End Violence Against Women International
(EVAWI)

Important Things to Get Right About the "Neurobiology of Trauma"

Part 1: Benefits of Understanding the Science

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Dr. Kimberly A. Lonsway has served as the Director of Research for EVAWI since 2004. Her research focuses on sexual violence and the criminal justice and community response system, and she has written over 60 published articles, book chapters, technical reports, government reports, and commissioned documents – in addition to numerous training modules, bulletins, and other resources. Over her career, she has trained thousands of professionals across the country and around the world, in a diverse array of disciplines and settings, and volunteered for over 15 years as a victim advocate; in 2012, she was awarded the first-ever Volunteer of the Decade Award from the Sexual Assault Recovery and Prevention (SARP) Center in San Luis Obispo, CA. She earned her PhD in the Department of Psychology at the University of Illinois, Urbana-Champaign.

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This training bulletin series was written to explore some central concepts in the "neurobiology of trauma," as it is understood by people working with sexual assault victims. Understanding essential scientific findings and avoiding any misinterpretation or misapplication can help professionals work more effectively with survivors. But before I do that, I want to briefly explain my experience and qualifications in this area.

Background

I am a clinical psychologist by training and an expert in psychological trauma, especially trauma resulting from interpersonal violence.[1] Since the mid-1990s, I have studied the scientific literature on how stress and trauma can impact neurobiological processes that underlie attention, thinking, behavior, and memory processes. I have also personally conducted research on the neurobiology of trauma and traumatic memories. Since the early 2000s, my affiliation with Harvard Medical School has given me easy access to a vast number of scientific publications, allowing me to track historical and emerging trends and also to connect with top-flight neuroscientists from around the world, some of whom have reviewed my writing and teaching or sought my input on their research.

I am also a therapist, and my website draws many sexual assault survivors seeking help, so I have heard directly from numerous people about their personal experiences of being physically or sexually assaulted, and their memories of these experiences. As an expert witness, I have reviewed many recordings and transcripts of interviews with investigators who either have – or lack – scientifically sound knowledge and realistic expectations about survivors' thinking, behavior, and memories. This can have a *huge* effect on the way questions are asked, how well survivors' answers are listened to and understood, and the quality of the information collected and documented in their reports.

Based on those experiences and knowledge, I work to educate people – professionals, survivors, and others – on the neurobiology of trauma in the most scientifically sound and practically useful ways I can. In doing so, I have identified some over-simplifications and misunderstandings that can prevent professionals from understanding and working effectively with sexual assault survivors. I wrote this training bulletin series to address some of those over-simplifications and misunderstandings. I would like to start by clarifying what exactly we mean when we refer to the "neurobiology of trauma."

What is the "Neurobiology of Trauma?" What Isn't It?

What the sexual assault field typically refers to as the "neurobiology of trauma" is actually a combination of various branches of brain science that help to explain common – but commonly misunderstood – ways that victims (a) respond during a sexual assault, (b) encode and store the experience in memory, and (c) recall these memories later.

[1] The International Society for Traumatic Stress Studies (ISTSS) defines traumatic events as "shocking and emotionally overwhelming situations that may involve actual or threatened death, serious injury, or threat to physical integrity." See http://www.istss.org/public-resources/what-is-traumatic-stress.aspx.

Yet this conceptualization includes only a small portion of the scientific research actually conducted on the neurobiology of psychological trauma.[2] As applied in the sexual assault field, the "neurobiology of trauma" framework draws primarily from research on (a) animal and human behavior under stressful or dangerous (not necessarily traumatic) conditions, and (b) the impacts of moderate (not traumatic) stress on human cognitive and memory processes. A great deal of scientific research is excluded from this discussion and framework. Therefore, **professionals who work in the sexual assault field should recognize that, scientifically speaking, "the neurobiology of trauma" involves much more than the focuses of their work and training, and they should not use the term as if it's an all-encompassing explanation for *all victim behaviors and memories.***

What is Neurobiology?

Simply stated, neurobiology is the biological study of the nervous system. It is a multidisciplinary field that draws upon scientific disciplines including anatomy, physiology, molecular biology, mathematical modeling, and psychology to understand the fundamental and emergent properties of neurons (i.e., brain cells) and neural circuitries. Neurobiology helps to explain human experience, thinking, emotions, memories, and behavior in terms of brain structures and processes.

In addition, **some of the most important insights into the behaviors and memories of sexual assault victims are *not* based on neurobiology research, and many victim responses do not require scientific research to be understood appropriately.** For example, there are plenty of *psychological and social* reasons why most victims don't physically resist during a sexual assault, why it often takes a while to tell someone about the assault or report it to law enforcement, and why many survivors maintain a relationship with a perpetrator. Many professionals in the field "understood" these victim behaviors, and responded appropriately, long before they knew anything about the "neurobiology of trauma."

Not Just Stress and Trauma

It is also helpful to recognize that stress and trauma cover a continuum, with mild stress at one end and traumatic stress at the other. For ethical reasons, scientists cannot (and do not want to) traumatize people in research experiments. So, there will never be

[2] In the psychiatric, behavioral, cognitive, and brain sciences the "neurobiology of trauma" is a term that refers to many different issues, explored with many different types of research. Most of that scientific research has focused on *long-term* impacts of traumatic experiences on a variety of brain structures, circuitries, and processes, especially in people diagnosed with posttraumatic stress disorder (PTSD). Less commonly, scientists have also studied the neurobiology of dissociative disorders, major depression, and other psychiatric disorders that can occur after traumatic events. Many potential impacts of trauma (e.g., gene expression, hippocampal volume) are seldom, if ever included in professional trainings provided for law enforcement, prosecution, health care, victim advocacy, higher education, or the military.

studies of what is happening in the brains of people while they are being sexually assaulted. But *we do not need such studies* to understand a great deal about what happens in people's brains during stressful or traumatic assaults – or during natural disasters, military combat, terrorist attacks, attacks by large predatory animals, etc.

This is because **the same brain structures and circuitries,[3] and the same chemical and electrical processes, are involved along the entire stress continuum (especially from moderate to traumatic stress), just to differing degrees.** This means that large bodies of scientific research – on how stress impacts (a) the brain's prefrontal cortex and its "executive functions,"[4] (b) behavior,[5] and (c) memory encoding, storage, and retrieval[6] – are all valuable to the sexual assault field. They shed light on thoughts and behaviors that are common during the stress and trauma of a sexual assault experience, and on common characteristics of sexual assault memories.

For more information on the "neurobiology of trauma" and the implications for behaviors and memories of sexual assault victims, please see three prior training bulletins from EVAWI: (1) *Becoming Trauma Informed: Learning and Appropriately Applying the Neurobiology of Trauma to Victim Interviews; (2) Trauma-Informed Interviewing and the Criminal Sexual Assault Case: Where Investigative Technique Meets Evidentiary Value; and (3) Understanding the Neurobiology of Trauma and Implications for Interviewing Victims.* Also available is a 2-part webinar series entitled, *Neurobiology of Sexual Assault* (Part 1 and 2).

Benefits of Understanding the Science

When we understand the neurobiological basics of how people commonly respond while being sexually assaulted, and how stress and trauma can alter their memory processes, we reap many valuable benefits. These include more realistic expectations for victim responses during a sexual assault, more perceptive listening to their account of what happened, and more effective information-gathering about their memories and responses. But this knowledge should not be used to explain or make assumptions about any *particular* survivor's responses or memories; each individual is unique.

[3] A brain "circuitry" is simply a collection of brain areas that work together to perform certain functions, and while the brain is not a computer, neuroscientists understand it has having many different circuitries.

[4] For reviews, see Arnsten, A.F.T. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. *Nature Reviews Neuroscience, 10,* 410-422; Arnsten, A.F.T. (2015). Stress weakens prefrontal networks: molecular insults to higher cognition. *Nature Neuroscience, 18,* 1376-1385.

[5] For review, see Kozlowska, K., Walker, P., McLean, L. & Carrive, P. (2015). Fear and the defense cascade. *Harvard Review of Psychiatry,* 23 (4), 263-287.

[6] For reviews, see Hopper, J. (2018) "Why incomplete sexual assault memories can be very reliable," and "Why Christine Blasey Ford can't remember how she got home," on my blog with *Psychology Today.*

More Realistic Expectations

One primary benefit of understanding this science, and accurately explaining it, is to create more realistic expectations about how people tend to respond during sexual assault, and how they encode and store such experiences as memories. Whether you are a police officer or other responding professional, or a friend or family member of a survivor, this understanding can help you avoid any expectation that the survivor might have yelled, fought, or tried to run away during the assault, or that they might have complete and linear memories of the experience. Instead, we will be better prepared to understand that rational thinking tends to be quickly impaired, that behavior tends to be reflexive and habitual, that people often dissociate and go on autopilot, and that only some parts of the experience get encoded and stored in memory.

More Perceptive Listening

A second benefit of understanding this science is to listen more perceptively to victim responses. For example, if we know the different types of freezing responses people can have, then we can recognize indicators of them when survivors say things like, "Suddenly I froze," "My mind was blank," or "All I could think was…" [7] If we know that stress and trauma can impair the decision making of the rational brain and shift a person toward habit-based behaviors, then we can recognize those behaviors for what they are, not as "failures" to respond rationally or effectively. If we know about tonic and collapsed immobility, we can recognize indicators of those reflexes, and know to gather more information about the person's thoughts and other experiences in those states.

Finally, if we understand that dissociation can kick in at any time, leading the person to "space out" and not notice what's happening to their body, then we won't be surprised by missing pieces of memory due to dissociation at any point during the sexual assault. If we understand that habit behaviors can happen in dissociative "autopilot" mode, then we won't be surprised that someone engaged in sex acts on autopilot, without wanting, choosing, or consenting.

The same is true for how we listen to people's *memories.* If we know common characteristics of traumatic memories, we can recognize them in victim accounts: vivid central details; vague, inconsistent, and missing peripheral details; and missing time sequencing of details – especially later in the assault, when the memory circuitry tends to go into a minimal-encoding mode. **We'll know to keep listening, without bias or assumptions about whatever else the victim may disclose, with greater confidence that we're unlikely to miss or misunderstand valuable information.**

[7] For a detailed explanation of "freezing" (from scientific and neurobiological perspectives), including how three different freezing responses can unfold over time (e.g., "detection freezing" and then "shocked freezing" in the initial seconds of a sexual assault, and "no-good-choices freezing" potentially following for seconds or even minutes into the experience), please see Hopper, J. (2018), "Freezing during sexual assault and harassment," Sexual Assault and the Brain (blog), *Psychology Today*.

More Effective Information-Gathering

A third benefit is to improve the effectiveness of information-gathering from sexual assault victims. With an accurate understanding of this science, we are better equipped to collect detailed information about possible freezing responses, impaired reasoning capacities, habit behaviors, and survival reflexes – the very types of responses that have long been unrecognized and misunderstood, even misinterpreted as evidence that no assault happened, or that the sexual acts were consensual rather than forced or coerced.

We can also apply this knowledge to ask non-leading questions about central details, which often elicit remarkable and unexpected information that may line up with other evidence and make for very compelling testimony. We can avoid pushing for peripheral details that may never have been encoded, or may have rapidly faded from memory, and thereby prevent inaccuracies and inconsistencies that can be weaponized later. We can also be more careful when seeking time sequence information, especially later during the sexual assault, when the victim's memory circuitry may not have had the capacity to encode and store some details about their experience, or how those details unfolded over time.

Avoiding Specific Assumptions

These three benefits can be true game changers for law enforcement investigators, prosecutors, and other professionals who work with survivors. But there is a risk if people take unwarranted leaps from such general understanding to specific assumptions about any *particular* survivor's responses to being sexually assaulted, or their memories of what happened during the experience.

For example, we shouldn't assume that a person froze during their sexual assault, because not everyone does. We shouldn't assume they suffered extreme prefrontal cortex impairment and lost all rational thinking capacities. And we shouldn't assume that the only habit behaviors a person will engage in while being sexually assaulted are passive and ineffective. Nor should we assume that someone experienced tonic or collapsed immobility the moment they say something like, "I felt like I couldn't move."

Instead, we must keep our minds open and engage in careful listening. And again, we must ask open-ended, non-leading questions to gather more information and fill in the entire picture, which will often have unique, new, or surprising aspects. These techniques allow us to avoid imposing assumptions, old or new, on survivors.

Next Up

With that general introduction in mind, I will provide more detailed information in the next two installments in this training bulletin series, focusing on two key topic areas: (1) Victim Responses During Sexual Assault and (2) Memory Retrieval or Recall.

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Part 2: Victim Responses During Sexual Assault

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This training bulletin series explores some central concepts in the "neurobiology of trauma," as it is understood by people working with sexual assault victims. Understanding essential scientific findings and avoiding any misinterpretation or misapplication can help professionals work more effectively with survivors. In this second installment, I focus on victim responses *during* a sexual assault.

Victim Responses During Sexual Assault

When it comes to describing the types of behaviors that people commonly exhibit while they are being sexually assaulted, **the term that is most accurate, effective, and scientifically sound is "reflexes and habits."** In contrast, "fight or flight" or even "fight, flight, freeze" (or other similarly alliterative phrases) do not accurately reflect the behaviors of survivors or the neurobiological impacts of stress and trauma on behavior. They also fuel misconceptions that harm survivors, by creating false expectations for how they *are supposed to behave* when they are being sexually assaulted.

The History of "Fight or Flight"

According to conventional wisdom, the century-old phrase "fight or flight" was first introduced by Walter Cannon, a famous early 20th century Harvard physiologist. But it was most likely coined by someone else, perhaps a journalist, who used it to characterize Cannon's research findings, and it stuck.[1] In fact, Cannon did not study behavior at all – not fighting, fleeing, or any other type of behavior. As a physiologist, he focused on the body's *internal* responses to stressful situations, not its outward behavior. This included studying how the body prepares to (among other things) potentially engage in behaviors that could facilitate coping and survival in dangerous situations. The behaviors that result from this preparatory response could include fighting or fleeing, but those behaviors are not what Cannon studied or wrote about.[2]

[1] Careful reading of Cannon's books and papers, even electronic searches of every word he ever published in the scientific literature, fails to turn up the phrase anywhere. He came the closest in his book *Bodily Changes in Pain, Hunger, Fear and Rage*, first published in 1915. Even then, the phrase was part of a longer one, used to refer to possible behaviors resulting from adaptations to wild life: "The increase of blood sugar, the secretion of [adrenaline], and the altered circulation in pain and emotional excitement have been interpreted in the foregoing discussion as biological adaptations to conditions in wild life which are likely to involve pain and emotional excitement, i.e., the necessities of fighting or flight." Cannon, W.B. (1915). *Bodily Changes in Pain, Hunger, Fear and Rage: An Account of Recent Researches into the Function of Emotional Excitement.* New York, NY: D. Appleton and Company (p. 211).

[2] Cannon primarily studied what he called "biological adaptations to conditions" that involve "pain and emotional excitement," especially physiological responses associated with activation of the sympathetic branch of the autonomic nervous system and the release of adrenalin, including increased heart rate and blood pressure, elevated blood sugar, and inhibition of digestive processes. These internal physiological processes and the resulting emotions may – or may not – give rise to behaviors of fighting or fleeing.

Nonetheless, someone coined the phrase "fight or flight," and attributed it to Cannon.[3] Over time, it gained such popularity that most people immediately recognize the phrase and, unfortunately, interpret it to mean that fighting and fleeing are the two most common responses to a threat. This has created harmful misunderstandings about how people respond while they are experiencing traumatically stressful events like sexual assault.

Most professionals who work with survivors know that the majority *do not* fight or flee when they're being sexually assaulted. That is especially true if the perpetrator is someone they know and thought they could trust, in situations that – just moments before – were normal social interactions (with a friend, acquaintance, co-worker, etc.). Instead, most people engage in reflex and habit behaviors that do not involve fighting or fleeing. Even when people *do* fight or flee while being sexually assaulted, those behaviors are usually reflexive or habit-based (e.g., as a result of law enforcement, military, or martial arts training). The phrase "reflexes and habits" is therefore more accurate and helpful for everyone, but especially for sexual assault survivors.

But what are these reflexes and habits? What follows is a very basic summary.

Reflexes and Habits: A Basic Primer

Research clearly demonstrates that the onset of stress and trauma frequently shift the brain from rational, deliberate processing by the prefrontal cortex to automatic, involuntary reliance on various reflexes and habits. Reflexive responses to stressful and traumatic situations are implemented by the brain's **defense circuitry**,[4] and habit-based behaviors evoked by stress and trauma are implemented by the brain's **habit circuitry**.[5] Under situations of stress and danger, the defense circuitry[6] tends to automatically take control of our brains and behaviors, by implementing survival reflexes or triggering habit behaviors via the habit circuitry.

This makes total sense from an evolutionary and survival perspective: When a predator is coming at you or has you in its grip, thinking through a logical response with the prefrontal cortex (the rational part of the brain) is too slow and could get you killed, while

[3] Whoever it was that coined the catchy phrase "fight or flight," their term has been a huge success. Databases for *The New York Times* and Google indicate that "fight or flight" first appeared in writing in 1919; that it was not used much in the 1920s and 30s; that its frequency of use rose over the 1940s, 50s and 60s; and that it finally took off in the late 60s and continued to increase greatly into the 2000s.

[4] Kozlowska, K., Walker, P., McLean, L. & Carrive, P. (2015). Fear and the defense cascade. *Harvard Review of Psychiatry,* 23 (4), 263-287; Hagenaars, M.A., Oitzl, M. & Roelofs, K. (2014). Update freeze: Aligning animal and human research. *Neuroscience and Biobehavioral Review, 47,* 165-176.

[5] Schwabe, L. (2017). Memory under stress: From single systems to network changes. *European Journal of Neuroscience,* 45, 478-489; Yin, H.Y & Knowlton, B.J. (2006). The role of the basal ganglia in habit formation. *Nature Reviews Neuroscience,* 7, 464-476.

[6] Many researchers used to refer to it as the "fear circuitry," but people whose brains are dominated by that circuitry don't necessarily experience fear, and we can't ask animals if they're afraid, so "defense circuitry" makes more sense. For more information, see: Kozlowska K., et al. (2015), Fear and the defense cascade: Clinical implications and management. *Harvard Review of Psychiatry, 23 (4),* 1-25.

reflexes and habits can be automatically implemented in a fraction of a second. It is important for those who work with survivors of sexual assault to understand these processes and to help survivors understand how their brains likely responded.

Survival Reflexes[7]

One survival reflex is **freezing,** as defined by scientists who study animal behavior: an inhibition of movement that may automatically and instantaneously arise when danger or an attack is detected, which typically lasts a second or two but can persist for minutes under some circumstances.[8] Others are **tonic immobility,** in which the body is literally paralyzed and muscles go rigid, and **collapsed immobility,** in which blood pressure and heart rate drop, the person may feel faint or pass out, and muscles go limp.

Tonic immobility is more common than collapsed immobility, and both survival reflexes typically come later than freezing, when people are restrained, fear for their lives, experience the assault as inescapable, or are being violated in a way they most feared and hoped to escape (e.g., being penetrated or forced to perform a particular act).

A fourth survival reflex is **dissociation.** When people are in a dissociative state, their awareness is automatically and involuntarily disconnected from disturbing and painful sensations and emotions arising in their bodies. Later the person may describe feeling "numb," "unreal," like they were "in a dream," or something else along those lines.

Dissociation is *much* more common than fighting or fleeing during a sexual assault, and it is also more common than the survival reflexes of tonic or collapsed immobility. But because dissociation is an alteration of attention and awareness – not a behavior – it can also accompany behaviors such as fighting or fleeing (whether those are reflexive or habit-based), as well as the other survival reflexes of tonic or collapsed immobility.

Habit Behaviors

Even more common than reflex behaviors during a sexual assault (or any other attack or very stressful experience) are *habit behaviors.* These are often old habits learned during prior experiences of abuse, assault, exploitation, or domination. Especially for girls and women, being sexually assaulted can trigger polite and passive habits they have learned to resist unwanted sexual advances without causing a scene or bruising an ego. This includes turning away from an unwanted kiss, pushing a hand away, or saying things like, "I have to go home," or "my boyfriend will find out."

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[7] I use the term "survival reflexes" (rather than "animal defense responses," often found in the animal research literature), because such behaviors are hard-wired and because reflexive and "survival reflexes" fits into an overall framework of "reflexes and habit." See Kozlowska, K., Walker, P., McLean, L. & Carrive, P. (2015). Fear and the defense cascade. *Harvard Review of Psychiatry,* 23 (4), 263-287.

[8] Hopper, J. (2018). Freezing during sexual assault and harassment, Sexual Assault and the Brain (blog), *Psychology Today*.

Neuroscience has revealed a great deal about the responses that are predominantly governed by the defense circuitry, which is hard-wired into our brains and can trigger survival reflexes and well-established habit circuitries.[9] But habits themselves are learned behaviors (not hard-wired), and they involve many different social and emotional aspects, so their variety and complexity are vast. As a result, while neuroscientists have learned a lot about the habit circuitry, they do not understand the detailed neurobiology of most of the unique habit behaviors that people learn from their individual experiences and then exhibit in stressful situations.

Neuroscience Cannot "Explain" Any Particular Response

This leads to a more general point, which is that **neuroscientists will never be able to explain the exact neurobiological causes of any particular thought, emotion, or behavior, in any particular situation.** This is especially true in highly complex social interactions, and it is important to keep in mind when considering the behaviors and neurobiological processes *after a sexual assault has ended.* To the extent the person is still stressed, they are likely to continue engaging in habit behaviors in the aftermath of the sexual assault. These habit behaviors can be quite complex, as described above. But plenty of non-habitual behaviors can get mixed in as well. Taken together, this means we will never know as much about the neurobiology of people's behaviors *after* the sexual assault or other traumatic experience, as we do *during* those experiences.

Some Examples

To illustrate, we can look at some specific types of emotional behaviors. If we consider laughing or crying, those behaviors can have many different variations, each involving different combinations of emotions, motivations, vocalizations and movements. Usually we laugh because we are happy, and cry when we are sad. But we may laugh because we are nervous, or cry when we are angry. We can also laugh because we want other people to like us, or at least not to dislike us. If we are afraid that crying will make us look weak or pathetic, we might feel extremely sad but barely cry at all, or, despite trying not to, we may suddenly sob out loud. From these examples alone, we can see that it would be simplistic (and incorrect) to assume that such different forms of laughter or crying have the same neurobiological causes.

We often see this with sexual assault victims. Sometimes people smile or laugh not long after being sexually assaulted, despite the traumatizing harm they suffered. Others smile or laugh when they are talking about their sexual assault – even while being interviewed by law enforcement about very difficult details of the assault and its impact on them. Such smiling or laughter, on its own, cannot tell us whether or not those people were sexually assaulted (although of course many people have wrongly believed that it does). And the presence of such laughter reveals little or nothing about what was

[9] For more information, please see Schwabe, L. (2017). Memory under stress: From single systems to network changes. *European Journal of Neuroscience, 45,* 478-489.

happening in their brains when they smiled or laughed, but it could be an indication that they have a habit of laughing when they are nervous or to avoid negative judgments.

The same could be said about many other behaviors that survivors may exhibit after a sexual assault, whether it is hours, days, or months later. They could be talking to a friend or family member, texting the person who assaulted them, or being interviewed by a law enforcement investigator or other professional. None of the behaviors exhibited at those times and in those situations can be explained simplistically by neuroscience.

The Same is True for Brain Chemicals

Similar logic applies to brain chemicals. Research has shown that during any traumatic or highly stressful experience, some brain chemicals play important roles in how the defense circuitry tends to dominate brain functioning, impair the prefrontal cortex, shift behavior to reflexes and habits, and alter the memory circuitry. Neuroscientists have also discovered that some brain chemicals can increase the probabilities of having certain kinds of thoughts and feelings, or the probabilities of engaging in certain kinds of reflexive or habitual behaviors. But while brain chemicals can influence such probabilities, they never determine the *particular* reflexes or habit behaviors produced. Therefore, we cannot attribute any particular behavior to any particular chemical.

Four Brain Chemicals You May Have Heard About

Over the past decade, four brain chemicals have gained attention for their potential roles in the brain's response to sexual assault and "the neurobiology of trauma": norepinephrine, cortisol, endogenous opiates, and oxytocin. Because there has been some confusion about the role of these particular chemicals, I will offer a very basic summary of what neuroscientists currently know about the activity levels and impacts of those chemicals during and after traumatic and highly stressful experiences, including sexual assault.

However, those who work with sexual assault survivors and other victims of violent crimes **need not worry about these specific chemicals.** It's enough (and less likely to result in confusion), to simply understand the basics – as described in these training bulletins – of how the defense circuitry's domination of brain functioning tends to alter attention, thinking capacities, behavior, and memory processing.

Norepinephrine

First, a great deal of scientific research has revealed that the defense circuitry increases norepinephrine activity in response to acute stress, with more severe or traumatic stress resulting in even greater activity.[10] While relatively low increased norepinephrine activity

[10] Increased norepinephrine activity also results in different *modes* of activity (i.e., phasic or brief vs. tonic or lasting), as reviewed by Valentino, R. J. & Van Bockstaele, E. (2008). Convergent regulation of locus coeruleus activity as an adaptive response to stress. *European Journal of Pharmacology, 583,* 194-203.

can enhance cognitive flexibility and prefrontal cortex function,[11] highly stressful situations cause high levels of norepinephrine release in the prefrontal cortex that impair its functioning. That results in decreased capacities for the control of attention and rational, deliberative thought.[12]

Generally speaking, the more stressful or traumatic an experience is, the higher the levels of norepinephrine activity are, which results in more prefrontal cortex impairment. This causes people's behavior to be more controlled by the brain circuitries responsible for reflexes and habits, and thereby more automatic and involuntary.

However, as noted above, it's simpler to leave norepinephrine (and other brain chemicals) out of the discussion, and just refer more generally to how the defense circuitry dominates brain functioning, which results in the common impacts described in these training bulletins on people's thinking and behavior.[13]

Cortisol

The neurohormone cortisol is another brain chemical that researchers have found to play a role in responses to stressful experiences.[14] Some studies have found increased cortisol activity after a sexual assault, but others have found *blunted* (decreased) cortisol activity afterward.[15] In particular, a history of prior sexual or physical assaults has been associated with reduced cortisol activity immediately after a sexual assault. Regardless, it is impossible to say in any particular case that brain cortisol activity

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[11] Sara, S. J. & Bouret, S. (2012). Orienting and reorienting: The locus coeruleus mediates cognition through arousal. *Neuron, 76 (1),* 130-141.

[12] Arnsten A.F.T. (2009). Stress signaling pathways that impair prefrontal cortex structure and function. *Nature Reviews Neuroscience, 10 (6),* 410-422; Arnsten, A.F.T. (2015). Stress weakens prefrontal networks: Molecular insults to higher cognition. *Nature Neuroscience, 18 (10),* 1376-1385. We also know that increased norepinephrine input to the hippocampus, a key structure in the brain's (episodic) memory circuitry, contributes to time-dependent effects of stress on encoding and storage processes, but those memory processes are not a focus here.

[13] Norepinephrine also has impacts on memory encoding and storage under stress and trauma, but again, it's not necessary to get into those details and we can just understand the basics of how the defense circuitry impacts memory processes.

[14] These time-dependent effects of cortisol on different receptor subtypes and genomic processes in different brain areas have been studied with respect to prefrontal cortex function, shifts to habit-based behavior, and memory processes in the hippocampus. For reviews, see Wirs, L., Bogdanov, M., & Schwabe, L. (2018). Habits under stress: Mechanistic insights across different types of learning. *Current Opinion in Behavioral Sciences, 20,* 9-16; Quaedflieg, C. W. E. M. & Schwabe, L. (2018). Memory dynamics under stress. *Memory, 26 (3),* 364-376.

[15] More than 20 years ago, studies found reduced cortisol activity immediately after a sexual assault, among women with a history of prior assaults: Resnick, H. S. et al. (1995). Effect of previous trauma on acute plasma cortisol level following rape. *American Journal of Psychiatry, 152,* 1675-1677; Yehuda, R. et al. (1998). Predictors of cortisol and 3-methoxy-4-hydroxyphenylglycol responses in the acute aftermath of rape. *Biological Psychiatry, 43,* 855-859.

increased or decreased,[16] during or right after a sexual assault, or to attribute any particular behavior of a sexual assault victim to that specific brain chemical.

Endogenous Opioids

Like opioids introduced externally (via pills or injection), the opioid peptides that are produced naturally within the brain (i.e., endogenous opioids) serve to decrease pain perception and sensitivity. It is therefore not surprising that endogenous opioid activity tends to increase in response to stress, danger, and trauma, and that it is involved in survival reflexes.[17]

But this does not mean that opioid activity is always the cause when someone experiences dissociation or numbing of pain and emotional experience, either during or after a sexual assault. Dissociation and numbing may have a variety of neurobiological causes.[18] There's no way to know the particular cause, or combination of causes, for dissociation or numbing experienced by a sexual assault survivor – or anyone else – in the midst of a dangerous, traumatic, or extremely stressful experience, or in its aftermath. To put it simply, those are common experiences, triggered by the defense circuitry through a variety of neurobiological mechanisms.

Oxytocin

The fourth brain chemical often speculated to play a role in sexual assault responses is the peptide hormone oxytocin (which is again, produced naturally within the brain). In the popular media, oxytocin is often referred to as the main brain chemical responsible for social bonding and connection, partly due to research on bonding between mothers and infants, and studies on people's experiences of connection to partners and friends.[19] Plenty of research, though, shows that things are more complex.[20]

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[16] At least it is impossible without actually collecting biological samples that reveal cortisol activity.

[17] Kozlowska, K. et al. (2015). Fear and the defense cascade. *Harvard Review of Psychiatry,* 23 (4), 263-287.

[18] For example, Simeon, D. et al. (2000). Feeling unreal: A PET study of depersonalization disorder. *American Journal of Psychiatry, 157,* 1782-1788; Lanius, R. A. et al. (2002). Brain activation during script-driven imagery induced dissociative responses in PTSD: A functional magnetic resonance imaging investigation. *Biological Psychiatry, 52,* 305-311; Hopper, J.W. et al. (2007). Neural correlates of reexperiencing, avoidance, and dissociation in PTSD: Symptom dimensions and emotion dysregulation in responses to script-driven trauma imagery. *Journal of Traumatic Stress, 22,* 713-725; Nicholson, A. A. et al. (2017). Dynamic causal modeling in PTSD and its dissociative subtype: Bottom-up vs. top-down processing within fear and emotion regulation circuitry. *Human Brain Mapping, 38,* 5551-5561.

[19] Colonnello, V. et al. (2017). Positive social interactions in a lifespan perspective with a focus on opioidergic and oxytocinergic systems: Implications for neuroprotection. *Current Neuropharmacology, 15,* 5543-561; Kanat, M., Heinrichs, M., & Domes, G. (2014). Oxytocin and the social brain: Neural mechanisms and perspectives in human research. *Brain Research, 1580,* 160-171.

[20] More than 10 years ago, research indicated that oxytocin activity can contribute to negative emotional experiences, e.g., Rockfield, H. et al. (2011). Effects of oxytocin on 'compassion focused imagery.' *Emotion, 11 (6),* 1388-1396; for a recent review of the complexity, see Steinman, M. Q., Duque-Wilckens, N., & Trainor, B. C. (2019). Complementary neural circuits for divergent effects of oxytocin: Social approach versus social anxiety. *Biological Psychiatry, 85,* 792-801.

Just as opioids aren't necessarily responsible for survivors' experiences of dissociation or numbing, oxytocin isn't necessarily the cause of smiling, laughing, or other seemingly happy behavior. In fact, research on oxytocin and trauma reveals a complex picture: (a) emotional trauma and PTSD can *decrease* oxytocin; (b) the administration of oxytocin can *increase* traumatic memories and distress, not just decrease them; (c) oxytocin activity in response to acutely stressful experiences can differ for females versus males and for people with histories of childhood physical versus sexual abuse.[21]

Therefore, if someone is smiling or laughing during a medical forensic examination, law enforcement interview, or other social interaction following a traumatic experience such as sexual assault, we cannot necessarily assume oxytocin activity is causing it. There could be many reasons – related to social perceptions and motivations, shaped by culture, personality, and how the particular interaction is unfolding – and the neurobiological causes of all those responses are complex and impossible to know.

Better to Think In Terms of Circuitries, Not Chemicals

As explained previously, neuroscientists understand the brain as composed of many *circuitries,* that is, collections of brain areas that work together to perform certain functions (such as the defense and habit circuitries). These circuitries communicate with and influence each other in a wide variety of complex ways, and these interactions are also influenced by many factors, including inherited genes and how (traumatic) experiences can determine which genes are turned on or off in the brain, and when. As a result, the same brain chemical can have very different effects on different brain regions, and even *within the same brain* region, depending on a variety of factors that can change over time.

That's why **it's much simpler, more accurate, and more helpful to understand the impacts of stress and trauma on the brain, thinking, behavior and memory in terms of *key brain circuitries* rather than specific brain chemicals.**

Next Up

This concludes my very brief discussion of victim responses during sexual assault. In the next training bulletin in this series, I will focus on memory processes.

[21] Donaldson, M. F. et al. (2018). The associations between oxytocin and trauma in humans: A systematic review. *Frontiers in Pharmacology, 9,* 154.

End Violence Against Women International
(EVAWI)

Important Things to Get Right About the "Neurobiology of Trauma"

Part 3: Memory Processes

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This training bulletin series explores some central concepts in the "neurobiology of trauma," as it is understood by people working with sexual assault victims. Understanding essential scientific findings and avoiding any misinterpretation or misapplication can help professionals work more effectively with survivors. In this final installment in the series, I focus on key issues involved in memory retrieval or recall.

Memory Encoding, Storage, and Retrieval

During any experience, we are paying more attention to some aspects of it than others. And of those aspects that get our attention, some have more emotional significance attached to them than others. The parts of an experience that are encoded into short-term memory (and stored for about 30-seconds), and then prioritized for storage in long-term memory (potentially the rest of one's life), are selected for encoding and storage as a function of both *attention* and *significance.*[1] In memory science, the parts of an experience that get substantial attention and significance are called **central details**, while the parts that get little attention or significance are **peripheral details**.[2] Some things that are happening during an event aren't even noticed by the brain and never get encoded into memory.

The neurobiological impacts of stress and trauma can increase the "storage strength" of central details.[3] Furthermore, when the brain's defense circuitry takes over and impairs the prefrontal cortex,[4] that can also result in the "tunnel vision" that police officers understand from critical incidents and soldiers know from combat experiences.[5] Tunnel vision (and other ways attention can be narrowed) result in a heightened focus on *some* parts of an experience but not others, which causes some details to never be encoded into memory and others to be lost from memory because they were experienced as peripheral in those moments.

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[1] Cohen, N., Pell, L., Edelson, M.G., Ben-Yakov, A., Pine, A. & Dudai, Y. (2014). Peri-encoding predictors of memory encoding and consolidation. *Neuroscience & Biobehavioral Reviews, 50,* 128-142; Levine, L.J. & Edelstein, R.S. (2009). Emotion and memory narrowing: A review and goal-relevance approach. *Cognition and Emotion, 23,* 833-875.

[2] Levine, L.J. & Edelstein R.S. (2009). Emotion and memory narrowing: A review and goal-relevance approach. *Cognition and Emotion*, 23, 833-875. For additional information, see Hopper, J. (2018). Why incomplete sexual assault memories can be very reliable. Sexual Assault and the Brain (blog), *Psychology Today;* Hopper, J. (2016). *Neurobiology of Sexual Assault (Part 2: Experience and Memory).* EVAWI webinar series; Wilson C., Lonsway, K.A. & Archambault, J. (2016). *Understanding the Neurobiology of Trauma and Implications for Interviewing Victims.* EVAWI training bulletin.

[3] McGaugh, J.L. (2015). Consolidating memories. *Annual Review of Psychology, 66,* 1-24.

[4] Kozlowska, K., et al. (2015). Fear and the defense cascade: Clinical implications and management. *Harvard Review of Psychiatry, 23,* 263-287; Arnsten, A.F.T. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. *Nature Reviews Neuroscience, 10,* 410-422; Arnsten, A.F.T. (2015). Stress weakens prefrontal networks: molecular insults to higher cognition. *Nature Neuroscience, 18,* 1376-1385.

[5] Mather, M. & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives in Psychological Science, 6,* 114-133; Clewett, D.V., Huano, R., Velesco, R. & Mather, M. (2018). Locus coeruleus activity strengthens prioritized memories under arousal. *Journal of Neuroscience, 38,* 1558-1574.

Most peripheral details will fade from memory within 24 hours, unless they happen to be recalled and then re-encoded and re-stored in the brain.[6] And even for central details, not all will be saved in memory forever, or even for a period of weeks, months, or years.

No One Can Remember "Everything"

If we reflect for a moment, these scientific facts fit with our lived experience and common sense. However, some people sincerely believe they "remember everything" about a stressful, traumatic, or otherwise emotionally significant experience they have had. Others believe the right interviewing methods can help people remember "everything."

It just isn't true. **No one can remember "everything" about any experience they have had, including a traumatic experience such as sexual assault.** Some people will remember more than others, but what people remember will always be a function of what their brain paid attention to and gave emotional significance to at the time. There will always be some information, including potentially important information, that simply does not get encoded or stored in memory.[7] Understanding this can help investigators and others avoid unrealistic expectations about what sexual assault victims will remember, including that they can remember "everything."

Recall Can Get Better Over Time

As noted above, peripheral details that are stored in memory about an event fade fast, and even some central details can be lost over time. But what people can recall – by retrieving into awareness (some of) what is still stored in the brain – *can improve over time.* That's because **retrieval conditions** can improve. For example, a second interview with law enforcement may be conducted, in comparison to the first interview, in a way that makes it easier for a person to remember details. In that sense people's memories (in terms of what can be retrieved, not what is stored) can and often do get better over time.

An important factor in memory retrieval is the victim's **stress level.** Because stress impairs retrieval,[8] a decrease in stress can increase a person's recall. For example, the

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[6] Antony, J.W., Ferreira, C.S., Norman, K.A. & Wimber, M. (2017). Retrieval as a fast route to memory consolidation. *Trends in Cognitive Sciences, 21,* 573-576.

[7] In addition to the central/peripheral phenomenon, there are time-dependent neurobiological impacts of stress and trauma on the functioning of the memory circuitry, such that there tends to be an initial "super-encoding phase" that's followed (from 5 to 20 minutes later) by a minimal encoding phase. During each of those phases the central/peripheral distinction and its impacts on memory formation still apply, but both central and peripheral details are better encoded and stored during the initial than the later phase. See Hopper, J. (2018) "Why incomplete sexual assault memories can be very reliable," and "Why Christine Blasey Ford can't remember how she got home," on my blog with *Psychology Today*.

[8] Gagnon, S. A., & Wagner, A. D. (2016). Acute stress and episodic memory retrieval: neurobiological mechanisms and behavioral consequences. *Annals of the New York Academy of Sciences, 1369,* 55-75.

safer and more comfortable a victim feels with an interviewer, the less stressed they will be, and the more likely they will be able to retrieve information that is stored in memory.

Context also makes a big difference. This can include the physical space or social situation a person is in, as well as the state of their mind and body. Various strategies have been used to try to "reinstate the context" associated with a particular experience, such as visualizing or physically returning to the location of the assault. While physically revisiting the crime scene may not be possible or practical in some situations, and it can potentially be retraumatizing for victims, under some circumstances this could be effective in improving recall.[9]

Retrieval Cues

Another major factor that determines the completeness of recall is what memory researchers refer to as *retrieval cues*. This can include interview questions or prompts, which can make a huge difference in the amount and quality of information victims can recall. Effective interviewing employs questions and prompts that are open-ended, non-leading, and that elicit thoughts, feelings, and sensations – including ones the investigator would never have expected and the victim hadn't previously remembered. To illustrate, an investigator might prompt victims with: "You said he grabbed your neck, tell me more about that," or "What were you thinking or feeling when he had his hands around your neck?" Such cues have the potential to trigger the activation of additional pieces of memory associated with those sensations and thoughts.

From one day to the next, from one interview to the next, or from an investigative interview to courtroom testimony months or years later, **there's always the potential for victims to recall more details, as a result of different contexts and cues.**

Helping Victims "Remember"

In short, memories *can* get better over time. And when they do, there's no scientific basis for assuming that the person's later (and more complete) memories are less reliable or credible than their earlier (and less complete) memories – even if perpetrators and their defense attorneys might argue otherwise. If we understand the basic and well-established principles of memory encoding, storage, and retrieval, then **we can strive to optimize our interviewing and investigative techniques to maximize the benefits of context- and cue-based facilitation of recall, and we can counter unwarranted attacks on victims' recollections and credibility.**

[9] For a remarkable account of investigators helping a sexual assault victim retrieve detailed memories of an experience she had been almost completely unable to recall, and thought might just be a dream, listen to Carmon, I. & Natt, O. (2019, October 15). Your driver is here / The only memory I had was getting in the car. *The Cut on Tuesdays* podcast. The section on the "reenactment ride" starts at 14:08.

Stress, Sleep, and Memory Retrieval

As one method of helping victims remember, **many professionals have been taught that law enforcement should allow sexual assault victims two full "sleep cycles"[10] before conducting an in-depth interview.** This recommendation appears to have come from the work of law enforcement trainers, including Lieutenant Colonel David Grossman and Bruce K. Siddle, who founded Pressure Point Control Tactics (PPCT).[11] It was reportedly based on studies of soldiers in combat and applied to interviews of police officers following critical incidents such as officer-involved shootings. However, no scientific evidence or neurobiological basis were provided for this recommendation, just the statement that two sleep cycles were necessary for a person who has experienced trauma to "fully recall" what happened.[12]

Putting it in Context

It is important to place this recommendation in the context of law enforcement culture and professional lore, which traditionally viewed interviews as a race against time. The assumption was that people are best able to recall an event right afterward, so every passing minute could result in a loss of critical information. The recommendation to wait two sleep cycles before interviewing officers after a critical incident was therefore a radical departure from tradition – and one designed to slow investigators down and avoid rushing the process. **Investigators were advised to conduct a preliminary interview to establish key fundamental information, then allow the officer time to rest, recover, and address logistical and emotional issues before undergoing a detailed follow-up interview.** Eventually the same logic was applied to everyone involved in a traumatic or highly stressful events, not just police officers or soldiers.

Fast-forward to today, and we can combine this practice-based recommendation with the science of stress and trauma, their impact on memory, and the role of sleep. There are three key findings to consider: (1) Sleep helps preserve some details in memory, but not others; (2) Stress impairs retrieval of memories; and (3) Sleep can reduce stress.

[10] The term "sleep cycle" has a different meaning to scientists than law enforcement. For law enforcement, it is used to describe extended periods of sleeping after a traumatic event (e.g., a night of sleep). In sleep research, however, "sleep cycle" refers to approximately 90-minute sequences that repeat several times over the course of a night of sleep, with each cycle divided into periods of rapid eye-movement (REM) sleep and non-REM (NREM) sleep. NREM is further divided into four stages.

[11] PPCT Management Systems, Inc. (1989), *Use of Force Human Factor* (Chapter 1).

[12] As explained above, no one ever has "full recall" of any experience, because it is always the case that some details are not noticed or encoded into memory during the event; that some of the details that are encoded and stored (peripheral details) rapidly fade from memory storage (in the absence of retrieval, which can enable re-encoding and re-storage); and that even some central details can be lost over time.

Sleep Helps Preserve Some Details, But Not Others

Researchers have found that the retention or storage of *emotionally significant central details* in memory is promoted neurobiologically during sleep. In contrast, peripheral details are lost just as rapidly during sleep as they are when people are awake.[13] Unfortunately, the details that are peripheral to someone's brain during an assault could later, during the course of an investigation, be of central importance to law enforcement.

Stress Impairs Retrieval

Just because information is stored in someone's brain, this doesn't necessarily mean it is accessible to recall. That's because stress impairs the brain's ability to retrieve memories that have been encoded and stored.[14]

People are often very stressed after a traumatic experience, and even a well-conducted interview might not elicit recall of details that are still stored in their brain. Also, even if someone approaches an interview not feeling stressed, the interview itself – even under the best circumstances – can still be stressful at times. This means that the experience of being interviewed can sometimes impede the very recall it is designed to elicit.

Sleep Can Reduce Stress

Memory retrieval impairments associated with extreme stress and trauma typically resolve when a person's stress level is reduced. This does not require sleep, but to the extent that sleep reduces stress (which it often does), it can contribute to improved memory retrieval. In other words, **it isn't about sleep per se, but rather stress reduction more generally.**

By the same principle, when victims' stress levels are reduced through compassionate care, their memory retrieval capacities could return to normal levels, sometimes even within an hour or so after the assault.

On the other hand, a victim could have two very restful nights of sleep, but then encounter trauma-related triggers that sharply increase their stress level (such as an investigator who uses interrogation tactics). This could potentially cause the victim to suffer recall impairment greater than immediately after the assault itself.

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[13] Payne, J.D., Chambers, A.M. & Kensinger, E.A. (2012), Sleep promotes lasting changes in selective memory for emotional scenes. *Frontiers in Integrative Neuroscience, 6,* 1-11; Bennion, K.A. et al. (2015). Sleep and cortisol interact to support memory consolidation. *Cerebral Cortex, 25 (3),* 646-657; Cunningham, T.J. et al. (2014). Psychophysiological arousal at encoding leads to reduced reactivity but enhanced emotional memory following sleep. *Neurobiology of Learning and Memory, 114,* 155-164.

[14] Gagnon, S.A. & Wagner, A.D. (2016). Acute stress and episodic memory retrieval: neurobiological mechanisms and behavioral consequences. *Annals of the New York Academy of Sciences, 1369,* 55-75.

For these reasons, **trauma-informed interviewing practices are always recommended, to reduce victims' stress and enhance their comfort, regardless of how much sleep they have had.**

No Magic in "Two Sleep Cycles"

In sum, there is no reason to believe that two rounds of sleep are specifically required to eliminate any stress-induced recall deficits. Because our sleeping brains are working to preserve central details in memory – but not peripheral details, which fade as quickly as if we weren't sleeping – this means waiting two sleep cycles to interview someone about their sexual assault will inevitably mean that some details will be lost during that time.

Combining Science and Practice

Too many victims are subjected to detailed interviews when they haven't eaten, have been awake for long periods of time, are intoxicated or under the influence of drugs, or are worrying about essential concerns such as children, pets, or other responsibilities for family, work or school. Victims are often exhausted, confused, and struggling just to absorb what happened. They may not be getting the support they need from friends and family, especially if they don't have a trained victim advocate helping them.

Determining the appropriate time for a follow-up interview will require balancing these considerations with the brain-based processes described above. In most cases, **it makes sense to allow victims some time before conducting the detailed interview – time to rest, reduce stress, seek support from loved ones and victim advocates, and begin processing what happened to them. But there is no universal timeframe for that, and every victim should be approached as a unique person, with unique needs, at a particularly difficult time in their life.**

To illustrate, for victims who are sexually assaulted late at night and report to law enforcement right away, the preliminary interview and medical forensic exam process will often last into the early morning hours. Yet investigators often call the victim just a few hours later, when they are assigned the case, to schedule a follow-up interview. They think of it as "the next day," but it's still "the same day" for a victim who has been awake most of the night, going through a difficult and likely exhausting process. By scheduling the follow-up interview for the following day at the earliest, the victim will have time to get an actual night's sleep and hopefully feel better for the interview.

On the other hand, some victims may not want to wait for the detailed interview. Especially for those who report their sexual assault after some period of time has passed, they may have finally worked up the courage to contact law enforcement and want to get the interview over with as soon as possible. Victim needs should remain at the center of any decision making around when to conduct the detailed interview.

Conduct Two Investigative Interviews

EVAWI's recommendation is to conduct at least two investigative interviews in most sexual assault cases, especially for survivors who report their assault within a few hours of its occurrence. The first interview is focused on addressing emergency needs and conducting a preliminary investigation. This includes inquiring about information related to the crime scene and other potentially vital information that the victim's brain might have processed as peripheral details during the assault and are thus vulnerable to rapidly fading from memory.

The second interview is much more detailed, conducted perhaps 2-3 days after the initial response, depending on the schedule and convenience of the victim and investigator. This allows time for the investigator to take critical investigative steps such as reading the preliminary report, conducting a criminal history check on the suspect, and reviewing any reports from the medical forensic examination, crime scene, etc. This time is also necessary to make arrangements regarding any accommodations the victim may need, in terms of physical disabilities, disabilities affecting cognition or communication, or interpretive services.

In other words, memory processes are not the only factors to consider for scheduling; investigative concerns are also key. A day or two of preparation allows investigators to conduct a more informed and effective follow-up interview.

Conclusion

This concludes our series of training bulletins summarizing the neurobiological basics of how people commonly respond while being sexually assaulted, and how stress and trauma can alter their memory processes. This basic understanding can yield several key benefits for professionals: It provides more realistic expectations for victim responses during a sexual assault, more perceptive listening to their account of what happened, and more effective information-gathering about their memories and responses. These are potential game-changers for the field of sexual assault response. However, this knowledge should not be used to explain or make assumptions about any *particular* survivor's responses or memories, because each individual is unique.

When it comes to understanding common victim responses, conducting effective victim interviews, and teaching other professionals on the "neurobiology of trauma," keep it simple, but scientifically sound. Focus on a few key brain circuitries and leave brain chemicals out of it. Otherwise, the risks of getting confused and getting it wrong are high, as are the risks of confusing others, giving them a false sense of understanding, and exposing yourself and others to (unfortunately justified) attacks on your credibility – and by extension, the credibility of anyone and everyone who teaches and speaks about the "neurobiology of (sexual assault) trauma." This strategy will help the field to reap valuable benefits of this scientific understanding, while avoiding possible pitfalls.