End Violence Against Women International
(EVAWI)

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

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 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)

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[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.

[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.

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 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

[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.

[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.

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]

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.**

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[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.

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

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.