor into sudden TASER-related deaths); Michael D. White & Justin Ready, *Examining Fatal and Nonfatal Incidents Involving the TASER*, 8 CRIMINOLOGY & PUB. POL'Y 865, 883–84 (2009) (claiming drug use and mental or emotional distress are predictors of TASER-related death); Douglas P. Zipes, *Sudden Cardiac Arrest and Death Following Application of Shocks from a TASER Electronic Control Device*, 125 CIRCULATION 2421, 2421 (2012) (concluding that the X26 can cause cardiac electrical capture, particularly in those with a preexisting susceptibility).

[262] *See, e.g.*, Dawes et al., *Conducted Electrical Weapon*, *supra* note 28, at 53–54; Strote et al., *supra* note 261, at 1244; Michael D. White et al., *An Incident-Level Profile of TASER Device Deployments in Arrest-Related Deaths*, 16 POLICE Q. 85, 101–02 (2012).

[263] Jason Szep et al., *How Taser Inserts Itself into Investigations Involving Its Own Weapons*, REUTERS (Aug. 24, 2017, 11:00 AM), https://www.reuters.com/investigates/special-report/usa-taser-experts/ [https://perma.cc/CM4Q-NHQW]; *see* Peyman N. Azadani et al., *Funding Source and Author Affiliation in TASER Research Are Strongly Associated with a Conclusion of Device Safety*, 162 AM. HEART J. 533, 536 (2011) (finding that studies of TASER safety funded by TASER International are eighteen times more likely to find no serious issues with the technology).

[264] *See, e.g.*, Peter Eisler et al., *Inmate Deaths Reveal "Torturous" Use of Tasers*, REUTERS (Dec. 6, 2017, 12:15 PM), https://www.reuters.com/investigates/special-report/usa-taser-jails/ [https://perma.cc/FLK6-RAG5]; Alex Horton, *Deputies Tortured a Restrained Teenager by Using a Stun Gun on Him, Lawyers Say*, WASH. POST (Aug. 2, 2017, 9:01 AM), https://www.washingtonpost.com/news/post-nation/wp/2017/08/02/would-you-like-to-comply-deputies-used-torture-by-tasering-a-restrained-inmate-lawyers-say/?utm_term=.0c92a3349b0a

The aforementioned issues aside, a brief history of CEWs reveals a powerful device that has worked its way "onto the duty belts of officers in about 90 percent of law enforcement agencies in the United States."[265] This ubiquity means that the weapons are used relatively frequently against suspects: Axon (formerly TASER International) estimates that TASERs have been deployed 4,168,242 times (privately or by law enforcement officers);[266] Sarah Kaufman, a reporter for *Vocativ*, estimates that TASERs are used by law enforcement officers over 300,000 times per year;[267] and a 2012 study reports a TASER International estimate that police officers had used TASERs roughly 1,520,000 times in the field by the end of 2011.[268]

Given how widely disseminated and oft-used CEWs are among law enforcement entities, knowledge of their potential effects on individuals' capacity to waive their constitutional rights is important for ensuring the just functioning of the criminal legal system.

B. How They Work

To properly assess whether CEWs impact cognition and individuals' capacity to knowingly, intelligently, and voluntarily waive their constitutional rights, minimal appreciations of electricity, its role in human bodily function, and the mechanism by which CEWs incapacitate targets are necessary. This subsection provides this information.

1. Electrical Current and the Human Body

Electrical current, both its production and transmission, is integral to the proper functioning of the human body:

> We're all familiar with the fact that machines are powered by electricity, but it's perhaps not so widely appreciated that the same is true of ourselves. Your ability to read and understand this

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[https://perma.cc/D95T-5528]; Tracey Kaplan, *Last Time Jail Santa Clara County Guards Had Tasers? Inmate Was Killed*, MERCURY NEWS (Sept. 22, 2017, 7:49 PM), https://www.mercurynews.com/2017/09/22/equip-jail-guards-with-tasers-old-taser-death-comes-to-life/ [https://perma.cc/5U6J-WHWN]; Mandy Locke, *Death by Taser, in a Padded Cell, Caught on Camera*, NEWS & OBSERVER (May 2, 2016, 3:00 PM), https://www.newsobserver.com/news/local/crime/article75138592.html.

[265] Stroud, *supra* note 177; *see* Michael R. Smith, *TASER Exposure,* Miranda *Warnings, and Police Interrogations: New Evidence and Implications*, 15 CRIMINOLOGY & PUB. POL'Y 75, 75 (2015) (estimating that TASER CEWs are carried by approximately 500,000 state and local police officers).

[266] *How Safe Are TASER Weapons?*, AXON, https://www.axon.com/how-safe-are-taser-weapons [https://perma.cc/B6A6-APXY] (last visited Apr. 14, 2020).

[267] Kaufman, *supra* note 178.

[268] White et al., *supra* note 262, at 86.

> page, to see and hear, to think and speak, to move your arms and legs—even your sense of self—is due to the electrical events taking place in the nerve cells in your brain and the muscle cells in your limbs.[269]

Electrical current is also the mechanism by which CEWs influence the human body.[270]

Fundamentally, all matter is made up of minuscule particles called "atoms," which, in turn, are made up of smaller particles called "neutrons," "protons," and "electrons."[271] Each of these subatomic particles has a corresponding charge: neutrons are neutrally charged, protons are positively charged, and electrons are negatively charged.[272] Neutrons and protons are much larger and cluster in an atom's nucleus, while the smaller electrons orbit the nucleus.[273] The entire structure is often presented as resembling a solar system with planets orbiting a central star. Atoms can have multiple electron orbits, and each orbit can hold a set number of electrons.[274] This number increases as orbits succeed upon one another away from the nucleus, with the exception that the outermost orbit, the "valence shell," can only hold a maximum of eight electrons, or "valence electrons."[275]

Atom nuclei, composed of neutrons and protons, are held firmly together by what is called the "strong force," but electrons travel more freely between atoms, particularly valence electrons.[276] The ease of movement of these electrons depends on how many there are along an atom's valence shell: materials with one, two, or three valence electrons have relatively weak holds on these particles, easily give them up, and are called "conductors"; materials with seven or eight valence electrons hold them more tightly and are called "insulators"; and materials with an amount of valence electrons between three and seven are referred to as "semiconductors" and can function as conductors or insulators depending on attendant conditions.[277]

Conductors are critical to the transmission of electrical force.[278] While atoms in their "natural" state possess equal numbers of protons and electrons and are therefore neutrally charged,

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[269] FRANCES ASHCROFT, THE SPARK OF LIFE: ELECTRICITY IN THE HUMAN BODY 5 (2012); *see* IRVING P. HERMAN, PHYSICS OF THE HUMAN BODY 819 (2d ed. 2007) ("It is impossible to overemphasize the importance of . . . human 'bioelectricity.' The function of every cell depends on it. Every neuron in the brain, every neuron transmitting any information within the body, every neuron enabling skeletal, cardiac, and smooth muscles is yet another vital example.").

[270] STEPHEN J. RAHM, TRAUMA CASE STUDIES FOR THE PARAMEDIC 77–78 (2005).

[271] RESEARCH & EDUC. ASS'N, BASIC ELECTRICITY 12 (2002).

[272] *Id.*

[273] *Id.*

[274] STEPHEN L. HERMAN, DELMAR'S STANDARD TEXTBOOK OF ELECTRICITY 38–39 (6th ed. 2016).

[275] *Id.* at 38–40.

[276] RESEARCH & EDUC. ASS'N, *supra* note 271, at 12.

[277] HERMAN, *supra* note 274, at 40–47.

[278] *Id.* at 41.

> [i]f . . . any number of electrons are removed . . . the whole body of matter will become electrically positive. Should the positively charged body come in contact with another body having normal charge, or having a negative (too many electrons) charge, an electric current will flow between them. Electrons will leave the more negative body and enter the positive body. This electron flow will continue until both bodies have equal charges.[279]

But the presence of a conductor between unequally charged materials is necessary for this movement; there must be something connecting the objects through which electrons can travel.[280] Without conductors, there is only "electrostatic force," which entails an electrical force between materials where electrons cannot flow: "When two bodies of matter have unequal charges, and are near one another, an electric force is exerted between them because of their unequal charges. However, since they are not in contact, their charges cannot equalize."[281] Yet if they come in contact or a conductor connects them, "electrical current" (i.e., the flow of electrons) can emerge[282]:

> Electrical energy is transferred through conductors by means of the movement of free electrons that migrate from atom to atom inside the conductor. Each electron moves a very short distance to the neighboring atom where it replaces one or more electrons by forcing them out of their orbits. The replaced electrons repeat the process in other nearby atoms.[283]

For continued effective discourse regarding electricity and its effects, several measurements and terms are important. A "coulomb" is a measure of charge that refers to a specific number of electrons: 6.25 x 1018 electrons.[284] An "ampere" is a measure of electron flow rate, and represents a rate of one coulomb per second (e.g., one ampere exists in a wire when one coulomb moves past a given point in one second).[285] "Voltage" is the potential difference in charge between two materials and is the force pushing electrons through a conductor; it is also referred to as "electrical pressure."[286] Voltage must be present for current to flow; there must be some pressure

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[279] RESEARCH & EDUC. ASS'N, *supra* note 271, at 15.

[280] *See id.*

[281] *Id.*

[282] HERMAN, *supra* note 274, at 42.

[283] RESEARCH & EDUC. ASS'N, *supra* note 271, at 13. This is the dominant "Bump Theory" of electrical current, which "states that current flow is produced when an electron from one atom knocks electrons of another atom out of orbit." HERMAN, *supra* note 274, at 42.

[284] HERMAN, *supra* note 274, at 53.

[285] *Id.* at 53–54.

[286] *Id.* at 59–60.

pushing the electrons.[287] A "volt" is a measure of electrical pressure and is the amount necessary to cause electrons to flow at a rate of one ampere through one "ohm" of resistance, an ohm being a unit of resistance to electrical current: one ohm is an amount of resistance such that one ampere can flow when one volt is applied.[288] Norbert Lechner offers a helpful summary of this information:

> Electrical pressure results from a difference of electrical charges. Electrons will flow from a negative charge to a positive charge, and the greater the difference in charges the greater the electromotive force [i.e., voltage] measured in volts (V). The electrical current [i.e., moving electrons] is propelled by the voltage and its units are amperes (. . . A). The electrical current is also impeded by the electrical resistance . . . measured in ohms (Ω).[289]

Resistance—the ease with which a material gives up its valence electrons and allows electrical current to pass—is critical to understanding how externally introduced electrical current flows through and affects the human body.[290] In order for current to flow, there must exist a complete path, or complete "circuit," along which it can travel.[291] If multiple complete circuits are available through which electrical current can proceed, it will follow the path of least resistance.[292] With regard to the human body, a circuit is most often formed by the two terminals of a device introducing electrical current to the body or by the current source and the ground, with the body acting as a conductor or "load" between the two points.[293] But the body is not a unified whole in terms of conducting electricity; there are numerous different tissues through which electrical current can potentially travel, each with distinct levels of resistance[294]:

> In simplistic terms, electricity passes through the body from the entrance site to the exit site . . . . Current will course through the body via multiple parallel paths. The amount is in inverse proportion

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[287] *Id.* at 60.

[288] *Id.* at 59–60.

[289] NORBERT LECHNER, PLUMBING, ELECTRICITY, ACOUSTICS: SUSTAINABLE DESIGN METHODS FOR ARCHITECTURE 4–5 (2012).

[290] *See* RAHM, *supra* note 270, at 77–78 (explaining resistance, electron flow, and assessing damage on the human body).

[291] HERMAN, *supra* note 274, at 57; *see* DONNA S. WATSON, PERIOPERATIVE SAFETY 196 (2011) ("The pathway of the electrical current as it flows through the conductor is called the electrical circuit. There must be a complete circuit . . . .").

[292] Martin Sandberg, *AC Power Conditioning*, *in* THE ELECTRONICS HANDBOOK 1024 (Jerry C. Whitaker ed., 1996).

[293] Raymond M. Fish & Leslie A. Geddes, *Conduction of Electrical Current to and Through the Human Body: A Review*, 9 EPLASTY 407, 411 (2009).

[294] RAHM, *supra* note 270, at 78.

> to the resistance of each path, so the majority of the current courses through the paths of least resistance. In real life these paths are not always the physically shortest or the most obvious paths from the entry to exit site.[295]

Typically, the first tissue electrical current comes into contact with is skin, the resistance of which varies depending on extant circumstances: "For example, while a clean and dry adult human hand has a resistance of approximately 5,000 ohms, a dirty or wet hand is less resistant (1,000 ohms), and a heavily calloused hand may have much more resistance (up to 1 million ohms)."[296]

When placed on a resistance continuum with other tissues, skin is in the middle: bone, fat, and tendon are more resistant while muscle, blood, and nerves are less so.[297] "Because nerves and blood vessels have low levels of resistance compared to bones and fat, the current tends to travel along nerves and blood vessels when it overcomes the resistance of the skin."[298]

Depending on its intensity (i.e., voltage, amperage, resistance, etc.), path through the body, and the length of contact, electrical current can directly damage tissue in two ways. First, it can cause "electroporation" in cells: "cellular damage in which cell membranes become permeable due to the formation of pores in [their outer membranes]."[299] Second, it can cause thermal injury where it meets resistance and generates heat.[300]

But electrical current can also cause indirect damage by manipulating the functioning of certain cells, particularly nerve cells ("neurons") and muscle cells, which are likely current paths given their relatively low resistance.[301] Neurons, for their part, form the human nervous system: "a complex network within the body [that] receives, processes, and transmits information from one part of the body to another."[302] The most substantial portion of this system is the brain, which alone contains 85 to 120 billion neurons and hundreds of trillions of connections between

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[295] Brandon C. Bryan et al., *Electrical Injury, Part I: Mechanisms*, 21 J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCE 241, 241 (2009).

[296] Joseph W. Fink et al., *Electrical Injury in the Workplace*, *in* NEUROPSYCHOLOGICAL ASSESSMENT OF WORK-RELATED INJURIES 84 (Shane S. Bush & Grant L. Iverson eds., 2012).

[297] *Id.*; *see* RAHM, *supra* note 270, at 78 ("[B]one offers the greatest resistance to electrical current, whereas blood vessels and nerves offer the least resistance."); Mark W. Kroll & Dorin Panescu, *Physics of Electrical Injury*, *in* ATLAS OF CONDUCTED ELECTRICAL WEAPON WOUNDS AND FORENSIC ANALYSIS, *supra* note 217, at 32 tbl.2.4 (providing a chart listing the resistances of various bodily tissues in ohms).

[298] Kevin Duff & Robert J. McCaffrey, *Electrical Injury and Lightning Injury: A Review of Their Mechanisms and Neuropsychological, Psychiatric, and Neurological Sequelae*, 11 NEUROPSYCHOLOGY REV. 101, 103 (2001).

[299] Fink et al., *supra* note 296, at 85.

[300] *Id.* at 84–85.

[301] *See* Amanda E. Hahn-Ketter et al., *Long-Term Consequences of Electrical Injury: Neuropsychological Predictors of Adjustment*, 30 CLINICAL NEUROPSYCHOLOGY 216, 217 (2016).

[302] PAUL DAVIDOVITS, PHYSICS IN BIOLOGY AND MEDICINE 173 (4th ed. 2013).

neurons, or "synapses."[303] In very general terms, these cells communicate through a system of chemical interactions that influence their internal charges (i.e., whether they are positively or negatively charged relative to the surrounding environment).[304] In their resting state, neurons are "polarized" in that they maintain an internal charge different from the surrounding environment; they are negatively charged relative to their surroundings.[305] Neuron cell membranes ensure this by allowing ions (i.e., atoms or molecules that have acquired an electric charge by gaining or losing electrons) that are negatively charged to enter the cell but not positive ions, the latter of which are also actively pumped out.[306] However, neurons are equipped with receptor sites to receive specialized communicative chemicals called "neurotransmitters" from other neurons.[307] The cells do not touch one another, but rather communicate through the transmission of neurotransmitters across synapses—which entail microscopic gaps between neuron communication points[308]—and neurotransmitters can have one of two effects on a neuron: they can either "excite" or "inhibit."[309]

Excitation entails a progressive process. To begin with, neurotransmitters bond with a receiving neuron and induce its cell membrane to open ion channels for the entry of positive ions into the cell body in the localized area where bonding occurs, slightly altering the cell's polarization (i.e., the difference in charge between that part of the neuron and the outside of the cell).[310] When bonding continues such that ion channels remain open and a threshold charge is reached in the area, a much larger number of "voltage-gated" ion channels open in the same region (i.e., channels responsive to a certain difference between a neuron's internal charge and the charge outside of the cell, and therefore a certain electrical pressure, or voltage, between these two locations), allowing for the substantially increased inflow of positive ions.[311] And once a specific, localized *positive* charge is reached, neighboring regions are stimulated to behave in the same manner in a cascading fashion down the length of the neuron, with sections progressively opening to positive ions and becoming positively charged.[312] The

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[303] *See* RICHARD E. CYTOWIC, THE NEUROLOGICAL SIDE OF NEUROPSYCHOLOGY 68 (1996); RONALD T. KELLOGG, FUNDAMENTALS OF COGNITIVE PSYCHOLOGY 14 (2d ed. 2012); Suzana Herculano-Houzel, *The Human Brain in Numbers: A Linearly Scaled-Up Primate Brain*, 3 FRONTIERS HUM. NEUROSCIENCE 1, 2 (2009).

[304] SUNDARARAJAN V. MADIHALLY, PRINCIPLES OF BIOMEDICAL ENGINEERING 63 (2010); *see* ERIC A. ZILLMER ET AL., PRINCIPLES OF NEUROPSYCHOLOGY 103 (2d ed. 2008) ("The language of human neural communication is chemical.").

[305] ZILLMER ET AL., *supra* note 304, at 102.

[306] *Id.*; *see* ROBERT M. SAPOLSKY, BEHAVE: THE BIOLOGY OF HUMANS AT OUR BEST AND WORST app. 1, at 683 (2017) ("Remarkably, neurons spend nearly half their energy on the pumps that generate the resting potential.").

[307] ZILLMER ET AL., *supra* note 304, at 103–04.

[308] GABRIEL A. RADVANSKY, HUMAN MEMORY 32 (3d ed. 2017).

[309] ZILLMER ET AL., *supra* note 304, at 103.

[310] SAPOLSKY, *supra* note 306, app. 1, at 683–84.

[311] *Id.* at 684–85.

[312] *Id.*

progressive "depolarization" (i.e., the loss of difference in charge between the neuron and surrounding environment) travels the length of the neuron, ultimately stimulating the release of neurotransmitters at the end of the cell to communicate with other neurons, completing a process known as an "action potential."[313]

Inhibition, on the other hand, is when a neurotransmitter prompts a receiving neuron's cell membrane to take in even more negative ions, thereby further increasing the cell's negative charge and "polarization" relative to its surroundings and lessening the probability that it will fire.[314] As a practical matter, excitation and inhibition occur incredibly rapidly such that "neurons fire more or less continuously, and the timing and sequences of impulses and pauses determine the message."[315]

For their part, muscle cells—often referred to as muscle "fibers"—contract and relax and are divided into three categories: visceral (or "smooth"), cardiac, and skeletal.[316] Visceral muscles operate involuntarily (i.e., they are not subject to conscious control) and form the walls of organs and blood vessels, modulating their activity.[317] Cardiac muscles also operate involuntarily and form the walls of the heart, contracting regularly to produce the heartbeat.[318] Finally, and of most relevance for the purposes of this Article, skeletal muscles operate *voluntarily* (i.e., they are subject to conscious control) and are connected to bone.[319] Their contractions pull bones and allow individuals to produce controlled body movements,[320] and they are stimulated to contract by "motor neurons" that relay commands from the brain.[321] Motor neurons' cell bodies are located in either the spinal cord or the brain, and they communicate with muscle cells through long branches called axons that have terminals at their ends that release neurotransmitters when the cells fire, sending the molecules across synapses to other cells.[322] Similar to neurons, muscle cell activity is mediated by polarization and depolarization.[323] That is, when stimulated by certain neurotransmitters (emitted by motor neurons), they take in positive ions that depolarize the cell and initiate the chemical process of contraction.[324]

The aforementioned cells' reliance on manipulations of charge to carry out their functions illuminates how the introduction of external electrical current might alter

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[313] *Id.*

[314] STEVEN YANTIS, SENSATION AND PERCEPTION 13 (2014).

[315] ZILLMER ET AL., *supra* note 304, at 103.

[316] GARY A. THIBODEAU & KEVIN T. PATTON, STRUCTURE & FUNCTION OF THE BODY 62 (14th ed. 2012).

[317] JOSEPH FEHER, QUANTITATIVE HUMAN PHYSIOLOGY: AN INTRODUCTION 240 (2012); THIBODEAU & PATTON, *supra* note 316, at 62.

[318] THIBODEAU & PATTON, *supra* note 316, at 62.

[319] *Id.*; M.N. Robinson et al., *Electric Shock Devices and Their Effects on the Human Body*, 30 MED., SCI. & L. 285, 297 (1990).

[320] *See* THIBODEAU & PATTON, *supra* note 316, at 62.

[321] Mark W. Kroll, *Crafting the Perfect Shock*, 44 IEEE SPECTRUM 27, 29 (2007).

[322] ASHCROFT, *supra* note 269, at 104.

[323] MICHAEL SHEETZ & HANRY YU, THE CELL AS A MACHINE 180 (2018).

[324] FEHER, *supra* note 317, at 240; SHEETZ & YU, *supra* note 323, at 180.

their operation, anywhere from slightly to significantly. This vulnerability in muscle cells is what CEWs take advantage of to physically incapacitate individuals, and its manifestation in neurons is a potential mechanism by which a target's cognitive abilities might be diminished as well.

2. Incapacitation via Electrical Current

There have been numerous CEW models over the years, and consumers continue to have their pick of different offerings.[325] This subsection, however, will focus on the TASER X26, which is the most popular CEW among law enforcement.[326] Accordingly, "[t]he . . . X26 model is currently the likely device to be used in an incident . . . due to the hundreds of thousands sold and currently deployed in the United States . . . ."[327] While the specific operating parameters of the X26 differ from those of other CEWs, the general process employed to incapacitate subjects is the same, giving the following analysis broad relevance.

The X26 resembles a handheld firearm, but looks more blocky and futuristic.[328] It consists of a handle, trigger, and large semi-rectangular cartridge.[329] The cartridge contains, foremost, two barbed, metal darts loaded one on top of the other, each with approximately .35-inch tips.[330] On the opposite ends of each dart are two "whisper-thin," insulated copper wires, connected to the darts on one end and to the body of the X26 on the other.[331] When the weapon is fired and the darts shoot out towards and strike a target, the wires maintain the connection between the darts and the main device through which electrical current flows.[332] The wires are roughly thirty feet long, giving the X26 an identical range of fire.[333] Providing the force to launch the darts is a canister of compressed nitrogen, which releases a portion of its contents upon the pressing of the device's trigger.[334] Fired along with the darts are twenty to

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[325] *E.g.*, Nystrom, *supra* note 217, at 1–23 (recounting past and present CEW designs and marketed models).

[326] *See* Jeffrey D. Ho et al., *Conducted Electrical Weapon Incapacitation During a Goal-Directed Task as a Function of Probe Spread*, 8 FORENSIC SCI., MED. & PATHOLOGY 358, 359 (2012) ("The X26 is the 'gold standard' CEW having been deployed in the field since 2003, and is the device most widely adopted by law enforcement agencies in the U.S.").

[327] R.T. Wyant, *Forensics: Conducted Electrical Weapons (Taser)*, *in* RISK MANAGEMENT OF LESS LETHAL OPTIONS: EVALUATION, DEPLOYMENT, AFTERMATH, AND FORENSICS 228 (Rick T. Wyant et al. eds., 2014).

[328] *See* Robin Levinson King, *How Do Tasers Work?*, STAR (Aug. 27, 2013), https://www.thestar.com/news/queenspark/2013/08/27/how_do_tasers_work.html [https://perma.cc/H2AJ-TVN8] (providing a detailed image of a TASER X26 and its component parts).

[329] *Id.*

[330] Kroll, *supra* note 321, at 27–28.

[331] *Id.* at 27, 29.

[332] *Id.* at 28–29.

[333] *Id.* at 29.

[334] *Id.* at 27–28.

thirty small, colorful, "confetti-like" identification tags adorned with the serial number of the specific X26 cartridge discharged.[335] To aid targeting, a laser sight is located on the underside of the cartridge.[336] And within the device's handle is a "data port" that records the date, time, and duration of every trigger pull.[337]

When the barbed darts lodge in a target, they form a complete circuit, electrical current flowing from a pulse generator in the X26, through one of the wire-dart pairs (the positively charged one), through the individual, and back out through the other wire-dart pair (the negatively charged one) to the device.[338] The initial characteristics of the electrical current vary depending on whether the darts embed in clothing or tissue. If the former, which happens roughly thirty percent of the time, a relatively high voltage of 50,000 volts is produced so the current can "arc" across the gap between a dart and tissue and create a complete circuit.[339] The weapon can therefore transmit electrical current "through two cumulative inches of clothing."[340] However, individuals are not exposed to such high voltage because it dissipates upon forming a circuit with the body, doing so by contacting tissue.[341]

Once a circuit is complete, the parameters of the electrical currents that targets are subjected to are identical regardless of whether darts embed in clothing or tissue, but the duration of exposure is dependant on the X26 operator. One squeeze-and-release of the trigger initiates a five-second current flow—the cycle can be halted sooner if the device's safety is engaged mid-operation.[342] But this can be extended if an operator continues pressing the trigger or pulls it additional times while the circuit is complete.[343]

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[335] *Police Tasers: Anti-Felon Confetti ID Tags*, BERNEWS (Apr. 23, 2010), http://bernews.com/2010/04/police-tasers-anti-felon-confetti-id-tags/ [https://perma.cc/J2SC-BSZS]; *TASER Cartridges Overview*, AXON (last visited Apr. 14, 2020), https://help.axon.com/hc/en-us/articles/235754308-TASER-cartridges-overview [https://perma.cc/9MD4-SJZ3].

[336] King, *supra* note 328.

[337] MATTHEW LIPPMAN, CRIMINAL PROCEDURE 171 (2011); Sandra Upson, *The TASER Gun, an Electroshock Weapon Used by Police Departments Worldwide, Is No Stranger to Bad Press*, 44 IEEE SPECTRUM 26, 26 (2007); King, *supra* note 328.

[338] Kroll, *supra* note 321, at 28–29.

[339] *Id.* at 29; James D. Sweeney, *Transcutaneous Muscle Stimulation*, *in* TASER CONDUCTED ELECTRICAL WEAPONS: PHYSIOLOGY, PATHOLOGY, AND LAW, *supra* note 191, at 51; *see* WILLIAMS, *supra* note 257, at 19 ("The purpose of such high voltage is to permit a spark to cross a gap between clothing and a person's body should the probes not contact the skin.").

[340] Jeffrey D. Ho et al., *Echocardiographic Evaluation of a TASER-X26 Application in the Ideal Human Cardiac Axis*, 15 ACAD. EMERGENCY MED. 838, 841 (2008).

[341] *See* WILLIAMS, *supra* note 257, at 19; Kroll, *supra* note 321, at 29.

[342] Larry Greenemeier, *TASER Seeks to Zap Safety Concerns*, SCI. AM. (Dec. 3, 2007), https://www.scientificamerican.com/article/taser-electric-shock-zap-law-canada/ [https://perma.cc/G9PC-V2RH].

[343] *See* Stuart Casey-Maslen et al., *The Review of Weapons Under International Humanitarian Law and Human Rights Law*, *in* WEAPONS UNDER INTERNATIONAL HUMAN RIGHTS LAW 434 (Stuart Casey-Maslen ed. 2014); Cheryl W. Thompson & Mark Berman, *Improper*

It must be noted that rather than maintaining a constant flow of electrical current, the X26 pulses current through the body at a rate of nineteen pulses per second, each pulse being approximately 100 microseconds long.[344] Thus, while a target's skeletal muscles appear to involuntarily contract for the duration of a strike, in reality they are contracting and relaxing at a rapid pace. This stimulation overrides the motor nervous system in the affected area and blocks an individual's command and control of his body.[345] In addition, secondary to inducing muscle contraction, the X26 "elicit[s] strong sensations of pain and/or exhaustion."[346]

With regard to the electrical current, the X26 is billed as delivering, on average over the course of one second, 600 volts and 2.1 milliamperes (i.e., .0021 amperes),[347] with a peak voltage of 1,200 volts and peak amperage of 3.3 amperes.[348] These numbers are based on the darts embedding in a target with a resistance of 400 ohms, that of a human body under the most conductive conditions.[349] A study of the characteristics of the X26's electrical current when applied to volunteers, however, reveals an average resistance of 602.3 ohms and a range of 470.5 to 691.4 ohms.[350] And, on average, individuals' resistance decreases by approximately eight percent over the course of a five-second exposure.[351] In turn, the average voltage was 580.1 volts

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Techniques, Increased Risks, WASH. POST (Nov. 26, 2015), https://www.washingtonpost.com/sf/investigative/2015/11/26/improper-techniques-increased-risks/?utm_term=.d60fd82177d5 [https://perma.cc/BG69-7XVN]. The civilian variant of the device produces a ten-second current flow when fired, which can be extended to thirty seconds if the trigger is pulled two more times. Michael Martinez, *Taser Aims at Home Market as Safety Concerns Mount*, CHI. TRIB. (Feb. 13, 2005), http://articles.chicagotribune.com/2005-02-13/news/0502130545_1_taser-international-stun-firearms/3 [https://perma.cc/MNV5-RC76].

[344] Kroll, *supra* note 321, at 29.

[345] Dorin Panescu & Robert A. Stratbucker, *Current Flow in the Human Body*, *in* TASER CONDUCTED ELECTRICAL WEAPONS: PHYSIOLOGY, PATHOLOGY, AND LAW, *supra* note 191, at 63.

[346] Sweeney, *supra* note 339, at 51.

[347] There is disagreement in the literature with regard to these figures, with the average voltage being presented as either 400 or 600 volts and the average amperage being presented as either 1.9 or 2.1 milliamperes. Following a survey of works, the figures that appear most accepted are presented. *See, e.g.*, James Benjamin Gleason & Ibrahim Ahmad, *TASER Electronic Control Device-Induced Rhabdomyolysis and Renal Failure: A Case Report*, 9 J. CLINICAL & DIAGNOSTIC RES. HD01, HD02 (2015); Jeffrey D. Ho et al., *Respiratory Effect of Prolonged Electrical Weapon Application on Human Volunteers*, 14 ACAD. EMERGENCY MED. 197, 199 (2007); Mark W. Kroll, *Physiology and Pathology of TASER Electronic Control Devices*, 16 J. FORENSIC & L. MED. 173, 173–74 (2009); James R. Roberts, *The Medical Effects of TASERs*, 30 EMERGENCY MED. NEWS 11, 13 (2008); Greenemeier, *supra* note 342.

[348] Sweeney, *supra* note 339, at 51–52.

[349] *See* Kroll, *supra* note 321, at 29.

[350] Donald M. Dawes et al., *Electrical Characteristics of an Electronic Control Device Under a Physiologic Load: A Brief Report*, 33 PACING & CLINICAL ELECTROPHYSIOLOGY 330, 335 (2010).

[351] *Id.*

(ranging from 491.1 to 673.9 volts) and the average amperage per pulse was .97 amperes (ranging from .83 to 1.04 amperes), which scales to an average of roughly 1.9 milliamperes, or .0019 amperes per second.[352] The average peak voltage was 1,899.2 volts and the average peak amperage was 3.1 amperes.[353]

Two numbers from the study are worth briefly expounding upon. First, the average resistance (602.3 ohms) is meaningfully higher than the 400 ohms generally used to model X26 performance, indicating that amperage should be lower than typically predicted, which it is, slightly: 1.9 milliamperes versus 2.1 milliamperes.[354] And second, the average peak voltage (1,899.2 volts) is noticeably greater than the typical model figure (1,200 volts), perhaps explaining why the amperage per second observed is only slightly below that predicted by the model, despite the resistance observed being notably higher.[355] Yet it has previously been indicated that the X26 actually has an average peak voltage of 1,900 volts, so the study's findings are not exceptional in this regard.[356]

The primary mechanism by which the X26's electrical current influences a target (i.e., incapacitates her) is by inducing the involuntary contraction of skeletal muscles.[357] And it does this through the "electrical capture" of motor neurons in the vicinity of the darts.[358] That is, the externally introduced current artificially depolarizes the neurons, causing them to fire and prompt the skeletal muscles with which they communicate to contract.[359] It is also likely that skeletal muscle cells are directly stimulated to depolarize and contract, but since they are less excitable than neurons, this would only occur immediately neighboring the darts where the electrical current is strongest.[360]

Since the electrical current flows primarily between the X26's two darts, the distance between them on a target's body is important in terms of how extensively motor neurons are captured, skeletal muscles contract, and the degree of incapacitation suffered. Generally, the farther apart the darts are the greater the distance the current traverses.[361] This means that more skeletal muscles are stimulated and a

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[352] *Id.*

[353] *Id.*

[354] *See id.*; Kroll, *supra* note 321, at 29.

[355] *See* Dawes et al., *supra* note 350, at 335; Kroll, *supra* note 321, at 29.

[356] *See* Kroll, *supra* note 347, at 173.

[357] Ho et al., *supra* note 340, at 840–41; *see* Panescu & Stratbucker, *supra* note 345, at 63 ("The CEW method of incapacitation is through electrical activation of skeletal muscle tissue innervated by peripheral nerves within the electric field created by the CEW.").

[358] Donald M. Dawes et al., *The Effect of an Electronic Control Device on Muscle Injury as Determined by Creatine Kinase Enzyme*, 7 FORENSIC SCI., MED. & PATHOLOGY 3, 4 (2011).

[359] Kroll, *supra* note 321, at 29.

[360] Sweeney, *supra* note 339, at 53.

[361] *See* CHARLIE MESLOH ET AL., A QUALITATIVE & QUANTITATIVE ANALYSIS OF CONDUCTED ENERGY DEVICES: TASER X26 VS. STINGER S200, at 9 (2008), https://www.ncjrs.gov/pdffiles1/nij/grants/222769.pdf [https://perma.cc/9N5C-5FYA] ("[Dart] spread is important in a projectile [CEW] to insure electrical current is traveling through a large amount of muscle mass.").

subject experiences more incapacity.[362] Accordingly, within the cartridge, the darts are positioned such that, when fired, they spread apart vertically at an eight-degree angle, separating approximately one foot for every seven feet traveled.[363] They must lodge in a target at least four inches apart for a complete circuit to form and electrical current to flow.[364] Furthermore, a study shows that the minimum dart spread needed to effectively prevent a target from advancing forward is at least nine inches, and at least twelve inches is ideal.[365] Current also travels outward from a given dart in directions other than toward the other dart, but to a much more diminished degree.[366]

This mechanism does not, however, explain how the X26 and other CEWs elicit muscle contractions in areas well away of those where they appear to directly apply current, which they are known to do.[367] In this vein, it is indicated in an animal study utilizing anesthetized pigs that the X26 accomplishes the aforementioned feat by stimulating "spinal reflexes," particularly when targets are struck on the back of the torso.[368] This is supported by findings that those struck by an X26 on the back of the torso suffer greater incapacitation than those struck on the front, despite identical dart spread,[369] as well as by the fact that, as noted above, the axons of motor neurons are highly conductive and lead back to cell bodies located in the spinal cord or brain.[370]

The potential involvement of spinal reflexes raises an interesting question: If CEW-introduced current stimulates distant motor neurons by way of the spinal cord, does it also influence neurons in the brain? As yet, there has been no relevant research on the matter, but it appears to have potentially important implications for the topic addressed by this Article.

The incapacitation suffered by those exposed to a five-second X26 strike has, however, been the subject of testing. A 2014 study tested police academy cadets' ability to press a button during such a strike and, if unable to do so, how long it took them to push it after.[371] Of the twenty-eight subjects measured, only two pushed the button while experiencing the current (roughly three and 4.5 seconds into the strike, respectively), and the average time for the rest was approximately 1.2 seconds after the

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[362] *See id.* at 29–30.

[363] *See id.* at 53; Robin Washington, *Happiness Is a Warm Phaser*, MARSHALL PROJECT (Mar. 27, 2017), https://www.themarshallproject.org/2017/03/27/happiness-is-a-warm-phaser [https://perma.cc/3M9M-P5V8].

[364] Greenemeier, *supra* note 342.

[365] Jeffrey Ho et al., *Conducted Electrical Weapon Incapacitation During a Goal-Directed Task as a Function of Probe Spread*, 8 FORENSIC SCI., MED. & PATHOLOGY 358, 365 (2012).

[366] *See* Kroll, *supra* note 321, at 28.

[367] *See* Florin Despa et al., *Electromuscular Incapacitation Results from Stimulation of Spinal Reflexes*, 30 BIOELECTROMAGNETICS 411, 418–19 (2009).

[368] *Id.* at 419–20.

[369] Ho et al., *supra* note 365, at 365.

[370] *See supra* notes 316–24 and accompanying text.

[371] John C. Criscione & Mark W. Kroll, *Incapacitation Recovery Times from a Conductive Electrical Weapon Exposure*, 10 FORENSIC SCI., MED. & PATHOLOGY 203, 203–04 (2014).

strike ended.[372] A control group of seven individuals pushed the button about one second after an audio stimulus.[373] The authors concluded that, "[e]ssentially, upon cessation of the CEW stimulus, all subjects immediately regained normal control and coordination required to trigger the button box with response times comparable to a baseline audio-triggered response."[374] But it is important to note that these measurements were taken under highly controlled circumstances and from ostensibly healthy, uncompromised individuals.[375] In addition, subjects were provided the task prior to experiencing an expected electrical current, eliminating any cognitive, information processing aspect from the study.[376] Real-world law enforcement situations are unlikely to be analogous.

In light of the concerns in the previous paragraph, to conclude this subsection and provide a less technical understanding of the impact of CEWs, the following is a description offered by law professor David Harris of the experience of being struck by an X26 in a controlled setting:

> I heard a rapid ticking sound, then a loud pop, and I felt the barbs strike my back with a sting. Faster than I could think, the sting was replaced with something that felt as if every muscle, from my legs through my chest and my jaw, had suddenly and painfully seized up. It was like the most painful cramp I'd ever had, but giant-sized, body-wide, and with a sharpness that is hard to describe. My teeth locked together. All the while, a painful pulse went through me at regular, rapid intervals; it seemed to zap through me, collecting in my chest. I let out an involuntary, grunting sound from somewhere deep in my gut. I remember only one coherent thought in my head while this was occurring: *STOP! STOP! GET THIS OFF ME!* Despite my strong desire to do something, all through the [TASER] exposure I was completely paralyzed. I could not move at all.
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> And then, just like that, it stopped. It lasted just five seconds, but it seemed much longer—the longest five seconds of my life. The officers held me up; I never lost consciousness, and wasn't aware of any feeling that I could not remain standing, but since most people do become unable to stand, the officers made sure I didn't fall. They eased me down to one knee and then to a

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372 *Id.* at 205.
373 *Id.* at 204.
374 *Id.* at 206.
375 *See id.* at 203–04.
376 *See id.*

> sitting position on the mat, though I insisted that I could stand. All the while, I felt a little hazy, a bit dazed, and I'd say it took a few minutes for my head to fully clear.[377]

C. Effects on Cognition

Research on CEWs has long focused on physiological safety, particularly with regard to cardiac health.[378] It is only recently that studies have examined the potential influence of the devices on individuals' cognitive abilities.[379] These projects were initially inspired the finding of cognitive deficiencies in patients exposed to electrical currents.[380] Accordingly, this subsection is divided into two parts. First, the literature on electrical injuries and their effects on cognition and its relevance to CEWs are presented. Second, studies investigating the potential connection between CEWs and declines in cognitive ability and their implications are comprehensively analyzed.

1. Electrical Injuries and Cognition

Electrical injury (EI) is generally defined as "damage to the skin or internal organs when a person comes into direct contact with an electrical current."[381] This includes impacts on organ function, which can be manifested by non-physical, psychological symptoms.[382] Since, as noted above, nerve cells are highly conductive compared to other body tissues,[383] "[n]eurons and the brain may . . . be uniquely

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[377] David A. Harris, *TASER Use by Law Enforcement: Report of the Use of Force Working Group of Allegheny County, Pennsylvania*, 71 U. PITT. L. REV. 719, 726–27 (2010).

[378] *See, e.g.*, Dawes et al., *supra* note 261; Feeney et al., *supra* note 261; Eric M. Koscove, *The Taser Weapon: A New Emergency Medicine Problem*, 14 ANNALS EMERGENCY MED. 1205 (1985); Dhanunjaya Lakkireddy et al., *Do Electrical Stun Guns (TASER-X26) Affect the Functional Integrity of Implantable Pacemakers and Defibrillators?*, 9 EUROPACE 551 (2007); Daniel J. O'Brien, *Electronic Weaponry: A Question of Safety*, 20 ANNALS EMERGENCY MED. 583 (1991); Robinson et al., *supra* note 319; Robert Stracbucker et al., *Cardiac Safety of High Voltage TASER X26 Waveform*, PROC. 25TH ANNUAL INT'L CONFERENCE IEEE EMBS 3261 (2003); Zipes, *supra* note 261.

[379] The first such study was conducted in 2008. *See* Bagley, *supra* note 20, at 6.

[380] Michael D. White et al., *Examining the Effects of the TASER on Cognitive Functioning: Findings from a Pilot Study with Police Recruits*, 10 J. EXPERIMENTAL CRIMINOLOGY 267, 268 (2014); Bagley, *supra* note 20, at 6.

[381] *Electrical Injury*, MEDLINE PLUS, https://medlineplus.gov/ency/article/000053.htm [https://perma.cc/MR9P-XBV3] (last updated Mar. 4, 2020).

[382] *See* Duff & McCaffrey, *supra* note 298, at 101 ("Electrical injury (EI) can be defined as sequelae due to accidental contact with man-made or generated electrical power.").

[383] *See supra* notes 297–98 and accompanying text; *see also* Hahn-Ketter et al., *supra* note 301, at 217 ("Electricity travels along the path of least resistance, and the central nervous system (CNS) is particularly susceptible to damage from electric shock due to the low resistance of the nervous system tissue.").

vulnerable to [EI]."[384] "[I]t is [therefore] not surprising that neurological, psychiatric, and neuropsychological sequelae are abundant in victims of EI."[385]

Several studies show that those who have experienced EIs report physical, cognitive, and emotional symptoms at much higher rates than those who have not, the latter two symptoms being most relevant to this Article. Cognitive deficits complained of predominantly relate to memory, concentration, and attention.[386] And emotional complaints frequently concern depression, irritability, and anxiety.[387]

Subject-reported issues generally match findings from studies involving cognitive testing, brain imaging, and psychiatric evaluation. Those who have experienced EIs perform markedly worse on memory, learning, concentration, and attention tests.[388] Visual memory appears to be particularly deficient among these individuals, "especially . . . initial acquisition of new information."[389] Brain imaging research suggests that "EI is associated with changes in brain function at a network level in neural substrates involved in cognition."[390]

With regard to clinical confirmation of emotional complaints, a study in which seventy-three EI patients received psychiatric evaluation found that forty-two, or 58%, warranted psychiatric diagnoses, predominantly of depression, post-traumatic stress disorder (PTSD), or both.[391] In another study in which eighty-six EI patients referred themselves for psychiatric evaluation, sixty-seven, or 78%, warranted psychiatric

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[384] Brandon C. Bryan et al., *Electrical Injury, Part I: Mechanisms*, 21 J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCE 240, 241 (2009).

[385] Duff & McCaffrey, *supra* note 298, at 112.

[386] *See id.* at 108; Michael S. Morse, *A Report on the Current State and Understanding of Human Response to Electrical Contacts*, *in* CONFERENCE RECORD OF THE 2013 IEEE IAS ELECTRICAL SAFETY WORKSHOP 29, 31 tbl.III (2013); Neil H. Pliskin et al., *Neuropsychiatric Aspects of Electrical Injury: A Review of Neuropsychological Research*, 720 ANNALS N.Y. ACAD. SCI. 219, 219–21 (1994) [hereinafter Pliskin et al., *Neuropsychological Aspects*]; Neil H. Pliskin et al., *The Neuropsychological Effects of Electrical Injury: New Insights*, 888 ANNALS N.Y. ACAD. SCI. 140, 143 (1999) [hereinafter Pliskin et al., *Neuropsychological Effects*].

[387] *See* Duff & McCaffrey, *supra* note 298, at 108; Morse, *supra* note 386, at 31 tbl.III; Pliskin et al., *Neuropsychological Effects*, *supra* note 386, at 143.

[388] *See* Joseph Barrash et al., *Neurobehavioral Sequelae of High Voltage Electrical Injuries: Comparison with Traumatic Brain Injury*, 3 APPLIED NEUROPSYCHOLOGY 75, 80 (1996); Todd J. Janus & Joseph Barrash, *Neurologic and Neurobehavioral Effects of Electric and Lightning Injuries*, 17 J. BURN CARE & REHABILITATION 409, 412–13 (1996); Neil H. Pliskin et al., *Neuropsychological Changes Following Electrical Injury*, 12 J. INT'L NEUROPSYCHOLOGICAL SOC'Y 17, 21 (2006); Pliskin et al., *Neuropsychological Effects*, *supra* note 386, at 144–45.

[389] Duff & McCaffrey, *supra* note 298, app. C at 114; Pliskin et al., *Neuropsychological Effects*, *supra* note 386, at 145; *see* Neil H. Pliskin et al., *Neuropsychological Symptom Presentation After Electrical Injury*, 44 J. TRAUMA: INJURY, INFECTION, & CRITICAL CARE 709, 112 tbl.3, 113 tbl.6 (1998).

[390] Alona Ramati et al., *Alteration in Functional Brain Systems After Electrical Injury*, 26 J. NEUROTRAUMA 1815, 1821 (2009).

[391] *See* Kathleen M. Kelley et al., *Life After Electrical Injury: Risk Factors for Psychiatric Sequelae*, 888 ANNALS N.Y. ACAD. SCI. 356, 357 (2006).

diagnoses, also of depression, PTSD, or both.[392] Sufferers of EIs also exhibit mood and behavioral disturbances, characterized by depression, anxiety, irritability, and aggressive outbursts.[393]

There are several additional interesting correlations. First, with regard to both subject-reported and objectively measured symptoms, "postacute" EI patients (i.e., those who experienced EIs more than three months pre-examination) appear to complain of and suffer more and more severe symptoms and perform worse on cognitive testing than "acute" patients (i.e., those who experienced EIs less than three months pre-examination).[394] Second, voltage is not shown to correlate with injury extent.[395] Rather, amperage is a more critical metric for predicting degree of harm suffered.[396] Third, EI sufferers experience varying and unique cognitive and emotional symptoms.[397] There is no consistent patient profile. Finally, a number of studies do not include individuals having experienced physical contact between the source of electrical current and their heads.[398] This means that many observed cognitive and emotional maladies are "diffuse" EIs: injuries or symptoms that manifest at points remote from the theoretical primary path of the electrical current.[399]

The last observation is particularly notable. Similar to the manner in which CEW strikes are postulated to influence bodily areas remote from dart impact locations,[400] researchers theorize that electrical current conduction by the spinal cord to the brain may be responsible for the cognitive and emotional symptoms of EIs when the head is not a current source's point of bodily contact.[401] This has implications for how CEWs might potentially influence the brain and cognition with the currents that they introduce into the body, even when they strike distant locations.

However, a number of limitations with regard to studies examining the link between EIs and cognitive and emotional impairments limit their relevance to CEWs.[402]

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[392] *See* Alona Ramati et al., *Psychiatric Morbidity Following Electrical Injury and Its Effects on Cognitive Functioning*, 31 GENERAL HOSPITAL PSYCHIATRY 360, 364–65 (2009).

[393] Barrash et al., *supra* note 388, at 79–80; Janus & Barrash, *supra* note 388, at 413.

[394] Pliskin et al., *Neuropsychological Effects*, *supra* note 386, at 143–45, 145 fig.3.

[395] *Id.* at 143.

[396] *See* Duff & McCaffrey, *supra* note 298, at 102; Jeffrey R. Jones, *Electrical Power and Electrical Injuries*, *in* PHYSICAL AND BIOLOGICAL HAZARDS OF THE WORKPLACE 233 (Gregg M. Stave & Peter H. Wald eds., 3d ed. 2017); Anastassios C. Koumbourlis, *Electrical Injuries*, 30 CRITICAL CARE MED. S424, S425 (2002).

[397] *See* Duff & McCaffrey, *supra* note 298, at 104; Pliskin et al., *Neuropsychological Aspects*, *supra* note 386, at 221.

[398] *See* Pliskin et al., *Neuropsychiatric Effects*, *supra* note 386, at 141; Ramati et al., *supra* note 390, at 1821.

[399] Morse, *supra* note 386, at 29; *see* Pliskin et al., *Neuropsychological Aspects*, *supra* note 386, at 219 ("Neurologic sequelae can occur whether or not the head is a point of direct contact with the electrical current.").

[400] *See* Morse, *supra* note 386, at 29–33.

[401] Ramati et al., *supra* note 390, at 1821.

[402] *See* Dawes et al., *Conducted Electrical Weapon*, *supra* note 28, at 55 ("[N]ot only is

Three are particularly noteworthy. First, although amperage is the most useful metric for predicting EI severity,[403] voltage is frequently the only measure provided because it is easiest to ascertain.[404] Second, research generally involves subjects who came in contact with domestic or commercial power sources,[405] which expose individuals to electrical currents with much higher amperages than those of CEWs.[406] And third, these studies assess individuals days, weeks, months, or years after exposure to electrical current,[407] or are retrospective, gathering past data on patients in order to glean insights.[408] With regard to CEWs and *Miranda* warnings, the concern is cognitive ability in the immediate aftermath of a strike.

Nevertheless, despite the aforementioned limitations, work at the intersection of EIs and cognitive and emotional impairment sparked investigations into a potential link between CEWs and similar symptoms.

2. Conducted Electrical Weapons and Cognition

This subsection comprehensively presents the current state of the art when it comes to research on the potential impact of CEWs on cognition. In so doing, it aims to provide the greatest possible aid to practitioners in assessing such possible influence in general and in specific situations, as well as make a substantial contribution to the literature in this area, which lacks an academic review. Relevant studies are therefore analyzed in relative depth, including their parameters, strengths, weaknesses, and implications.

The first examination of the potential effects of CEWs on cognition is Amy Bagley's unpublished, non-peer reviewed 2008 doctoral dissertation in the field of clinical psychology.[409] Inspired by research on the potential link between electrical

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the extrapolation of [EI] literature of questionable validity, but the literature which forms the premise of this extrapolation is of poor quality . . . .").

[403] Duff & McCaffrey, *supra* note 298, at 102; Koumbourlis, *supra* note 396, at S425.

[404] Duff & McCaffrey, *supra* note 298, at 102.

[405] *See, e.g.*, Pliskin et al., *Neuropsychological Effects*, *supra* note 386, at 141; Ramati et al., *supra* note 390, at 1816; *see also* Duff & McCaffrey, *supra* note 298, at 101–02 ("EI[s] are most common in [the] workplace (e.g., repairing power lines, bumping power lines with machinery)[,] but can also occur frequently in and around the home (e.g., installing a television antenna, dropping an electrical appliance in water)."(internal citation omitted)).

[406] Jones, *supra* note 396, at 233; Koumbourlis, *supra* note 396, at S425; Raphael C. Lee, *Biophysical Injury Mechanisms in Electrical Shock Victims*, 12 ENGINEERING MED. & BIOLOGY SOC'Y 1502, 1502 (1990); Laura Proctor & Srin Kuchibotla, *Electricity Remains a Serious Workplace Hazard*, OCCUPATIONAL HEALTH & SAFETY (Aug. 1, 2013), https://ohsonline.com/Articles/2013/08/01/Electricity-Remains-a-Serious-Workplace-Hazard.aspx?Page=1 [https://perma.cc/7W2X-V489].

[407] *See, e.g.*, Pliskin et al., *Neuropsychological Effects*, *supra* note 386, at 141 fig.1, 141–42; Ramati et al., *supra* note 390, at 1816.

[408] *See, e.g.*, Barrash et al., *supra* note 388, at 76–77; Janus & Barrash, *supra* note 388, at 410–11.

[409] Bagley, *supra* note 20.

injury and cognitive ability,[410] she hypothesizes that "if neuropsychological impairment were to result from [CEW] use, the pattern of deficits would be similar to those most commonly reported to occur from electrical injur[ies]."[411] To test this proposition, Bagley employs a non-experimental study design. She solicited volunteers from several Illinois police departments, ending up with sixty-two participants that she divided into two categories: thirty officers who had experienced CEW strikes and thirty-two who had not.[412] Due to the dearth of CEW deployments in society generally, police officers, who "are often administered a [CEW] shock before using this tool in the community," were singled out.[413] Each participant was interviewed regarding the following topics: the circumstances of their experience(s) with CEWs (for those having such experience), relevant medical history (individuals with prior traumatic brain injuries or who suffered falls and head injuries when subjected to a CEW strike were excluded), and educational history.[414] Of those who had previously been struck, the number of such administrations experienced ranged from one to nineteen, with a mean of 1.03.[415] And the time that had elapsed since the last such experience ranged from 21 to 2760 days, with a mean of 689 days.[416] Bagley classifies those struck within six months prior to being interviewed as "acute" subjects and those struck greater than six months before being interviewed as "delayed" subjects.[417] After the interview, subjects completed two hours of cognitive testing.[418]

Overall, participants struck by CEWs performed more poorly than those not, although the former did not suffer clinical cognitive impairment.[419] The cognitive deficiencies appeared relatively consistent with those experienced by individuals who have suffered electrical injury.[420] Moreover, those subjected to more CEW events performed poorer on memory tests than those subjected to fewer, and individuals struck by the older TASER M26 model performed worse on attention tests than those exposed to the newer TASER X26 model.[421] Bagley therefore tentatively puts forth that "[t]hese findings may suggest that it is not simply the mechanism of [CEW] shock, but also the factors surrounding the [CEW] administration (frequency and model type) that potentially contribute to or exacerbate any potential cognitive manifestations."[422]

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[410] *Id.* at 2, 16.
[411] *Id.* at 16.
[412] *Id.* at 17.
[413] *Id.*
[414] *Id.* at 17–18.
[415] *Id.* at 27.
[416] *Id.*
[417] *Id.* at 32.
[418] *Id.* at 18.
[419] *Id.* at 33.
[420] *Id.* (first citing Pliskin et al., *Neuropsychological Aspects*, *supra* note 386; then citing Pliskin et al., *Neuropsychological Effects*, *supra* note 386; and then citing Barrash et al., *supra* note 388).
[421] *Id.* at 34.
[422] *Id.*; *see id.* at 37 ("These results could suggest that the newer X26 Taser [sic] International

Additionally, there were no significant differences between the "acute" and "delayed" subject populations.[423] Participants expressed no subjective appreciation of any of the aforementioned cognitive effects.[424]

Bagley's study, however, suffers a great many limitations, which she details.[425] The most significant being that it is not experimental in design, thereby precluding causal inferences with regard to the relationship between CEW strikes and cognitive impairment.[426] For example, there is no baseline against which to compare the cognitive test results of participants who experienced CEW events (i.e., there are no measures of their cognitive performance prior to any CEW administrations).[427] But despite its many weaknesses, Bagley is right to assert the importance of her study: it is the first to examine the potential influence of CEW strikes on cognition.[428]

The next presentation is a 2009 case report by Esther Bui et al.[429] It addresses a male police officer in his thirties who took part in a police chase involving a suspected robber.[430] The sequence of events giving rise to the patient's affliction are recounted as follows:

> [The officer] and a colleague cornered the suspect, who initially appeared to surrender but then attempted an escape. The officer had begun to chase the suspect on foot when he experienced a sudden, severe pain in the back of his head . . . . Police records indicate that the officer's colleague had fired a [CEW] shot meant for the suspect but that the 2 copper darts had instead

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model is possibly associated with less deficient cognitive performance relative to non-Tased participants.").

[423] *Id.* at 34.

[424] *Id.* at 36.

[425] *Id.* at 36–39.

[426] *Id.* at 38. For a detailed presentation on designing experiments, see generally KLAUS HINKELMANN & OSCAR KEMPTHORNE, 1 DESIGN AND ANALYSIS OF EXPERIMENTS: INTRODUCTION TO EXPERIMENTAL DESIGN (2d ed. 2008).

[427] Bagley, *supra* note 20, at 39.

[428] *Id.* at 2.

[429] Esther T. Bui et al., *Generalized Tonic-Clonic Seizure After a Taser Shot to the Head*, 180 CAN. MED. ASS'N J. 625 (2009). There are a number of other case reports presenting patients who suffered CEW strikes to the head, but they focus on surgical approaches to such situations and do not contain information regarding any effects on cognition that these injuries might have generated. *See, e.g.*, Sandy L. Chen et al., *Perforating Ocular Injury by Taser*, 34 CLINICAL & EXPERIMENTAL OPHTHALMOLOGY 378 (2006); Paul E. Kaloostian & Huy Tran, *Intracranial Taser Dart Penetration: Literature Review and Surgical Management*, 2012 J. SURGICAL CASE REP. 1 (2012); Isabelle Le Blanc-Louvry et al., *A Brain Penetration After Taser Injury: Controversies Regarding Taser Gun Safety*, 221 FORENSIC SCI. INT'L e7 (2012); Barry E. Mangus et al., *Taser and Taser Associated Injuries: A Case Series*, 74 AM. SURGEON 862 (2008); Tausif-Ur Rehman et al., *Intracranial Penetration of a TASER Dart*, 25 AM. J. EMERGENCY MED. 733.e3 (2007).

[430] Bui et al., *supra* note 429, at 625.

> struck the officer in the occiput [the back and lower part of the skull] and upper back.[431]

The patient remembered feeling intense pain in the back of his head, then he collapsed unconscious.[432] His colleague next described the patient as "unresponsive and foaming at the mouth," rolling his eyes upward, and experiencing "tonic-clonic movements" (i.e., muscle stiffening (the tonic phase) and rapid, rhythmic motions (the clonic phase)) and apnea (i.e., the suspension of breathing) for approximately one minute.[433] The patient was then confused and combative.[434] His next memory after initially falling unconscious was of being in the emergency room, where he steadily regained orientation over several hours, felt tightness in his chest, and experienced a severe headache, but physical and neurological examinations returned normal results.[435] After being monitored overnight, he was discharged in stable condition.[436]

The patient returned to work five days after the incident, but reported experiencing "persistent headaches, dizziness, back pain[,] and chest tightness."[437] A psychiatric evaluation performed seven months after the strike suggested a diagnosis of adjustment disorder with depressed and anxious mood.[438] The patient had no history of psychiatric conditions prior to the CEW injury.[439] But neuropsychological testing nine months after the event revealed no evidence of cognitive impairment, and brain imaging performed twelve months after the incident showed nothing anomalous.[440] Finally, patient symptoms of anxiety, difficulties concentrating, irritability, dizziness, and persistent headaches continued over a year after the strike.[441]

Though certainly of limited explanatory value given the non-experimental nature of case reports and their narrow focus,[442] it is interesting that the patient in question exhibited no cognitive impairment when tested.[443]

Five years later, in 2014, in light of arguments at trial by defendants that CEW strikes during arrest rendered them incapable of knowingly and intelligently waiving their Fifth and Sixth Amendment rights,[444] and given the dearth of research examining

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[431] *Id.*
[432] *Id.*
[433] *Id.*
[434] *Id.*
[435] *Id.*
[436] *Id.*
[437] *Id.*
[438] *Id.*
[439] *Id.*
[440] *Id.*
[441] *Id.* at 626.
[442] *See, e.g.*, Trygve Nissen & Rolf Wynn, *The Clinical Case Report: A Review of Its Merits and Limitations*, 7 BIOMED CENTRAL RES. NOTES 264 (2014).
[443] Bui et al., *supra* note 429, at 625.
[444] White et al., *supra* note 380, at 268–69.

the relationship between CEWs and cognitive function, Michael White et al. (White et al. 2014) published a study addressing this topic.[445] They solicited twenty-one police recruit volunteers who were scheduled to be subject to a CEW strike as part of their training.[446] Each completed a series of cognitive tests at three points in time: (1) between three and four hours prior to CEW exposure; (2) immediately following (within five minutes of) CEW exposure; and (3) twenty-four hours after exposure.[447]

As an initial subjective matter, subjects "reported experiencing significantly more difficulty with concentration and memory immediately following [CEW] exposure" and "feeling more overwhelmed" during their first post–CEW strike test.[448] With regard to test performance, participants "experienced statistically significant reductions in several measures of cognitive functioning [immediately] following [CEW] exposure."[449] When tested twenty-four hours post-exposure, scores returned to baseline, suggesting that cognitive impacts are short-lived.[450]

White et al. 2014 present their results as having important implications for the validity of waivers of constitutional rights:

> [T]hese findings suggest that [CEWs] may indeed produce deficits in some dimensions of cognitive functioning. These potential effects clearly warrant additional empirical study. If these effects are replicated in additional studies and are severe enough to impair an individual's ability to understand and waive *Miranda* rights, the implications for police policy and practice could be profound. Results could influence how and when police read *Miranda* rights to suspects who have received a [CEW] exposure.[451]

Moreover, it is noted that the relatively good health of the study's participants "stands in stark contrast to the [often] poor health of individuals who receive [CEW] exposures in 'real-life' encounters with police,"[452] the latter of whom are "often under the influence of drugs or alcohol, are mentally ill and in crisis, and have a number of serious medical and psychological conditions."[453] Accordingly, CEWs

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[445] *Id.*

[446] *Id.* at 272.

[447] *Id.* at 272–74.

[448] *Id.* at 275.

[449] *Id.* at 278.

[450] *Id.*

[451] *Id.*

[452] *Id.* at 279 (citing White & Ready, *supra* note 261; Michael D. White & Justin Ready, *The Impact of the Taser on Suspect Resistance: Identifying Predictors of Effectiveness*, 56 CRIME & DELINQ. 70 (2010)).

[453] *Id.* (citing NAT'L INST. OF JUSTICE, STUDY OF DEATHS FOLLOWING ELECTRO MUSCULAR DISRUPTION (2011), https://www.ncjrs.gov/pdffiles1/nij/233432.pdf [https://perma.cc/353K-WEXD]; Michael D. White & Justin Ready, *The TASER as a Less-Lethal Force*

could produce greater cognitive deficiency in those whom law enforcement officers tend to use them against.[454]

An important limitation of the study mentioned by the authors, however, is the fact that it is unclear if general cognitive tests are an accurate proxy for the ability to understand and waive constitutional rights.[455] Employment of tests specifically designed to measure comprehension of *Miranda* warnings and the rights they are meant to convey would have meaningfully enhanced the relevance of the findings. An additional weakness of the study is that it only presents a scenario involving the use of a CEW. By recounting literature on the cognitive effects of electrical injuries, White et al. appear to imply that the electrical nature of CEWs could be responsible for their study results.[456] But the cognitive impacts of alternate forceful or stressful arrest situations (e.g., subduing a suspect by hand, chasing a suspect, administering pepper spray, etc.) are not presented, so it is unclear if CEWs have a unique effect or influence individuals in a manner consistent with other arrest methods. The study also lacks a control condition wherein participants are not subjected to any intervention, allowing the impacts of other conditions to be more reliably assessed.[457] Finally, the authors use a convenience sample of police recruits who volunteered for the study and were going to be subjected to CEW strikes regardless.[458] This is not a representative sample of the population and hinders extrapolation of the results.

The same year, Donald Dawes et al. (Dawes et al. 2014) published their own study of the cognitive effects of CEWs.[459] They additionally endeavored to place such effects within the context of the cognitive impacts of other simulated forceful arrest scenarios in order to determine whether CEWs have unique influence.[460]

The study's participant population consisted of fifty-seven law enforcement and correctional officers.[461] These individuals completed an initial battery of cognitive tests and were then subject to one of five scenarios:

> (1) a 5 [second] . . . CEW . . . exposure, (2) a sprint of 100 yards with obstacles, simulating a foot chase, (3) a 45 [second] simulated

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Alternative: Findings on Use and Effectiveness in a Large Metropolitan Police Agency, 10 POLICE Q. 170 (2007)).

[454] *Id.*

[455] *Id.* at 280.

[456] *Id.* at 270–72.

[457] *See* Daniel Nelson, *What an Experimental Control Is and Why It's So Important*, SCI. TRENDS (Nov. 8, 2017), https://sciencetrends.com/experimental-control-important/ [https://perma.cc/48TL-9AJV].

[458] White et al., *supra* note 380, at 272; *see* Roger D. Yusen & Benjamin Littenberg, *Study Eligibility and Participant Selection*, *in* TRANSLATIONAL AND EXPERIMENTAL CLINICAL RESEARCH 45–47 (Daniel P. Schuster & William J. Powers eds., 2005) (explaining sampling methods, including the weaknesses of convenience sampling).

[459] Dawes et al., *Use-of-Force Scenarios*, *supra* note 28, at 9–10.

[460] *Id.* at 10.

[461] *Id.* at 10, 12.

> fight against a padded instructor, (4) a [canine] search and bite exercise with a bite suit, and (5) a spray of oleoresin capsicum (O.C.), or pepper spray, to the face with the eyes shielded . . . .[462]

Immediately post-scenario, the participants completed the battery again, then two more times at fifteen minutes post-scenario and one hour post-scenario.[463] Three cognitive tests from the Automated Neuropsychological Assessment Metrics (ANAM) were used: those measuring visual scanning, processing speed, and learning; attention and processing speed; and visual spatial discrimination and working memory.[464]

The following findings were reported: "Over all [sic], we found a decreased cognitive performance . . . immediately following the scenarios that recovered to baseline within 1 [hour]. There were no statistical differences between the scenarios."[465] Moreover, the decreases from baseline performance were not such as to be deemed clinically significant.[466] Dawes et al. 2014 therefore determined that "the effects [of CEW strikes] on the cognitive domains tested are transient, of questionable clinical significance, and similar to the effects of other use-of-force scenarios."[467] The effects are also contended to "possibly [be] non-specifically related to stress and not to a specific use-of-force . . . ."[468]

Nevertheless, cognitive impacts presented, and the authors note that their "data would seem to suggest that it could be optimal to wait for 15 [minutes] to 1 [hour] before presenting subjects with more complex neurocognitive tasks[,]" though this may be a conservative recommendation given the non-clinically significant changes observed.[469] With regard to the study's implications for the validity of waivers of constitutional rights following CEW strikes, "it will be debatable whether these changes will meet the court's threshold for sufficient magnitude. This will take additional study and debate."[470] Importantly, the findings suggest that if courts give special consideration to waivers following CEW administration, they would also need to give such consideration when other stressful arrest methods are employed and not subject CEW use to special scrutiny.

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462 *Id.* at 10.

463 *Id.* at 11.

464 *Id.*; *cf.* Robert L. Kane et al., *Identifying and Monitoring Cognitive Deficits in Clinical Populations Using Automated Neuropsychological Assessment Metrics (ANAM) Tests*, 22S ARCHIVES CLINICAL NEUROPSYCHOLOGY S115, S119 tbl.1, S124 (2007) ("[D]ata are consistent in suggesting that brief ANAM batteries are both sensitive and specific in identifying patients with neurocognitive difficulties.").

465 Dawes et al., *Use-of-Force Scenarios*, *supra* note 28, at 14–15.

466 *Id.* at 15.

467 *Id.* at 16.

468 *Id.*

469 *Id.*

470 *Id.*

As with White et al. 2014, the findings of Dawes et al. 2014 are limited by the fact that tests specifically designed to measure *Miranda* warning and constitutional rights comprehension were not used. The study also lacks a control condition and uses a convenience sample.[471]

Also in 2014, Jeffrey Ho et al. (Ho et al. 2014) tested individuals' ability to take and pass standardized field sobriety tests (SFSTs) fifteen minutes after the following conditions: (1) five-second CEW application; (2) one-hundred-yard sprint with directional changes; (3) forty-five-second simulated combat with an opponent; (4) police dog attack; and (5) pepper spray to the face.[472] SFSTs include three tasks. First, the "one-leg stand" task tests balance, attention, and cognitive ability by requiring a subject, with arms at his side, to raise one leg six inches off the ground and count rapidly from 1,001 to 1,030.[473] Second, the "walk and turn" task tests motor control and attention by requiring a subject to place one foot in front of the other roughly nine times on a line, make a six-step turn, and repeat the heel-to-toe steps.[474] Finally, the "horizontal gaze nystagmus" test involves an officer presenting a stimulus to a subject, who must follow it with his eyes while keeping his head still.[475] Nystagmus (i.e., the uncontrolled jerking of the eyes) is watched for.[476] Ultimately, all participants passed the SFSTs fifteen minutes post-condition.[477] Like Dawes et al., however, the study lacks a control condition and uses a convenience sample.[478]

The following year, Michael White et al. 2015 published a study examining CEWs and cognition.[479] The participant population consisted of 142 individuals from the four Arizona State University campuses.[480] Each person was subject to one of four conditions: (1) control (nothing was done to them); (2) exertion (punching a heavy bag vigorously for thirty seconds); (3) a five-second CEW strike; and (4) the CEW strike then exertion.[481] Participants completed a battery of cognitive tests at five points in time: (1) one hour prior to the condition; (2) immediately following the condition; (3) one hour after the condition; (4) one day after the condition; and

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[471] *Id.* at 16–17.

[472] Jeffrey Ho et al., *Neurocognitive Effect of Simulated Resistance and Use of Force Encounters on Standardized Field Sobriety Testing*, 46 J. EMERGENCY MED. 283, 283 (2014).

[473] Gary W. Kunsman, *Human Performance Toxicology*, *in* PRINCIPLES OF FORENSIC TOXICOLOGY 20 (Barry Levine ed., 2d ed. 2003).

[474] *Id.* at 19.

[475] *Id.* at 19–20.

[476] *Id.* at 20.

[477] Ho et al., *supra* note 472, at 283.

[478] *See id.*

[479] Michael D. White et al., *Examining Cognitive Functioning Following TASER Exposure: A Randomized Controlled Trial*, 29 APPLIED COGNITIVE PSYCHOL. 600, 600 (2015). The study is also presented in a different article. *See* Kane & White, *supra* note 22.

[480] White et al., *supra* note 479, at 601.

[481] *Id.* at 601–02.

(5) one week after the condition.[482] They also completed a series of "subjective state questions" at the same five points.[483]

Participants experienced statistically significant mean score changes with regard to one of the cognitive tests: the Hopkins Verbal Leaning Test (HVLT).[484] The test

> [m]easures 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.[485]

With regard to participant scores on the HVLT, the mean participant score declined by a statistically significant amount from baselines immediately following exertion, a CEW strike, and the CEW strike-then-exertion combination.[486] These effects dissipated within one hour.[487] The difference between the exertion and CEW-then-exertion groups was statistically significant, while the difference between the exertion and the CEW and CEW-then-exertion groups were not.[488]

In a different article presenting the same study, Robert Kane and Michael White provide more detail on the results.[489] They explain that the mean HVLT score for individuals under seventy-eight years old is 25, and that scores of 18–19 or 19–20 are indicative of mild cognitive impairment.[490] The initial mean scores for the participants subject to one of the four conditions ranged from 25.75 to 26.68.[491] Immediately following the respective interventions, each group had the following mean scores: 25.46 for control, 23.94 for exertion, 22.89 for the CEW strike, and 22.53 for the CEW-then-exertion.[492] But Kane and White further note that 25.7% of the CEW group and 28.9% of the CEW-then-exertion group scored below 20, while only

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482 *Id.* at 602.
483 *Id.*
484 *Id.* at 606; *see* Kane & White, *supra* note 22, at 98.
485 Kane & White, *supra* note 22, at 88.
486 White et al., *supra* note 479, at 603–04, 606.
487 *Id.* at 606.
488 *Id.* at 604.
489 *See* Kane & White, *supra* note 22.
490 *Id.* at 98 (internal citations omitted).
491 *Id.* at 93 tbl.2.
492 *Id.*

18.8% of the exertion group did (and only 2.7% of the control group).[493] In addition, only 20% of the CEW group and 18.4% of the CEW-then-exertion group scored 26 or higher, compared to 31.2% of the exertion group and 45.9% of the control group.[494] Thus, approximately one-fourth of individuals subject to a CEW strike, according to the metric adopted by the authors, had HVLT scores indicating mild cognitive impairment, while only roughly one-fifth of those subject to solely exertion did.[495]

With regard to participants' subjective assessments of themselves immediately following the study conditions, on average, those subject to only a CEW strike reported feeling less able to concentrate, more anxious, and more overwhelmed than those exposed to exertion only.[496] In turn, on average, those subject to the CEW strike-then-exertion reported feeling less able to concentrate, more anxious, and more overwhelmed than those who experienced a CEW strike alone.[497] These differences, however, are not consistently statistically significant.[498]

Kane and White assert that the study's results depart from those of Dawes et al. 2014 because of the statistically significant difference in cognitive performance between the exertion and CEW-then-exertion groups, whereas Dawes et al. 2014 presented no statistically significant difference between any of their conditions.[499] Kane and White believe this shows a unique CEW effect on cognition and, as a result, that the study has significant implications for the administration of *Miranda* warnings and assessments of the validity of constitutional rights waivers.[500] Citing research indicating that those with mild cognitive impairment are more likely to waive their constitutional rights and provide inaccurate information to law enforcement than those without, the authors speculate that individuals subject to CEW strikes might behave in a similar fashion immediately following these events.[501] Their concerns are heightened by the fact that the study participants were relatively healthy, well-educated young adults, as opposed to what they term "typical" criminal suspects "who may be drunk, high, or mentally ill and in crisis at the time of [CEW] exposure" and might therefore experience even greater cognitive declines.[502]

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[493] *Id.* at 98–99 (internal citations omitted).
[494] *Id.* at 99.
[495] *Id.* at 98–99.
[496] *Id.* at 96 tbl.3.
[497] *Id.*
[498] *Id.* at 95–98.
[499] *Id.* at 102.
[500] *See id.* at 99–100 (internal citations omitted).
[501] *Id.* at 99 (citing Saul M. Kassin et al., *Police-Induced Confessions, Risk Factors, and Recommendations: Looking Ahead*, 34 L. & HUM. BEHAV. 49 (2010); Michael J. O'Connell et al., Miranda *Comprehension in Adults with Mental Retardation and the Effects of Feedback Style on Suggestibility*, 29 L. & HUM. BEHAV. 359 (2005); Richard Rogers et al., *An Analysis of* Miranda *Warnings and Waivers: Comprehension and Coverage*, 31 L. & HUM. BEHAV. 177 (2007)).
[502] *Id.* at 100.

To address the aforementioned potential risks, Kane and White make the following recommendation: law enforcement officers should wait sixty minutes following a successful CEW deployment before administering *Miranda* warnings to suspects and seeking to obtain waivers of constitutional rights.[503] They contend that this would be beneficial for both suspects and law enforcement by having the following effects:

> (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 [CEW] exposure.[504]

The limitations of the study giving rise to these recommendations are, however, numerous and significant. First, Kane and White's highlighting of individual HVLT scores by noting the percentages of participants who scored below the marker for mild cognitive impairment after administration of the conditions is troubling.[505] The data reveal no statistically significant differences between the exertion and CEW groups, but the authors attempt to illuminate a meaningful difference by presenting information on individual responses, despite White et al. 2015 acknowledging that "[t]he nature and severity of cognitive deficits following [CEW] exposure were highly individualized."[506] It is well known that individual physiological and psychological stress reactivity, as a general matter, are variable.[507] Moreover, Kane and White do not present the individual baseline HVLT scores or the degree to which any individuals scored below the authors' marker for mild cognitive impairment after intervention, providing no context for post-condition scores. If twenty-five percent of participants who were subject to a CEW strike barely scored above the authors' marker for mild cognitive impairment pre-condition, and barely scored below the marker post-condition, then CEW cognitive effects are marginal and likely of little relevance to courts determining the validity of waivers of constitutional rights. The information on individual responses therefore has no value with regard to the

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[503] *Id.* at 101.

[504] *Id.*

[505] *Id.* at 98–99.

[506] White et al., *supra* note 479, at 606.

[507] *See, e.g.*, Adam Bibbey et al., *Personality and Physiological Reactions to Acute Psychological Stress*, 90 INT'L J. PSYCHOPHYSIOLOGY 28, 28 (2013); Emma Childs et al., *Personality Traits Modulate Emotional and Physiological Responses to Stress*, 25 BEHAV. PHARMACOLOGY 493, 493 (2014); André B. Negrão et al., *Individual Reactivity and Physiology of the Stress Response*, 54 BIOMEDICINE & PHARMACOTHERAPY 122, 122 (2000); Anita Singh et al., *Differential Hypothalamic-Pituitary-Adrenal Axis Reactivity to Psychological and Physical Stress*, 84 J. CLINICAL ENDOCRINOLOGY & METABOLISM 1944, 1944 (1999).

relationship between CEWs and cognitive ability and muddies the study's results and scientific contribution.

Second, the conditions administered in the study do not appear as comparable as those administered by Dawes et al. 2014.[508] The exertion condition did not involve the imposition of stress upon participants by another actor or the application of physical discomfort or pain, simply the punching of a heavy bag.[509] CEW strikes entail these potentially stress-enhancing and cognitive ability-diminishing aspects. Dawes et al. 2014, on the other hand, included conditions involving a simulated physical fight with an opponent, a police dog bite on an individual wearing a bite suit, and the administration of pepper spray, which more closely resemble the confrontation and physical discomfort or pain of a CEW strike.[510]

Third, Kane and White's claim that the study results are "contradictory" to those of Dawes et al. 2014 appears false.[511] Kane and White assert that because the CEW-then-exertion group had a statistically significantly lower mean HVLT score than the exertion group post-intervention, the data support CEWs having a unique effect on cognition beyond that of other stressors.[512] Yet there is no statistically significant difference in mean scores between the exertion and CEW groups,[513] suggesting, rather, that there is an additive effect on cognition when two stressors are experienced as opposed to one, not a unique, elevated CEW effect.

Fourth, similar to White et al. 2014,[514] by invoking the literature on electrical injuries, White et al. 2015 and Kane and White allude to the electrical nature of CEWs being responsible for any subsequent cognitive impairment in individuals who suffer a CEW strike.[515] This, however, is not supported by the data since the difference between the mean cognitive declines experienced by the exertion and CEW groups is not statistically significant, suggesting that an analogous stress response is responsible in both instances.[516]

Finally, like previous studies, White et al. 2015 do not utilize tests specifically designed to gauge *Miranda* warning comprehension, but instead use general cognitive tests,[517] limiting the relevance of their results. They also study a convenience sample of college students that is not representative of the population.[518]

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[508] *See* White at al., *supra* note 479, at 601.

[509] *Id.*

[510] Dawes et al., *Use-of-Force Scenarios*, *supra* note 28, at 10.

[511] Kane & White, *supra* note 22, at 102.

[512] *Id.*

[513] White et al., *supra* note 479, at 604.

[514] White et al., *supra* note 380, at 270–72.

[515] *See* Kane & White, *supra* note 22, at 82–83; White et al., *supra* note 479, at 600, 606 (internal citations omitted).

[516] Kane & White, *supra* note 22, at 102.

[517] White et al., *supra* note 479, at 601.

[518] *Id.* Problems with using college student convenience samples are well documented. *See, e.g.*, Paul H. P. Hanel & Katia C. Vione, *Do Student Samples Provide an Accurate Estimate of the General Public?*, PLOS ONE, Dec. 21, 2016, at 1; Robert A. Peterson & Dwight R.

In addition to the aforementioned internal issues and problematic interpretations, others have seized on the study's results and further distorted them. Notably, Henry Fradella titles his article, *Neuroscience and the Potential Need for a New Bright-Line Rule Concerning* Miranda *Waivers After CED Exposure*,[519] the first word portending trouble. Based on White et al. 2015's findings, Fradella supports Kane and White's recommendation for a sixty-minute waiting period between CEW strikes and administrations of *Miranda* warnings.[520] But he couches his support in the following terms: "Kane and White suggest that although use of force produces a stress response that impairs cognitive functioning, [CEW] exposure seems to compound that decline . . . significantly *as a result of electricity scrambling brain signals* . . . ."[521] He goes on to argue that "it would be fundamentally unfair *to scramble the electrical signals in the brain*, thereby significantly impairing cognition, and then claim that what is said during the period of impairment was voluntary, knowing, and intelligent."[522] But White et al. 2015's study does not involve neuroscience, nor is there any indication that CEWs are directly impacting the brain by way of electrical current. In fact, White et al. 2015 specifically note that their study sheds no light on the mechanisms by which CEWs induce cognitive deficits and that neuroscience research in this regard could be helpful.[523]

Ultimately, White et al. 2015's results are interesting and meaningfully add to the literature on CEWs and cognitive impairment. Unfortunately, however, Kane and White's presentation of these results is misleading and shows them apparently bending over backwards to argue that the data support CEWs diminishing cognitive function in an extraordinary fashion (not to mention Fradella's dubious understanding of White et al. 2015's findings).[524]

The final study to examine the potential cognitive impacts of CEW strikes was published in 2018 by Donald Dawes et al. (Dawes et al. 2018).[525] The participant population consisted of 115 individuals taking part in a CEW training exercise, a large number of whom were law enforcement, correctional, or security officers.[526] They were divided into five groups depending on the condition they were to experience: (1) a five-second CEW exposure; (2) a high intensity interval training routine (HIIT); (3) "low" alcohol intoxication (LAI); (4) "high" alcohol intoxication (HAI); and (5) control.[527] With regard to the HIIT, this

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Merunka, *Convenience Samples of College Students and Research Reproducibility*, 67 J. BUS. RES. 1035 (2014).

[519] Fradella, *supra* note 27, at 117.

[520] *Id.* at 126.

[521] *Id.* at 125 (emphasis added).

[522] *Id.* at 126 (emphasis added).

[523] White et al., *supra* note 479, at 606.

[524] *See* Kane & White, *supra* note 22, at 98, 102.

[525] Dawes et al., *Conducted Electrical Weapon*, *supra* note 28.

[526] *Id.* at 52–53.

[527] *Id.* at 52.

> consisted of 10 steps/jumps onto an 8-inch (20 cm) plyometric box, followed by 10 ground-to-overhead lifts of 15-pound (7 kg) dumb bells, followed by 10 strikes on a large tractor tire with an 8-pound (3.6 kg) sledge hammer with the stations repeated in order until . . . 90 [seconds] elapsed.[528]

In turn, LAI is marked by a blood alcohol content (BAC) below or equal to 0.12 grams/210 liters, as estimated from a portable breath-alcohol test (the mean BAC for this group was 0.08 g/210 L, the legal limit for an adult of drinking age to operate a motor vehicle in the United States), and HAI delineates a BAC above 0.12 g/210 L (the mean BAC for this group was 0.16 g/210 L).[529] Participants completed a battery of cognitive tests at five points in time: (1) pre-condition; (2) ten minutes post-condition; (3) thirty-five minutes post-condition; (4) sixty minutes post-condition; and (5) eighty-five minutes post-condition.[530] Similar to Dawes et al. 2014's study, three cognitive tests from the ANAM were used, though with one substitution: those measuring attention and processing speed; visual spatial discrimination and working memory; and abstract reasoning and verbal syntax.[531]

The results indicated that, ten minutes post-condition, while all groups except the control group experienced mean score declines, only the LAI and HAI groups experienced statistically significant declines in cognitive performance across all three tests.[532] All mean scores for the CEW and HIIT groups returned to baseline within thirty-five minutes post-condition, and those of the LAI group did so within eighty-five minutes post-condition.[533] The mean scores of the HAI group did not return to baseline within the eighty-five-minute testing period.[534]

After presenting their findings, given the lack of empirical support for CEWs having a unique impact on cognitive ability, Dawes et al. 2018 note the oddity of Kane and White recommending a bright-line rule for the delayed administration of *Miranda* warnings following CEW strikes on suspects.[535] Rather, they offer the following summation of the relevant literature:

> [T]he CEW neurocognitive literature suggests many stressors can transiently cause neurocognitive changes that can be measured in a neurocognitive battery, but these changes may not be

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[528] *Id.*

[529] *Id.* at 53. For an explanation of BAC estimation based on breath-alcohol measurement, see RACHEL BLACK, ALCOHOL IN POPULAR CULTURE: AN ENCYCLOPEDIA 39 (2010).

[530] Dawes et al., *Conducted Electrical Weapon*, *supra* note 28, at 53.

[531] *Id.*; *see supra* note 464 and accompanying text.

[532] Dawes et al., *Conducted Electrical Weapon*, *supra* note 28, at 54–55.

[533] *Id.* at 55.

[534] *Id.*

[535] *Id.*

> of a magnitude to be deemed "clinically" important or legally relevant to the issue of *Miranda* or consent. The results of our present study would suggest that the transient neurocognitive changes after a CEW exposure are not legally relevant with regard to *Miranda* and consent. All of the literature shows that, although there are measurable neurocognitive changes, these changes are transient with no long-term effects.[536]

The study does, however, suffer many of the same limitations as previous ones: it utilizes tests designed to measure cognition generally, not *Miranda* warning comprehension specifically, and a convenience sample.[537]

Study weaknesses aside, the supposition that CEWs influence cognition as stressors by inducing general stress responses, rather than producing exceptional cognitive declines by way of unique electrical influence, is further supported by research examining physiological responses to CEW strikes. These are presented here in slightly less detail.

In 2009, John Criscione produced a non-peer reviewed report consisting of a study of the physiological effects of CEWs, sponsored by the Department of Defense's Joint Non-Lethal Weapons Directorate.[538] The participants were thirty-two police cadets exposed to CEWs as part of their training.[539] Pertinently, blood samples were taken from them at three points in time: (1) immediately pre-condition; (2) immediately post-condition (it is unclear exactly how soon after the CEW administration); and (3) twenty-four hours post-condition.[540] The mean levels of several molecules were analyzed,[541] but only cortisol and lactic acid increased above baseline levels immediately post-condition, and only the latter by a statistically significant amount.[542] The upsurge in lactic acid—a waste product of muscle tissue during strenuous exercise—reflects the extensive muscle contractions induced by CEWs.[543] In turn, increased cortisol concentration in blood is a typical response to stressful stimulation, indicating that a CEW strike is a stressful event.[544]

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[536] *Id.* at 56.

[537] *See* White et al., *supra* note 479, at 601.

[538] JOHN CRISCIONE, AN INDEPENDENT ASSESSMENT OF THE PHYSIOLOGICAL AND COGNITIVE EFFECTS FROM THE X-26 TASER DEVICE IN VOLUNTEER HUMAN SUBJECTS (2009), https://pdfs.semanticscholar.org/f03a/e8b48686aacaee397d2269bc1ecf1af889b8.pdf?_ga=2.45535271.205894286.1584482559-1654866579.1584482559 [https://perma.cc/37JB-ZT6V].

[539] *Id.* at 6.

[540] *Id.* at 5–6.

[541] *Id.* at 6 ("Levels of particular relevance to this investigation include C-reactive protein (cardiac), cardiac troponin I, creatine kinase, serotonin, serum potassium, serum myoglobin, lactic acid and cortisol.").

[542] *Id.* at 6–7.

[543] *Id.* at 9; *see* BRUCE ABERNETHY ET AL., THE BIOPHYSICAL FOUNDATIONS OF HUMAN MOVEMENT 128 (2d ed. 2005) ("Excess lactic acid is associated with muscular fatigue.").

[544] CRISCIONE, *supra* note 538, at 9; *see* CHERYL WATSON, HUMAN PHYSIOLOGY 54

The same year, Donald Dawes et al. (Dawes et al. 2009) published a more comprehensive study examining CEW strikes and physiological stress markers.[545] The fifty-two participants were culled from those taking part in a law enforcement training course and subjected to one of four conditions: (1) a five-second CEW exposure; (2) a five-second spray of oleoresin capsicum (the raw material from which pepper spray is made) to the eyes; (3) a forty-five-second placement of the hand and forearm in zero degree Celsius water; or (4) a one-minute defensive tactics drill (i.e., "[one] [minute] of the subject preventing multiple defensive tactics instructors from trying to remove a simulated handgun from his holster on his duty belt while in the supine position on a training mat").[546] Salivary samples were procured from participants ten to fifteen minutes pre-condition, ten to twenty minutes post-condition, and forty to sixty minutes post-condition.[547] The mean levels of two molecules indicative of the physiological stress response were analyzed: alpha-amylase and cortisol.[548] With regard to the first post-condition measurement (ten to twenty minutes post-condition), mean alpha-amylase levels increased in the oleoresin capsicum and defensive tactics participants, most dramatically in the latter.[549] These levels remained roughly constant in the CEW condition and decreased in the cold-water condition.[550] By forty to sixty minutes post-condition, they had decreased in the CEW and defensive tactics conditions, most significantly in the latter.[551] The mean level increased slightly at this point in the oleoresin capsicum and cold-water condition participants.[552] Turning to mean cortisol levels, these increased in all participants, but most significantly in those subject to oleoresin capsicum, followed by those exposed to CEWs.[553] Cold-water participants displayed only a slight increase.[554] By the second measurement, levels continued increasing in all participants, with the defensive tactics cohort experiencing the largest increase, followed by the CEW group.[555] The oleoresin capsicum and cold-water groups experienced only modest increases.[556]

(2015) ("Physiological stresses, such as cold, severe exercise, and injury, or psychological stresses like fear or anxiety can increase the release of . . . cortisol.").

[545] Donald Dawes et al., *The Neuroendocrine Effects of the TASER X26: A Brief Report*, 183 FORENSIC SCI. INT'L 14 (2009).

[546] *Id.* at 15.

[547] *Id.*

[548] *Id.*; *see* WATSON, *supra* note 544, at 54 (noting cortisol's relationship to stress); Urs Markus Nater et al., *Stress-Induced Changes in Human Salivary Alpha-Amylase Activity—Associations with Adrenergic Activity*, 31 PSYCHONEUROENDOCRINOLOGY 49, 55 (2006) (finding a "clear and distinct pattern of stress-related changes in salivary alpha-amylase").

[549] Dawes et al., *supra* note 545, at 17 figs.1–2, 18.

[550] *Id.*

[551] *Id.* at 17 fig.1.

[552] *Id.*

[553] *Id.* at 17 fig.2, 18.

[554] *Id.*

[555] *Id.*

[556] *Id.*

Dawes et al. 2009 proffer that the results "suggest that exertion and [oleoresin capsicum] may have the most important influence on these markers of stress when compared to the cold-water immersion tank or the . . . CEW."[557]

A study published one year later, by Jeffrey Ho et al. (Ho et al. 2010) presents similar results.[558] Participants were taken from those taking part in a training event sponsored by TASER International and consisted of sixty-two law enforcement and corrections officers, non-law enforcement public safety personnel, TASER International employees, and academic researchers.[559] Each was subjected to one of five conditions: (1) a 150-meter sprint and wall hurdle; (2) forty-five seconds of punching and kicking a heavy bag; (3) a ten-second CEW exposure; (4) a simulated attack by a law enforcement canine; or (5) the application of oleoresin capsicum foam to the face and neck.[560] Participants had blood taken pre-condition, immediately (within thirty seconds) post-condition, every two minutes after the first post-condition draw until ten minutes passed, and twenty-four hours post-condition.[561] Several indicators of stress were examined.[562] Mean blood concentrations of substances (lactate and potassium)[563] and markers (blood acidity)[564] associated with exercise increased or decreased appropriately in accordance with the physical strenuousness of the condition, with the sprint and heavy bag conditions exhibiting the greatest changes.[565] In addition, immediately post-condition, mean levels of each catecholamine (epinephrine, norepinephrine, and dopamine; hormones associated with the body's stress response)[566] increased, most dramatically in the heavy bag group.[567] Mean levels for those subject to a CEW strike were the second-highest with regard to epinephrine and norepinephrine, and roughly equal to the heavy bag group with regard to dopamine.[568] These

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[557] *Id.* at 18.

[558] Jeffrey D. Ho et al., *Acidosis and Catecholamine Evaluation Following Simulated Law Enforcement "Use of Force" Encounters*, 17 ACAD. EMERGENCY MED. E60 (2010).

[559] *Id.* at E61–E62.

[560] *Id.* at E61.

[561] *Id.* at E62.

[562] *Id.* at E63–E65 tbls.2–5, fig.1.

[563] *See* Mark Hargreaves, *Skeletal Muscle Carbohydrate Metabolism During Exercise*, *in* EXERCISE METABOLISM 41 (Mark Hargreaves & Lawrence Spriet eds., 2d ed. 2006) ("Blood lactate exponentially increases with exercise of increasing intensity . . . ."); Michael I. Lindinger, *Potassium Regulation During Exercise and Recovery in Humans: Implications for Skeletal and Cardiac Muscle*, 27 J. MOLECULAR & CELLULAR CARDIOLOGY 1011, 1011–13 (1995).

[564] *See* JOHN CLANCY & ANDREW MCVICAR, PHYSIOLOGY AND ANATOMY FOR NURSES AND HEALTHCARE PRACTITIONERS: A HOMEOSTATIC APPROACH 130 (3d ed. 2009) (noting that blood acidity increases as a result of the body's response to stress).

[565] Ho et al., *supra* note 558, at E63–E64 tbls. 3–4.

[566] *See* GEORGE S. EVERLY, JR. & JEFFREY M. LATING, A CLINICAL GUIDE TO THE TREATMENT OF THE HUMAN STRESS RESPONSE 33–34 (2d ed. 2002) (detailing the role of catecholamines in the human physiological stress response).

[567] Ho et al., *supra* note 558, at E65 fig.1.

[568] *Id.*

levels then lowered considerably by the second measuring point (two minutes after the first), and continued declining until measurement ceased.[569] The authors tentatively conclude that "[t]he [CEW] device, [canine], and [oleoresin capsicum] groups show that [law enforcement] intervention with these tactics and tools may have less negative consequences for acidosis and catecholamine levels than physical resistance or allowing the subject to flee . . . ."[570]

It must be noted that funding for the studies by Dawes et al. 2009, Ho et al. 2010, Dawes et al. 2014, Ho et al. 2014, and Dawes et al. 2018 was provided by TASER International, the leading producer of CEWs, and several of the authors received compensation from the company.[571] A review of studies investigating the physiological safety of CEWs concluded that "studies funded by TASER International or written by authors affiliated with the company are nearly 18 times more likely to conclude that [CEWs] are safe."[572] Nevertheless, it is telling that the study with no affiliations with TASER International—that by White et al. 2015—produced results analogous to those with links to the corporation.[573] Moreover, the findings of the CEW-specific research are consistent with those of the robust literature examining the impact of physiological and psychological stress on cognitive ability. These studies, including those applying electrical stimulation, show that stress disrupts cognition.[574] They also show a positive link between stressors and levels of certain hormones in the body (e.g., cortisol and catecholamines), and a negative link between elevated levels of such hormones and cognitive ability.[575]

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[569] *Id.*

[570] *Id.* at E67.

[571] *See* Azadani et al., *supra* note 263, at 533–36, 536 nn.6 & 13–16 & 19 & 22, 537 nn.33 & 38 & 45 & 49–51 & 58.

[572] *Id.* at 536; *see* Jared Strote, *Lay Person Use of Conducted Electrical Weapon Research*, 238 FORENSIC SCI. INT'L e20 (2014) (cautioning against lay person reliance on studies conducted in controlled settings to assess the effects of CEW administrations during real life arrests, particularly studies funded by TASER International, Inc.).

[573] *See* White et al., *supra* note 479, at 29.

[574] *See generally, e.g.*, Arnoud Arntz & Miranda Hopmans, *Underpredicted Pain Disrupts More than Correctly Predicted Pain, but Does Not Hurt More*, 36 BEHAV. RES. & THERAPY 1121 (1998); Roman Duncko et al., *Working Memory Performance After Acute Exposure to the Cold Pressor Stress in Healthy Volunteers*, 91 NEUROBIOLOGY LEARNING & MEMORY 377 (2009); Chris Eccleston & Geert Crombez, *Pain Demands Attention: A Cognitive-Affective Model of the Interruptive Function of Pain*, 125 PSYCHOL. BULL. 356 (1999); Peter A. Hancock et al., *A Meta-Analysis of Performance Response Under Thermal Stressors*, 49 HUM. FACTORS 851 (2007); Vicki R. LeBlanc, *The Effects of Acute Stress on Performance: Implications for Health Professions Education*, 84 ACAD. MED. S25 (2009); James S. Olver et al., *Impairments of Spatial Working Memory and Attention Following Acute Psychosocial Stress*, 31 STRESS & HEALTH 115 (2015).

[575] *See generally, e.g.*, Amy F.T. Arnsten, *The Biology of Being Frazzled*, 280 SCI. MAG. 1711 (1998); Bernet M. Elzinga & Karin Roelofs, *Cortisol-Induced Impairments of Working Memory Require Acute Sympathetic Activation*, 119 BEHAV. NEUROSCIENCE 98 (2005);

The CEW-focused research and its accordance with the broader literature on stress and cognition strongly support CEW exposure influencing cognition by way of the human stress response, not by directly altering brain function with electrical current. But regardless of the method of influence, CEWs also do not appear to have a uniquely significant effect on cognitive ability relative to other comparable stressors, such as physical exertion (e.g., simulated combat and sprinting) and the application of pepper spray.[576]

Going forward, in order to produce results of more value to legal practitioners in assessing in-custody waivers, researchers should heed the following non-exhaustive list of recommendations: utilize tests designed to specifically measure *Miranda* warning comprehension; conduct testing at more frequent intervals and closer in time to the conditions to better approximate the length of cognitive effect; employ conditions that better approximate forceful arrest interactions, such as those involving more physical confrontation between subjects and other actors; compare the impact on cognition and *Miranda* warning comprehension when the CEW darts are still embedded in a subject with when they are not; and utilize more conditions that expose subjects to more than one stressor to assess their potential additive effects on mental abilities.

D. Legal Implications

With regard to Fifth and Sixth Amendment rights and *Miranda* warnings, given CEWs' apparently non-specific, likely stress-mediated effect on cognition, a CEW-specific delay period between CEW strikes and the administration of *Miranda* warnings, as recommended by several authors, does not appear warranted.[577] Rather, the occurrence of a CEW administration during arrest and its proximity to a *Miranda* warning and waiver of one's constitutional rights are likely simply further variables for consideration by a judge determining the waiver's validity.

It must, however, be cautioned that the cognitive effects of CEW strikes revealed by studies are those elicited under highly controlled conditions with ostensibly mentally and physically healthy subjects. It is likely that the often chaotic and violent circumstances of actual arrests in which CEWs or other forceful means are

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Sonia J. Lupien et al., *The Effects of Stress and Stress Hormones on Human Cognition: Implications for the Field of Brain and Cognition*, 65 BRAIN & COGNITION 209 (2007); Bruce S. McEwen & Robert M. Sapolsky, *Stress and Cognitive Function*, 5 CURRENT OPINION NEUROBIOLOGY 205 (1995); Terry McMorris et al., *Heat Stress, Plasma Concentrations of Adrenaline, Norepinephrine, 5-Hydroxytryptamine and Cortisol, Mood State and Cognitive Performance*, 61 INT'L J. PSYCHOPHYSIOLOGY 204 (2006); Carmen Sandi & M. Teresa Pinelo-Nava, *Stress and Memory: Behavioral Effects and Neurobiological Mechanisms*, 2007 NEURAL PLASTICITY 1.

[576] *See* Dawes et al., *Use-of-Force Scenarios*, *supra* note 28, at 17.

[577] Fradella, *supra* note 27, at 124–25; Kane & White, *supra* note 22, at 101.

deployed, which frequently involve psychologically and physically compromised individuals, will produce more severe cognitive deficits in targets.[578]

But the aforementioned body of work has broader legal implications than that noted above. By focusing on the mental effects of CEWs relative to other simulated arrest situations, these studies illuminate and begin to fill a hole in court opinions and the literature on *Miranda* warning comprehension: research-informed examination of the cognitive impacts of forceful arrest methods.

III. FILLING A VOID IN COURT OPINIONS AND LEGAL SCHOLARSHIP

Courts "ha[ve] long recognized that the right to make an arrest or investigatory stop necessarily carries with it the right to use some degree of physical coercion or threat thereof to effect it."[579] Nevertheless, they also generally accept that "the force used to subdue a person may contribute to his inability to understand *Miranda* warnings and to the involuntariness of any statements he subsequently makes."[580] (In a similar vein, other stressful events prior to arrests and waivers are considered for their potential to negatively augment an individual's knowledge, intelligence, and volition.)[581] But the manner by which courts assess the impact of forceful arrests on defendant cognition and competence to waive constitutional rights is largely observational and visceral, and would benefit from the assembly of an objective foundation.

For the most part, courts rely on their own observations (of recordings or transcripts) or those of witnesses to deduce the impact of forceful arrests on defendant mental competence for the purpose of assessing in-custody waivers of constitutional rights.[582] They key in on several details, including: the intensity of the event, the temporal proximity of the event to any waiver, the severity of any resulting injury, and behavioral indicators of cognitive impairment like slurred words, confusion, or abnormal movements.[583] Not included in this list are references to studies investigating

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[578] Kane & White, *supra* note 22, at 100.

[579] Graham v. Connor, 490 U.S. 386, 396 (1989).

[580] United States v. Gonzales, 719 F. Supp. 2d 167, 180–81 (D. Mass. 2010); *see* United States v. Havlik, 710 F.3d 818, 822–23 (8th Cir. 2013) (assessing the circumstances of Appellant's arrest and the injuries he suffered therefrom as part of a waiver validity determination); United States v. Brown, 557 F.2d 541, 549 (6th Cir. 1977) ("The circumstances of the arrest and the amount of force employed have relevance to determining Appellant's state of mind when he made the incriminating statements a short time afterwards.").

[581] *See, e.g.*, Sample v. Eyman, 469 F.2d 819, 823–24 (9th Cir. 1972); United States v. Rezac, No. 3:16-CR-30051-RAL, 2017 WL 2536540, at *3–4 (D. S.D. June 9, 2017); People v. Panah, 107 P.3d 790, 840–41 (Cal. 2005); People v. Whitson, 949 P.2d 18, 29 (Cal. 1998); Harris v. State, 475 S.W.3d 227, 230–31 (Mo. Ct. App. 2015).

[582] *See, e.g.*, United States v. Kirk, No. 2:12-cr-114-Ftn1-99SPC, 2013 WL 1899604, at *1–4 (M.D. Fla. Apr. 1, 2013).

[583] *See, e.g.*, United States v. Upton, 512 F.3d 394, 399 (7th Cir. 2008), *overruled on other grounds by* United States v. Garrett, 757 F.3d 560 (7th Cir. 2014); United States v. Annis, 446 F.3d 852, 856 (8th Cir. 2006); *Kirk*, 2013 WL 1899604, at *8–9; *Gonzales*, 719 F. Supp. 2d

the cognitive impairments suffered by those who are arrested in a violent manner. That is, there are no base, objective data on cognitive decline resulting from certain distressing circumstances upon which courts layer subjective, observational factors.

The absence of such a scientific foundation in court determinations is, however, reflective of an anemic literature. As noted above, scholarship examining the interaction between acute stress and cognition roundly shows the former deleteriously affecting the latter, but the experiment parameters are not comparable to forceful arrest methods.[584] Acute stress is experimentally induced in a number of different ways, including: the stimulation of small degrees of pain (by way of, for example, brief electric shocks or the submersion of participants' hands in cold water),[585] threats of pain or other unpleasant interactions,[586] the imposition of stressful social situations,[587] and the artificial introduction of stress hormones into subjects.[588] It is understood that "[m]odeling acute pain remains a significant scientific and ethical challenge," let alone modeling acute, violent, and painful arrest circumstances.[589] Those studies that assess the cognitive effects of potentially comparable situations do not examine acute effects, but rather analyze mental impacts some time after the

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at 181; *Harris*, 475 S.W.3d at 230–32; Commonwealth v. Talmadge Garwood, 1 Phila.Co.Rptr. 89, 92–94 (Pa. Ct. Common Pleas 1978).

[584] *See supra* notes 574–75 and accompanying text.

[585] *See generally, e.g.*, C. Richard Chapman et al., *Central Noradrenergic Mechanisms and the Acute Stress Response During Painful Stimulation*, 28 J. PSYCHOPHARMACOLOGY 1135 (2014); Geert Crombez et al., *The Disruptive Nature of Pain: An Experimental Investigation*, 34 BEHAV. RES. & THERAPY 911 (1996); Priya G. Patil et al., *Effects of a Cold-Water Stressor on Psychomotor and Cognitive Functioning in Humans*, 58 PHYSIOLOGY & BEHAV. 1281 (1995).

[586] *See generally, e.g.*, Kesong Hu et al., *Threat of Bodily Harm Has Opposing Effects on Cognition*, 12 EMOTION 28 (2012); Dean Mobbs et al., *Neural Activity Associated with Monitoring the Oscillating Threat Value of a Tarantula*, 107 PROC. NAT'L ACAD. SCIS. 20582 (2010); Oliver J. Robinson et al., *The Effect of Induced Anxiety on Cognition: Threat of Shock Enhances Aversive Processing in Healthy Individuals*, 11 COGNITIVE AFFECTIVE & BEHAV. NEUROSCIENCE 217 (2011); Oliver J. Robinson et al., *The Impact of Anxiety Upon Cognition: Perspectives from Human Threat of Shock Studies*, 7 FRONTIERS HUM. NEUROSCIENCE 1 (2013).

[587] *See generally, e.g.*, Jonathan Guez et al., *The Effect of Trier Social Stress Test (TSST) on Item and Associative Recognition of Words and Pictures in Healthy Participants*, 7 FRONTIERS PSYCHOL. 1 (2016); Christian J. Merz et al., *The Impact of Psychosocial Stress on Conceptual Knowledge Retrieval*, 134 NEUROBIOLOGY LEARNING & MEMORY 392 (2016); Taiki Takahashi et al., *Social Stress-Induced Cortisol Elevation Acutely Impairs Social Memory in Humans*, 363 NEUROSCIENCE LETTERS 125 (2004).

[588] *See generally, e.g.*, Sonia J. Lupien & Bruce S. McEwen, *The Acute Effects of Corticosteroids on Cognition: Integration of Animal and Human Model Studies*, 24 BRAIN RES. REV. 1 (1997); Sonia J. Lupien et al., *The Effects of Stress and Stress Hormones on Human Cognition: Implications for the Field of Brain and Cognition*, 65 BRAIN & COGNITION 209 (2007); John W. Newcomer et al., *Decreased Memory Performance in Healthy Humans Induced by Stress-Level Cortisol Treatment*, 56 ARCHIVES GEN. PSYCHIATRY 527 (1999).

[589] Valéry Legrain et al., *A Neurocognitive Model of Attention to Pain: Behavioral and Neuroimaging Evidence*, 144 PAIN 230, 232 (2009).

incidents; they typically investigate the more distant and constant effects of chronic exposure to violence.[590]

Nevertheless, the aforementioned research appears relevant to considerations of the potential impacts of stressful circumstances—particularly highly stressful circumstances like forceful arrests—on a defendant's ability to knowingly, intelligently, and voluntarily waive his constitutional rights. But scholars have largely failed to build on this work by explicitly exclaiming its pertinence to in-custody waiver assessments or conducting experiments involving the imposition of stress while subjects undertake legally relevant tasks. The three studies that have examined the connection between stress and *Miranda* warning comprehension only involve stress being induced by accusations of wrongdoing.[591] They each find that comprehension is diminished in such situations.[592] These works aside, research on *Miranda* warning

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[590] *See generally, e.g.*, Mary Ann Dutton et al., *Battered Women's Cognitive Schemata*, 7 J. TRAUMATIC STRESS 237 (1994); Salah U. Qureshi et al., *Does PTSD Impair Cognition Beyond the Effect of Trauma?*, 23 J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCE 16 (2011); Kasey M. Saltzman et al., *IQ and Posttraumatic Stress Symptoms in Children Exposed to Interpersonal Violence*, 36 CHILD PSYCHIATRY & HUM. DEV. 261 (2006); Patricia B. Sutker et al., *Cognitive Deficits and Psychopathology Among Former Prisoners of War and Combat Veterans of the Korean Conflict*, 148 AM. J. PSYCHIATRY 67 (1991); Elizabeth W. Twamley et al., *Cognitive Impairment and Functioning in PTSD Related to Intimate Partner Violence*, 15 J. INT'L NEUROPSYCHOLOGY SOC'Y 879 (2009).

[591] Richard Rogers et al., *Decrements in* Miranda *Abilities: An Investigation of Situational Effects via a Mock-Crime Paradigm*, 35 L. & HUM. BEHAV. 392, 392 (2011); Kyle C. Scherr & Stephanie Madon, *"Go Ahead and Sign": An Experimental Examination of* Miranda *Waivers and Comprehension*, 37 L. & HUM. BEHAV. 208, 208 (2013) [hereinafter Scherr & Madon, *"Go Ahead and Sign"*]; Kyle C. Scherr & Stephanie Madon, *You Have the Right to Understand: The Deleterious Effect of Stress on Suspects' Ability to Comprehend* Miranda, 36 L. & HUM. BEHAV. 275, 275 (2012) [hereinafter Scherr & Madon, *You Have the Right to Understand*].

[592] Rogers et al., *supra* note 591, at 398; Scherr & Madon, *"Go Ahead and Sign," supra* note 591, at 214; Scherr & Madon, *You Have the Right to Understand*, *supra* note 591, at 281. It is, however, arguable whether these results should factor into court waiver assessments. While *Miranda* and subsequent case law do not limit what influences on cognition can be recognized, an accusatory environment is inherent to interrogations and waivers. In fact, this is why *Miranda* warnings are required: to counter such an atmosphere by making individuals aware of their rights and the consequences of waiving them. *See supra* notes 45–50 and accompanying text. Accordingly, it could be contended that the warnings themselves are the means intended by the Supreme Court to account for the inherent stress of in-custody questioning and that considering it separately leads to the double counting of this factor. So even though the psychological pressure of interrogation can inhibit *Miranda* warning comprehension, this pressure is an underlying constant upon which the *Miranda* framework is laid, and the framework is therefore meant to take into account *additional* variables, not the basic stress of in-custody questioning. In addition, or alternatively, it could be argued that officer conduct is the determinative variable with regard to the stress of an interrogation (this is supported by the articles cited in this footnote, which involve specific questioning approaches and examine them either explicitly or implicitly). Rogers et al., *supra* note 591, at 396–97; Scherr & Madon, *"Go Ahead and Sign ," supra* note 591, at 210; Scherr & Madon, *You Have the Right to Understand*, *supra* note 591, at 277–78. This stress is, therefore, already accounted for by

comprehension, waiver volition, and cognitive ability focuses entirely on more constant personal characteristics, such as age,[593] education and specific academic skills (e.g., reading and listening comprehension),[594] mental health,[595] and intelligence (as measured by IQ tests).[596] Consequently, for an extensive amount of time there has been no legal situation-oriented objective data for courts or attorneys to turn to with regard to the cognitive effects of forceful arrest methods and their implications for in-custody rights waivers. The works presented in detail in this Article finally alter this persistent reality.[597] In doing so, they will hopefully stimulate more work in the area from more researchers and be a frequently relied upon resource for legal practitioners who confront the situations the studies address, adding an important and much-needed objective stepping stone to what is generally a highly subjective and discretionary review process.

Having assessments of the influence of forceful arrests on an individual's capacity to waive her constitutional rights completely untethered from objective data, as it currently is, is potentially problematic. This is illustrated by two hypothetical situations that might cause courts to differentially consider the cognitive effects of a forceful arrest. The first involves authorities employing a degree of force to subdue a defendant deemed unwarranted by a court, whether intentionally or because they misappreciate the situation, and the defendant waiving his rights shortly thereafter. Meaningfully weighting any alleged cognitive impairment he suffered as a result of the physical

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court analysis of officer interrogation methods and whether they are improper. *See supra* notes 80–85 and accompanying text.

[593] *See generally, e.g.*, ALAN GOLDSTEIN & NAOMI E. SEVIN GOLDSTEIN, EVALUATING CAPACITY TO WAIVE *MIRANDA* RIGHTS 55–63 (2010); Barry C. Feld, *Juveniles' Competence to Exercise* Miranda *Rights: An Empirical Study of Policy and Practice*, 91 MINN. L. REV. 26 (2006); Grisso, *supra* note 107, at 1134; Ronald Roesch et al., *The Capacity of Juveniles to Understand and Waive Arrest Rights*, *in* LEARNING FORENSIC ASSESSMENT: RESEARCH AND PRACTICE 251–71 (Rebecca Jackson & Ronald Roesch eds., 2d ed. 2016).

[594] *See, e.g.*, GOLDSTEIN & GOLDSTEIN, *supra* note 593, at 66–68. *See generally* Daniel P. Greenfield et al., *Retrospective Evaluation of* Miranda *Reading Levels and Waiver Competency*, 19 AM. J. FORENSIC PSYCHOL. 75 (2001); Rachel Kahn et al., *Readability of* Miranda *Warnings and Waivers: Implications for Evaluating* Miranda *Comprehension*, 30 L. & PSYCHOL. REV. 119 (2006).

[595] *See, e.g.*, GOLDSTEIN & GOLDSTEIN, *supra* note 593, at 70–72. *See generally, e.g.*, Cooper & Zapf, *supra* note 106; William C. Follette et al., *Mental Health Status and Vulnerability to Police Interrogation Tactics*, 22 CRIM. JUST. 42 (2007); Richard Rogers et al., *Knowing and Intelligent: A Study of* Miranda *Warnings in Mentally Disordered Defendants*, 31 L. & HUM. BEHAV. 401 (2007).

[596] *See* GOLDSTEIN & GOLDSTEIN, *supra* note 593, at 63. *See generally, e.g.*, Cloud et al., *supra* note 103; Solomon M. Fulero & Caroline Everington, *Assessing the Capacity of Persons with Mental Retardation to Waive* Miranda *Rights: A Jurisprudent Therapy Perspective*, 28 L. & PSYCHOL. REV. 53 (2004); Michael J. O'Connell et al., Miranda *Comprehension in Adults with Mental Retardation and the Effects of Feedback Style on Suggestibility*, 29 L. & HUM. BEHAV. 359 (2005).

[597] *See supra* Section II.C.2.

confrontation, aside from any manifestations of mental deficits, is very clearly in line with the purpose of the law of *Miranda* to safeguard constitutional rights and deter objectionable law enforcement conduct.[598] The narrative is that improper police behavior impacted a defendant's capacity to knowingly, intelligently, and voluntarily waive his constitutional rights, making it an attractive fact to be recognized to have diminished his cognitive capacity in a subjective assessment framework.

The second situation, however, involves authorities employing a degree of force to arrest a defendant deemed reasonable by a court, whether actually reasonable or reasonable based on legitimate officer beliefs at the time, and the defendant waiving his rights shortly thereafter. Here, an individual ostensibly brought violence upon himself, and may have even endangered the health or lives of officers. Considering cognitive decline resulting simply from the confrontation, let alone considering it in a meaningful way, awards the defendant a favorable fact for conducting himself in a socially and legally undesirable fashion. A purely subjective assessment framework allows courts to consider this and decide that the arrest circumstance did not affect a defendant's cognitive abilities.

United States v. Mack and *United States v. Patterson* (two cases involving CEWs presented above) provide examples of this type of reasoning.[599] In *Mack*, before delving into the potential cognitive effects of the CEW strikes in question, the court describes the appropriateness of the degree of force utilized by officers to subdue the defendant, clearly deeming the information relevant.[600] When it moves on to specifically address Mack's mental state at the time of waiver, it notes the following: testimony of officers who had experienced CEW strikes putting forth that once the electrical current discharged by a CEW ceases, "they were able to function normally";[601] that the defendant provided no evidence of the cognitive effects of CEWs; and that he understood and complied with the commands of officers and responded affirmatively when administered a *Miranda* warning and asked if he understood his rights.[602] While the court's conclusion that Mack's waiver was knowing, intelligent, and voluntary is arguably unobjectionable,[603] its entirely subjective

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[598] *See* Brewer v. Williams, 430 U.S. 387, 426 (1977) (commenting that the law of *Miranda* is "designed to safeguard other constitutional guarantees and deter impermissible police conduct"); *see also* Smith v. Zant, 887 F.2d 1407, 1427–28 (11th Cir. 1989) (stating that the "voluntary" prong of the *Miranda* waiver standard ensures that "a waiver is uncoerced" and "'deter[s] lawless conduct by police and prosecution,'" while the "knowing and intelligent" prong aims to provide that individuals are aware of their rights and options in the face of government pressure (internal citation omitted)).

[599] United States v. Patterson, No. 3:09-cr-7(S1)-J-32TEM, 2009 WL 10670083, at *1 (M.D. Fla. June 22, 2009); United States v. Mack, No. 07-238, 2009 WL 580430, at *1 (M.D. La. Mar. 6, 2009).

[600] *Mack*, 2009 WL 580430, at *2 & n.7.

[601] *Id.* at *3 n.11.

[602] *Id.* at *3 & n.9.

[603] *See id.* at *3.

analysis ignores the fact that, since the defendant was subjected to three CEW strikes immediately prior to his waiver (one apparently involving darts and electrical current and two from the device in drive-stun mode),[604] he was experiencing some degree of cognitive impairment. With no objective data before it, the court was not forced to at least tersely address this reality.

In *Patterson*, the court begins its assessment of the potential psychological impacts of CEW strikes by paraphrasing an officer's testimony that includes the following: "[E]lectrical charge generated from the Taser [sic] affects the muscle tissue, but it does not affect the brain," and, "[N]o one he has tased has ever lost cognitive function, or the ability to speak and otherwise communicate rationally."[605] It then cites *Mack*, in which the waiver was deemed valid despite very recent CEW administrations.[606] Finally, as part of its appraisal of the CEW's mental effects, the court explains that the degree of force employed by law enforcement to subdue the defendant was appropriate.[607] Although the time between the CEW strike and waiver was longer in this case than in *Mack*,[608] the court's entirely subjective analytical approach allows it to avoid confronting the objective cognitive impairment experienced by individuals immediately following forceful arrests. This is highlighted by a subsequent, more lengthy analysis of Patterson's claim that he was also intoxicated at the time of waiver and that this additionally prevented him from adequately comprehending his rights.[609] Here, the court begins with the premise that intoxication diminishes a person's ability to think, and works against this objective impact to ultimately conclude that the defendant's waiver was knowing, intelligent, and voluntary.[610]

The hypotheticals and cases above show how an influence scientifically shown to diminish cognitive faculties can be disregarded or considered incorrectly in a system of review insulated from objective inputs. The incorporation of study data on cognitive declines in those subjected to forceful arrest situations in in-custody rights waiver determinations would remove a measure of subjectivity and discretion from court considerations of these events. While this is unlikely to significantly influence judicial determinations, arrests involving physical confrontation should be facts indicative of mental diminishment, full stop. That is, just as a low IQ test score weighs against a waiver being knowledgeable, intelligent, and voluntary, so too should a forceful arrest when the waiver occurs close enough in time to such an incident. This fact should then be intermixed with personal qualities of a defendant and observations to approximate his cognitive abilities at the time of waiver.

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[604] *Id.* at *2–3.

[605] United States v. Patterson, No. 3:09-cr-7(S1)-J-32TEM, 2009 WL 10670083, at *6 (M.D. Fla. June 22, 2009).

[606] *Id.* (citing *Mack*, 2009 WL 580430, at *3).

[607] *Id.* (citing Draper v. Reynolds, 369 F.3d 1270, 1278 (11th Cir. 2004)).

[608] *Compare id.* at *2, *with Mack*, 2009 WL 580430, at *1.

[609] *Patterson*, at *7–8.

[610] *Id.*

CONCLUSION

Coercion by way of CEW is a ubiquitous means of law enforcement, deployed against hundreds of thousands of criminal suspects annually.[611] Determining whether such tactics subvert the Constitution is therefore a critical enterprise to ensure the just functioning of the criminal legal system. Endeavoring to do so in a rigorous, science-focused fashion, this Article deduces a number of matters of cross-disciplinary import.

First, it details the cognitive facets of the requirements that a defendant's in-custody waiver of his Fifth and Sixth Amendment rights be knowing, intelligent, and voluntary.[612] And that courts tend to rely on subjective observation when assessing individual psychological competence over objective indicia (e.g., age, education, and mental health).[613] This places a high bar on the latter metrics—which include the research-ascertained cognitive effects of CEWs—in terms of the degree of mental impairment they must indicate to meaningfully sway courts on their own.

Second, the population of studies on the relationship between CEW administrations and mental deficits reveals the former to negatively influence the latter, but to a degree similar to other forceful arrest methods (e.g., person-to-person physical force, canine attack, and pepper spray administration).[614] Accordingly, while arrest via CEW should be a factor in judicial assessments of the validity of in-custody rights waivers, so should other forceful modes of subduing individuals. And the cognitive effects of CEW administrations do not warrant unique legal safeguards for those subjected to these weapons.

Finally, a complete lack of reliance by courts on research findings indicating that forceful arrest methods diminish cognitive faculties is disclosed. Instead, they subjectively appraise individual arrest circumstances and whether they influenced defendant mental acuity at the time of waiver.[615] And scholarship on *Miranda* warning and constitutional rights comprehension largely ignores the effects of arrest circumstances. This Article therefore puts forth that forceful arrest methods are an objectively negative influence on a defendant's ability to knowingly, intelligently, and voluntarily waive his rights when close in temporal proximity to the waiver.

Ultimately, one can tase the Constitution, but one can, among other abuses, bludgeon and pepper spray it as well. Going forward, researchers should further develop the body of literature on these means of arrest and the impact they have on individuals' mental competence to assert or waive their constitutional rights. In addition, courts should consider forceful arrest methods, conducted close in time to waivers, per se negative influences on such competence.

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611 *See supra* notes 265–68 and accompanying text.
612 *See supra* Part I.
613 *See supra* Section I.D.
614 *See supra* Section II.B.2.
615 *See supra* Section I.D and Part III.