Opioid Addiction and Recovery: Examining Neurobiology, Attachment, and the Survival-Stress Response in Relation to Opioid Addiction

by

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Abstract

The severity of the opioid crisis in Vancouver has intensified over the last 10 years with increasing numbers of overdose-related deaths. Among people living with opioid use disorder, a disproportionate number are also living with post-traumatic stress disorder (PTSD) and have high rates of adverse childhood experiences compared to the general population. This paper will explore how attachment experiences, trauma, the survival-stress response and nervous system dysregulation intersects with the use of exogenous opioids to provide a conceptual understanding of opioid use disorder and to give context to the functional use of opioids. The probability of developing patterns of addiction is directly impacted by the experiences of and need for safety and attachment. Attachment exchanges, in which a caregiver is responsive and attuned to infant/child develops the child's implicit sense of self and is the first step in developing their capacity for self-regulation. The experience of responsiveness, safety, and attunement by the caregiver primes the infant for optimal development, a felt sense of safety and worthiness, flexibility in the nervous system, and a greater capacity for social connection later in life. The opposite occurs when there is a lack of responsiveness, attunement and safety; the infant/ child is primed to respond to an unsafe or unresponsive environment and forms adaptations to cope with a suboptimal environment. Early attachment exchanges directly impact the body's survival-stress response, the capacity for self-regulation, social connectedness, and the endogenous opioid system. Understanding how opioids interact with the body's survival and social attachment systems and the relevant neurobiology can inform therapeutic interventions used in substance use recovery programs.

Keywords: attachment, defence cascade, addiction recovery, opioid use disorder, endogenous opioid system

Table of Contents

Chapter 1: Introduction

Connection, attachment, safety, and belonging are fundamental needs of all people. Although people are resilient and learn to adapt to the absence of secure attachment and safety, their absence inevitably results in suffering. Even at a biological level, the human nervous system is sculpted by experiences of attachment and safety, or people adapt to the experience of unsafety and disconnection. One way that people may learn to adapt is by moderating the experience of disconnection, trauma, and dysregulation through opioid use. In fact, addiction is now conceptualized by some academic and therapeutic professionals as an attachment disorder (Morgan, 2019; Schindler et al., 2009). Additionally, while research on addiction and treatment has largely focused on understanding the reward-motivation system in the brain and its implications on behaviour, less is known about other neural systems that are relevant to addiction. Understanding the interconnection between attachment, trauma and opioid addiction can can offer a more complete understanding of the function of opioid addiction in a person's life and provide insight into how mental health practitioners can develop more specialized therapeutic interventions for people recovering from opioid use disorder.

Purpose Statement

The severity of the opioid crisis in Vancouver has intensified over the last 10 years with increasing numbers of overdose-related deaths. Among people living with opioid use disorder, a disproportionate number are also living with post-traumatic stress disorder (PTSD) and have high rates of adverse childhood experiences compared to the general population. Given this context, I will look at how people's attachment experiences and nervous system dysregulation intersects with their use of opioids. The purpose of this paper is to provide a conceptual understanding of opioid use disorder that gives context to the functional use of opioids.

Understanding more about how opioids interact with the body's survival and social attachment systems, which have profound roles in organizing the human experience, can inform therapeutic interventions used in substance use recovery programs.

Overview of the Context and Problem

The Downtown Eastside (DTES)

The Downtown Eastside (DTES) in Vancouver, British Columbia, Canada is a diverse and resilient community. The neighbourhood also has comparatively high rates of people experiencing homelessness, mental health challenges, poverty, previous experiences of trauma, and who are coping with substance use, compared to other neighbourhoods in Vancouver (British Columbia Centre for Excellence in HIV/ AIDS [BCCE], 2009; Buxton et al., 2007; Linden et al., 2013). The DTES has some of the highest rates for substance use and addiction in Canada and has been identified as one of the poorest postal codes in Canada (BCCE, 2009; Linden et al., 2012). Many people living in the DTES live in single-room occupancy buildings, which are frequently old buildings with a single room, shared bathrooms, and pest infestations that are in poor repair; others are homeless; live in encampments; or residing in line-up shelters (Linden et al., 2012; Scher, 2020). Research conducted by one of the biggest municipal government-run outreach programs in the DTES makes a conservative estimate that one out of every 18 people residing in the DTES does not have a permanent address (Carnegie Community Action Project, 2016). Furthermore, the mortality rate in the DTES is seven times the provincial mortality rate and has higher rates of overdose and drug-induced deaths (Bruxton et al., 2007).

In addition to complex primary and mental health challenges, homelessness and poverty, the synthetic opioid crisis has resulted in a significant increase in overdose-related deaths in the DTES and throughout BC (Willcocks, 2021). In the early 1990s, the risk of overdose was highest among people using cocaine and heroin concurrently (Fischer et al., 2018). Since that time, there has been a 400% increase in drug-related deaths in British Columbia, with 1,473 in 2017, and increasing to 1,746 in 2020 (Fischer et al., 2018; Substance-related Overdose and Mortality Surveillance Task Group [SOMS-TG], 2021). The BC Provincial Government announced in 2022 that overdose from illicit drug toxicity is one of the leading causes of unnatural death in the province, and with only cancers superseding drug toxicity in the number years of life lost (Public Safety and Solicitor General, 2022). The Provincial Health Authority in BC announced a public health emergency due to a spike of 137% increase in overdose-related deaths in April 2016 compared to April 2015 (Chu et al., 2018). Since 2016, there has been a staggering 22,828 opioid-related death between January 2016 and March 2021 in Canada (SOMS-TG, 2021). In 2020, BC had the highest crude rate per 100,000 of opioid-related deaths in all of Canada (SOMS-TG, 2021). Since the onset of the COVID-19 pandemic, the community has seen an increase of five death per day related to overdose, as street drugs are frequently laced with fentanyl in the DTES (Willcocks, 2021). Given the intensity of the opioid overdose crisis, effective treatment and support options must be available for people seeking addiction recovery support.

Special attention should be given to the context and environment in which people in the DTES live, as substance use, behaviour, interpersonal patterns, and cognition may be better understood in light of this environment (Maté, 2010). Part of the context that must be considered, in addition to the environment described above, are the structural systems of power and oppression, including racism, classism, sexism, heteronormativity, ageism, ableism, eurocentrism, and colonialism. The collective trauma of oppression and colonization, and multiple intersecting systems of power and oppression are some of the most significant etiological reasons for the suffering of many people within the community (Alexander, 2000; Sagram et al., 2020). While a deeper exploration of this subject is beyond the scope of this paper, understanding that systemic oppression results in trauma and creates the social and structural conditions that beget further trauma is critical when providing care in the DTES. Community members of the DTES should never be treated or seen as solely responsible for having had challenges in their lives, or worse, as morally deficient, socially deviant, or beyond hope (Alexander, 2008; Maté, 2010). As such, I would like to acknowledge that while this paper examines trauma on an individual level, there is convincing evidence to suggest that the historical, social, colonial, economic, and political environment of Canada has facilitated the conditions for addiction and marginalization to flourish. These macro issues must be treated to provide long term, sustained, and systematic recovery for substance use disorders (Alexander, 2000), rather than exclusively treating people who have been harmed by these systems of power.

Disconnection & Dislocation of Addiction

Many of the efforts and resources in treating addiction in Canada has been directed to providing acute treatment for addictions (BC Mental Health and Substance Use Services, 2021). Acute treatment is short-term residential addiction treatment, often between 30 to 90 days, and a person will reside in a residential treatment program to receive intensive psychoeducation and brief cognitive-behavioural psychotherapy (BC Mental Health and Substance Use Services, 2021). This model of treating addiction is based on the medical model that assumes that addiction is a disease that can be treated like any other disease by addressing the issue within a person. Following a similar clinical course to other medical diseases, a pathology is diagnosed, the patient receives treatment for the specific pathology, and then the symptoms are reduced (Sheedy & Whitter, 2013). There was a shift in addiction care in the 1960s and 1970s, partially due to the War on Drugs, from a peer-based and lay support model to care being provided through a professional medical and acute treatment model (White, 2008). However, in relation to substance use, addiction may not be the core issue, and thus treating only the patterns of substance use and addiction may not be sufficient to maintain abstinence from substance use.

Despite the investment of extensive resources over decades into the acute treatment model, recovery programs and practitioners still see high rates of relapse and overdose, even after a person receives intensive residential support (Maté, 2010; Wilbourne & Miller, 2003). Hubbard et al. (2001) found that half of the people who participated in a recovery program experienced a recurrence of use within 30 days of discharge, and 80% of participants had a recurrence within 90 days of discharge. The assumption within the acute model of treatment is that recovery is completed after discharge from the program and that most resources are directed into supporting the person in recovery during this time (White, 2008). However, some researchers have found that substance use recovery is often not self-sustaining and stable until four to five years into sobriety (Best, 2019). With the professionalization of care in the medical model paradigm, that is the shift from lay and peer support to support from people with professional designations, there is less of a reliance on peer, community-based supports and less opportunity for people to create meaningful natural supports that persist beyond the residential recovery program (White 2008). Acute treatment alone is not sufficient to facilitate long-term, sustained recovery.

Moreover, while specific therapeutic support, including psychotherapy and psychoeducation, may be required or even essential to support recovery, we must try to understand what the underlying issue is to provide effective assistance and support sustained recovery. Are the issues cognitive distortions (Beck, 1976), a lack of interpersonal effectiveness and skills (Linehan, 1993), cognitive fusion or inflexibility (Hayes et al., 2012), chemical and biological dependence, moral deficiencies, trauma, poverty, a lack of employment skills, or another unidentified variable? How can practitioners effectively support people living with addiction when the central mechanism is not identified or understood? What should treatment, particularly acute treatment, address?

Addiction and Trauma

The DTES has many members who have experienced abuse, intergenerational trauma, communal trauma and colonization, alongside the arguably traumatic daily environment that necessitates the use of street survival skills (Maté, 2010). It is important to understand the role of opioid use in the context of impoverished communities like the Downtown Eastside, particularly when addressing opioid use and trauma therapeutically. Gabor Maté (2010), a well-known physician and addiction specialist in the DTES states, “the question is never ‘why the addiction?’ but ‘why the pain?’” (p. 36). Among people who access treatment for addictions, there are comparatively high rates of people who have experienced abuse and victimization. For example, among women accessing treatment for addictions, 62%-81% experienced childhood abuse or neglect, compared to 26%-30% in the general population (Min et al., 2007). Sagram et al. (2021) found that among people who use illicit drugs in Vancouver, 34.8% reported moderate to extreme childhood physical abuse, and 32% reported subsequent violent victimization in the past 6 months. In light of this, it is important to also consider the role and impacts of traumatic events among people seeking recovery.

Adverse childhood events and childhood trauma can result in attachment injury, poor health outcomes, high-risk behaviour, substance use and addiction, and changes to the brains neurochemistry and physiology (Dube et al., 2003; Felitti et al., 1998; Kyte et al., 2020; Min et al., 2007). These early adverse experiences can interrupt the development of the self-regulation pathways and sensitization of the survival-stress response, which is correlated with an earlier onset of substance and alcohol use and heavier alcohol used compared with people who experience trauma in adulthood (Dass-Brailsford & Myrick, 2010). As a result of these neurophysiological changes, the drugs that act on these natural neurocircuits may provide the neurotransmitters that the brain lacks because of trauma and attachment-related changes (Kyte et al., 2020; Maté, 2010). People with lived experience of problematic substance use reported that coping with daily stressors, to feel comfortable in social settings, and self-medicating trauma intrusions were some of the primary motivations for using substances (Gielen et al., 2016).

Traumatic experiences have direct impacts to the autonomic nervous system, which is activated in response to stress and threat (Porges, 2008). Polyvagal Theory and a more nuanced look at the incremental changes in a person's autonomic state through the defence cascade (which will be discussed in subsequent sections) provides insight into the role of substance use in self-regulation (Kozlowska et al., 2014; Porges, 2008). Symptoms of PTSD can simulate symptoms of withdrawal, and vice versa (Danovitch, 2016). Additionally, while there are different hypotheses attempting to explain the relationship between PTSD and opioid use (Danovitch, 2016), there is a complex relationship between the physiology of traumatic activation, the survival-stress response, the attachment system, self-regulation and opioids. Dynamics of these intersecting relationships will be explored throughout this review.

The Nervous System, Dysregulation & the Implicit Self

There is a complex interrelationship between addiction, trauma, and the nervous system; understanding how the nervous system is shaped by attachment experiences and exposure to trauma is critical in understanding problematic opioid use. Some of the impacts of trauma can be observed in changes to the nervous system through the attachment system, and through sensitization and reactivity in the nervous system to signs of threat. Maté (2010) notes that addiction acts on neurological and chemical centers in our brain that are necessary for human survival, such as the attachment system. Similarly, traumatic experiences may also result in a reorganization of the nervous system, in which it is rewired and sensitized to threat to ensure survival; this may result in chronic hyper-/hypo-arousal, a smaller window of tolerance, and a nervous system that is primed to activate survival responses (Fisher, 2019; Porges, 2011).

Nervous system regulation is also integrated with the formation of attachment patterns. The attachment style of the child is shaped through the relationship with the caregiver and their attentiveness to the child, particularly in the first two years of life (Feldmen, 2007). While the child does not yet have the capacity to store declarative memory, they retain implicit/ sensory memory that lays the foundation of their nervous system (Ogden & Fisher, 2015). This occurs through the parent's intentional attending to the infant, and through other biological markers. For example, Feldmen (2007) noted that the heart rate of an infant's heartbeat synchronized to the rhythm of the mother's in under one second. For a parent that has chronic sympathetic activation because of trauma, the impacts of traumatic dysregulation can be transmitted to the children through these biological processes and interpersonal patterns that are constrained by these physiological states (Feldmen, 2007; Fishbane, 2019; Flores & Porges, 2017). Feldmen (2007) highlights the importance of the parents' ability to attune and appropriately respond to the infant's needs and nonverbal behaviours, such as emotion, vocalizations, movement, arousal, and gaze.

In their research, Feldmen (2007) found that the relational patterns and the coordination of attachment cues between the infant and caregiver shape the disposition and behavioural traits of the infant over time. Since the memories that are formed in the first two years of life are preverbal, they are encoded as sensorimotor and implicit memory (Ogden & Fisher, 2015). Infants have not yet developed the cognitive capacity to organize their experiences and are wholly reliant on their caregiver for this (Schore, 2015). If an infant is frightened and the caregiver soothes them, the nervous system of the infant releases a cascade of neurochemicals that provide a sense of wellbeing and reinforce the relationship with the caregiver, and they experience regulation in their nervous system (Morgan, 2019). However, if they are not soothed, the infant remains in a state of dysregulation, fear and distress (Fisher, 2017a). When there is a lack of responsiveness from the caregiver, the infant's nervous system 'learns' that the world is unsafe, to expect danger, and the survival/defence system may become chronically activated (Fisher, 2017a).

These early attachment experiences then shape the internal working models or rather the blueprints, of the person's implicit self-concept, understanding of themselves in interpersonal relationships and felt sense of safety in the world (Schore, 2015). The sensorimotor experiences and sensations of nervous system dysregulation are disconnected from explicit narrative memory in which someone 'thinks', rationalizes or makes sense of their experiences, as the areas of the brain that facilitate this information processing are not yet developed nor connected with the regions that encode implicit, sensorimotor experiences (Schore, 2015). An adult may 'know' that they are not a bad person, as the left brain and cortical regions that process information are developed, yet implicitly feel that they are bad because of the disorganized sensorimotor memory. Similarly, traumatic memory is encoded in somewhat of a similar way since the regions of the brain that are responsible creating narrative memory, future planning, social engagement, and higher order cognitive processes also shut off in service of survival via the defense cascade. Traumatic memory may arise in the form of sensory information through flashes of imagery, ad somatic senses, accompanied by a strong arousal of the autonomic nervous system long after the initial event (Fisher, 2019; van der Kolk, 2015).

Processing sensorimotor memory requires ‘bottom up’ approaches to reintegrate these forms of memory (Ogden & Fisher, 2015). That is, therapeutic processes that engage the lower regions of the brain in which this memory is stored, rather than ‘top down’ approaches that rely on the areas of the brain that store narrative memory (Fisher, 2017a). Unfortunately, many of the current best practice recommendations, such as cognitive behavioural therapy rely on ‘top down’ processing, and while helpful may not be able to address some of the foundational memory and etiological experiences (Fisher, 2017a).

Morgan (2019) suggests that addiction is an attachment disorder, and that substances are used as an alternative attachment figure. Attachment figures both in childhood and throughout life have an important role in regulating the nervous system and supporting a felt and physiological sense of safety (Siegel et al., 2021). In this context, substances may be used for self-regulation of somatic states, to either up-regulate or down-regulate the nervous system when there is chronic activation of the sympathetic nervous system (high arousal) or dorsal vagal (low arousal) responses (Corrigan et al., 2010; Dass-Brailsford & Myrick, 2010; Fisher, 2019). Throughout this paper, I will explore the hypothesis of addiction as an attachment disorder and as a means to self-regulate. I will do this by looking at research on the relationship between PSTD and opioid use, attachment patterns and opioid use, the Brain Opioid Theory of Social Attachment. Additionally, I review research on the defence cascade to provide an overview on the different biobehavioral survival responses, and how counsellors can recognize these states in clients they are working with.

Theoretical/Conceptual Framework

This capstone has three theoretical frameworks: Dislocation Theory, Polyvagal Theory, and Attachment Theory, in this section these frameworks are introduced in the context of addiction recovery. They will be used in order to evaluate research on opioid addiction recovery and the overlapping relationship between opioid use disorder and the attachment system, nervous system stress/ survival responses, and the endogenous opioid system.

Dislocation Theory

The increasing tides of addiction may be symptomatic of a larger social issue. Research in the past 40 years has suggested that addiction may be a symptom of dislocation and disconnection from meaningful roles, relationships, and community (Alexander et al., 1981; Alexander, 2000). Alexander (2008) suggests that free-market capitalism and neoliberal restructuring of the global economy and international relations (Harvey, 2005) have produced the social, economic, historical, and political conditions that result in people becoming disconnected from their communities and lacking psychosocial integration. In other words, people experience dislocation from community, meaningful social connections, and lack a sense of purpose and identity.

Alexander (2008) suggests that when people have a role within their family and local community, they can derive a sense of identity, connection, and belonging. This contributes to a transcendent sense of purpose. While dislocation occurs over time, he hypothesizes that people learn to adapt to the experience of dislocation. Addiction in this context, he suggests, is the natural response to dislocation and an absence of meaningful roles and connections. These roles historically would have been organically generated in local communities and economies but have now been displaced through international free-market capitalism (Alexander, 2000).

Dislocation theory suggests that addiction is not a disease, as conceptualized by the medical system, or a moral failure, but is life with a restricted and truncated focus to compensate for a lack of psychosocial integration. Psychosocial integration, as he defines it, is a meaningful sense of identity, purpose, connection, relationships, and roles (Alexander, 2008). This conceptualization, though less specific and clear than the criteria outlined for a diagnosis of a substance use disorder (APA, 2013), includes a useful component; it highlights the role of substances as a way to cope within the context that the person is embedded and that addiction is not simply a problem to be treated within a person but must be considered within the ecology of a person's life and their wider context.

Research in rats has supported Alexander's hypothesis (2008); rats were raised in isolation or a group environment and were then given unrestricted access to morphine in an enriched environment or plain cage environment (Alexander et al., 1981). The enriched environment included boxes and other things to climb on. The researchers found that rats living in a group environment consumed less morphine than rats in an isolated environment, despite being raised in isolation. They found that an enriched living environment also led rats to consume less morphine. Furthermore, rats that were raised in isolated conditions consumed more morphine in the enriched environment than those raised in a group context, but this result was statistically significant only at the lowest dose of morphine. This suggests that social connection and enriching environmental factors have a moderating role between an early lack of attachment and nurturing and the later development of addictions.

Dislocation theory is one of the organizing theoretical models that I will use throughout this paper to understand and interpret literature on addiction and its etiology. Oliver Morgan, an addictions therapist, professor of counselling, and person in recovery, suggests that the increase in addictions is the first sign of greater social dangers, and offers an attachment-oriented perspective on addictions recovery that is informed by interpersonal neurobiology (Morgan, 2019). While looking at the underlying social, cultural, and spiritual roots of the issue is beyond the scope of this paper, I will similarly look at the role of interpersonal neurobiology and the attachment system and how they are impacted by the experience of dislocation and trauma. In considering both the macro view of addictions through dislocation theory and a detailed micro perspective of the impacts of addiction within a person's psyche and physiology, I aim to provide a well-rounded perspective on addiction. My goal is to add nuance and insight for mental health practitioners working in recovery settings on how they can support people in acute recovery settings.

Polyvagal Theory & The Nervous System

Polyvagal theory, developed by Stephen Porges (1995, 2007, 2011, 2017) provides a framework to understand how the state of the autonomic nervous system is directly connected with behaviour. While survival-stress responses have been traditionally conceptualized as the activation of the fight-flight response thought the sympathetic nervous system, Polyvagal Theory includes another biological response to threat through a major downregulation of the autonomic nervous system (Porges, 2017). The framework of a multilayered biological defence system provides a biological understanding of how and why people feel safe and new ways to both understand and treat trauma (Porges, 2017).

In summary of polyvagal theory, the autonomic nervous system has three subsystems that moderate social behaviour and human responses to threat. The systems are hierarchically organized: first the myelinated ventral vagal pathway, then then sympathetic nervous system, and lastly the unmyelinated dorsal vagal pathway (Porges, 2017). The ancient unmyelinated dorsal vagal pathway that was first to evolve in vertebrates and elicits the immobilization responses [feign death response]; then the sympathetic nervous system that generates that fight-flight response, and lastly the myelinated ventral vagal pathway in humans which was the last to evolve and supports social behaviour and higher order cognitive processes (Porges, 2017). These two vagal pathways have different origins in the brainstem and different pathways throughout the body; the unmyelinated dorsal vagal pathway provides regulation to the organs below the diaphragm and the myelinated ventral vagal pathway provides regulation to the organs above the diaphragm (Porges, 2017). The newer, more evolved systems inhibit the more ancient systems, but will yield to the older defence systems in the face of threat. Though human behaviour is typically conceptualized as being voluntary, particularly through cognitive-behavioral theories, these defence systems are activated involuntarily and biologically to promote survival (Porges, 2017). People may not be aware of the cues that activated these defences but may be aware the bodily reactions that subsequently arise.

The Autonomic Nervous System & the Vagus Nerve. The autonomic nervous system is part of the peripheral nervous system and has three branches: the sympathetic, the parasympathetic, and the enteric (Waxenbaum et al., 2021). In a healthy and regulated state, the body will naturally oscillate between sympathetic and parasympathetic activation without moving into more extreme activations of either state (Rothschild, 2017). The sympathetic nervous system, when activated, increases arousal throughout the body, increases attention and activity, and mobilizes the fight-or-flight response (Waxenbaum et al., 2021). The fight-flight response will result in increased blood pressure and heart rate, a release of glucose from stored glycogen into the bloodstream, and a halt to digestion. The sympathetic nervous system also supplies nerves throughout almost every tissue in the body. The parasympathetic nervous system initiates the ‘rest-and-digest’ process, reduces heart rate and blood pressure, and resumes digestion (Waxenbaum et al., 2021). In contrast to the sympathetic branch, the parasympathetic nervous system supplies nerves only to the head, viscera, external genitalia, and does not have nerves in the musculoskeletal system and skin. It is active when exhaling; the nerves fire to cause airways to become firmer so they do not collapse. Additionally, the vagus nerve accounts for approximately 75% of the parasympathetic nervous system (Waxenbaum et al., 2021).

The vagus nerve is a collection of nerves that include motor fibers and sensory fibers. It receives signals from body/ sensory fibers into the central nervous system and will send signals from the central nervous system via motor fibers (Porges, 2011). That is, the motor fibers send signals from the brain to the viscera/ muscles, and sensory fibers send signals from the viscera to the brain (Porges, 2017). The ventral myelinated branch includes myelinated motor fibers, and the unmyelinated dorsal branch includes unmyelinated motor fibers and sensory fibers. Sensory fibers that transmit signals from viscera to the brain account for 80% of the fibers in the vagus (Porges, 2017). A minority of vagal fibers are myelinated- one in six fibers- and are critical in sending motor signals from the brainstem to the organs above the diaphragm, such as the heart (Porges, 2017). These nerves are profoundly involved in listening for the prosody of voice (vocal intonation that communicates emotion), facial expressions, heartbeat, and generating vocalizations (Porges, 2017).

Brain-Body Connection. The human nervous system must be sensitive to the environment, movements of other creatures, and social interactions of people who occupy the surrounding environments to adequately detect a threat (Flores & Porges, 2017). Polyvagal theory (Porges, 2007, 2017) provides a foundation to understand how this occurs through the expression of emotion, social communication, and physiological regulation and their connection to human behaviour. From an evolutionary perspective, it is adaptive for the facial regulation and bodily regulation to be connected; a mammal would have a better chance of survival if it could detect if another mammal were in a physiological state of rage or if it was injured so that it could avoid it. This is adaptive for both those in proximity to the mammal in a defensive state so that they could safely keep away from it, and for the one in a defensive state to reduce the likelihood of attack or approach. For the one in proximity to the mammal in a defensive state, when its nervous system detects cues of threat or danger, it would physiologically activate a defensive state. By contrast, cues of safety, such as relaxed muscle tone, prosodic vocalizations, and friendly facial expressions would promote the up regulation of a ventral vagal state/ the activation of the social engagement system, indicating safety to approach.

The process described above is called ‘neuroception’; it is the subconscious process in which the nervous system scans the environment for cues of safety or threat to determine whether to activate or suppress the defence cascade (Porges, 2007). Neuroception is different than perception; it is an unconscious, non-cognitive process in which the nervous system scans the environment for cues to determine if it is safe (Porges, 2017). By contrast, perception implies a cognitive awareness and evaluation- it is a cognitive process in which a person weighs information that is available to them in their conscious awareness (Porges, 2017). Porges (2007) suggests that the temporal cortex will evaluate if biological movements and social interactions are safe. These biological movements include gestures, facial expressions, and vocalizations that communicate safety or a possible threat to survival (Flores & Porges, 2017; Porges, 2007).

Neuroception is facilitated by the connection between the brain and body. Through the connection in the brainstem of nerves from the head and the viscera, the expression of human emotion through vocalizations, muscle tone, and facial expression is directly connected to the physiological state of the body in the viscera (Porges, 2017). In his theory, Porges (2007) highlights the link between the striated muscles in the face and the smooth muscles of the viscera/gut. When the environment is perceived as safe through the process of neuroception, the body will enter a state of repair, growth, and healing. The myelinated vagal pathway will cause the heart rate to slow, will hinder the sympathetic fight-flight reactions, will reduce a survival-stress response that results in the release of cortisol through the HPA-axis, and will regulate immune reactions (Porges, 2007). Furthermore, he notes that the myelinated vagus nerve connects the heart and lungs in a bidirectional relationship to the muscles that regulate the upper portion of the face, facial expressions, the vocal tone, the mid-ear/ hearing, and sight through the nuclei in the brainstem. The brainstem has a critical role in regulating homeostatic states, physiological process, and behavioural regulation (Porges, 2017).

Felt Safety: Ventral Vagal States. Polyvagal Theory outlines three arousal states that can be observed within the nervous system (Porges, 2007). These states are activated in a hierarchal order and in an involuntary way to ensure survival and to respond to threat. The most complex and evolved state is the ventral vagal state which is dependent on the myelinated vagus. The ventral vagal response is characterized by the dominance of the cortex in moderating social engagement behaviours and social communication. The neural pathways of the social engagement system that are activated in supportive social interactions are the same pathways that support healing, restoration, and growth (Porges, 2017). Healing necessitates a physiological state of safety (a ventral vagal state) that is activated through cues of safety and subsequently, the deactivation of defensive states that absorb metabolic resources for defence and survival (Porges, 2017).

Sympathetic Nervous System Activation and the Survival-Stress Response. The first response that is activated by the hypothalamus is the sympathetic nervous system which then activates the adrenal glands to release epinephrine and norepinephrine that initiate the fight-flight response. Oxygen is then directed to the muscles for rapid movement and breathing and heart rate increase. The second response is the release of corticotropin-releasing hormone (CRH). CRH activates the pituitary gland that releases adrenocortico-tropic hormone (ACTH), causing the adrenal glands to release hydrocortisone (cortisol). After the event, cortisol will help the body to return to homeostasis by inhibiting the defensive reaction and the release of epinephrine and norepinephrine. This is called the HPA axis. Research has found that some people with PTSD compared to controls have lower levels of cortisol; this means on a biological level that the body did not receive the message that the traumatic incident ended, vis-à-vis cortisol dampening the defensive reaction (Rothschild, 2000).

Opioids have a direct effect on the HPA axis and the down regulation of survival-stress responses (Danovitch, 2016). Opioids reduce the amount of ACTH that is released in the HPA axis, they inhibit the release of CRH, and reduce activity in the locus coeruleus and its release of norepinephrine during the survival-stress response. The brain also has opioid receptors in areas of the brain that are implicated in the survival-stress response. These include: the hypothalamus, anterior pituitary gland, amygdala, and the prefrontal cortex. During a survival-stress response, the body will naturally release endogenous opioids; if opioids are blocked with opioid antagonists, more stress hormones will be released.

Dorsal Vagal Complex. Last is the evolutionarily ancient dorsal vagal circuit of the unmyelinated vagus. A dorsal vagal state is characterized by immobilization, dissociation, collapse, and a feign death response (Flores & Porges, 2017; Porges, 2007). Further, Porges

(2007) suggests that people respond to threat in the same evolutionary, phylogenic order that the nervous system developed. In short, the human social engagement system and capacity for higher-level reasoning and planning will shut off in the face of a serious threat that cannot be addressed through social engagement. The fight-flight-freeze response is then dominant. When it is neither possible to fight nor escape from the threat, a dorsal vagal response is engaged, in which a collapsed, feigning death response is engaged to 'play dead' and prepare the body to dissociate from the experience of attack. This immobilization response through the dorsal vagal pathway is characterized by dissociation, immobilization, and a significant down regulation of autonomic activity (Porges, 2017). Through the process of evolution, the nervous system evolved to quickly transition between sympathetic arousal and the social engagement system; the nervous system, however, did not evolve to have a quick transition between dorsal vagal states and mobilized sympathetic states or ventral vagal states (Porges, 2017). The human body and nervous system do not have a quick pathway to transition out of a dorsal vagal state, resulting in chronic states of hypo-arousal (Porges, 2017). Different variations of hypo-states will be discussed below. Each passive defence response has distinct physiological processes that occur, which can be adaptive when it is not possible to fight or flee.

Attachment Theory

Attachment theory was originally developed by John Bowlby, and has been further developed by Mary Ainsworth, Mary Main, Patricia Crittenden, and Peter Fonagy. The attachment system is an inborn system within the brain that motivates the infant to interact and remain close to their caregivers (Siegel, 2012). As infants are entirely reliant on their caregivers for survival, the establishing attachment bonds and proximity to their caregivers increases their chances of survival and allows the child to draw upon the developed nervous system of the caregiver through attachment-based processes that synchronize the caregiver's and infant's nervous systems (Kyte et al., 2020; Seigel, 2012). Attachment processes provide the blueprint early in life for the way people learn to understand themselves, relationships, and other people; in other words, attachment relationships shape a person's internal working model (Seigel, 2012).

Attachment relationships may be organized or disorganized (Fisher, 2017a). That is, the infant has an internal working model that suggests that the caregiver's response is predictable in some way (such as being available and secure, or unavailable and insecure). As a result, the infant/ child's behaviour will adapt accordingly. However, the caregiver is unpredictable, the infant may not have observable and predictable behaviours around the caregiver due to the lack of predictability of the responsiveness of the caregiver.

If the attachment relationship with the caregiver is secure, the infant will feel safe enough to explore their environment and will return to the caregiver for comfort when in distress (Seigel, 2012). The caregiver provides a safe haven of comfort for the infant when they are in distress; they act as a secure base from which the infant can explore; and they provide safety and protection for the child (Ainsworth, 1989). This allows the child to separate from the caregiver in a healthy way, to mature, and yet still remain emotionally and psychologically connected (Seigel, 2012). Attachment bonds develop through emotional attunement between the caregiver and infant (Ainsworth, 1989; Schore & Schore, 2008). However, if the relationship is insecure as a result of misattunement, missed (or misinterpreted) cues from the infant, or frightening exchanges between the caregiver and infant, the infant may develop an insecure inner working model of the caregiver (Siegel, 2012). This may result in disrupted development of exploratory behaviours that require the infant to an internal working model of a secure base (Seigel, 2012).

Attachment processes are foundational in the development of the right brain and the neurological networks that process emotions, regulate stress, support self-regulation, and lay the foundation for the implicit self/ internal working models of the self and others (Schore & Schore, 2008). Attachment processes also play an important role in the neurobiological foundations of the social engagement system through which people interpret and understand social cues (Schore & Schore, 2008). Secure attachment primes the child to have a regulated nervous system, which is able to respond in a flexible way to distress and maintain access to the cortical structures that are required for learning, social engagement, and higher order cognitive processes are engaged (Porges, 2017; Schore & Schore, 2008). Conversely, insecure attachment primes the nervous system to be reactive to stress in order to maintain attachment to the caregiver, which is necessarily for the infant's survival; either they will learn to ramp up attachment behaviours in the face of threat and stress, to engage avoidance strategies, or both of these responses may collapse (Schindler et al., 2009; Schore & Schore, 2008).

Statement of Positionality

I will first position myself relative to the research explored in this review. I am currently working in a substance use recovery program in the DTES with individual women and mothers with infants who are in early recovery. Prior to working in the DTES, I worked with survivors of trafficking and exploitation, supporting them to access wraparound care and recover from the effects of control and exploitation. During this time, I have worked with hundreds of people who are doing their best to cope and to establish a meaningful life beyond addiction and exploitation. However, due to the severity of abuse, traumatic experiences, and marginalization, I witnessed many of the people I worked with use very self-destructive means to cope with the severe states of hyper/hypo-arousal and symptoms of PTSD. Many experienced intolerable emotional states, nightmares, flashbacks, near-constant fear and dread, intrusive memories and imagery, and profound feelings of hopelessness, grief, and disconnection, despite having accessed multiple recovery programs. Sadly, many of the people who presented with hypo-responses did not receive the help that they needed, as this can be a challenging issue to treat, even for experienced practitioners (Brantbjerg, 2021). Furthermore, few accessible resources provided care specific to trauma; most of the people that I worked with were never able to receive care specific to trauma recovery, which many had identified was at the root cause of their substance use. This in part was due to issues of accessibility, such as cost, location, or waitlists.

I also want to humbly acknowledge that I am an uninvited settler; I live and work on the traditional lands of the Musqueam, Squamish, and Tsleil-Waututh First Nations. I do not live in the DTES, nor do I have lived experience of trauma, addictions, or poverty. Much of the learning that I have received has been from the opportunity to work with colleagues and the communities I serve, and other people in my personal life. I am continually learning from them, am grateful for the privilege to be invited into sensitive parts of their story and am humbled and amazed by their resilience.

Contribution to the Field

One of the most accessible intensive forms of support for people who do not have an income or insurance to pay for other supports is addiction recovery programs since funding is available through the BC Ministry of Social Development and Poverty Reduction. Since recovery programs are one of the most available and intensive supports and is often a steppingstone out of homelessness for people living in the DTES and communities with low income, my aim in writing this review is to provide a conceptual understanding of opioid use disorder that gives context to the functional use of opioids. Understanding more about how opioids interact with the body's survival and social attachment systems, which have profound roles in organizing the human experience, can inform therapeutic interventions used in substance use recovery programs. I also wish to provide practical tools for practitioners, including counsellors and mental health workers, to understand the intersection of opioid use and trauma, and to be able to recognize hypo-arousal/ hypo-responses in the people they are working with and to have practical ways to support them to self-regulate.

Additionally, the medical model has been the dominant way of understanding addictions throughout the past 60 years (Alexander, 2008). As a result, addictions treatment programs have developed their interventions by focusing on the symptoms of addiction as the primary issues requiring intervention, rather than the underlying causes (White, 2008). Unfortunately, this approach has had limited success since the role of addiction and its etiology is far more complex than symptom alleviation (Sheedy & Whitter, 2013). A deeper understanding of the underlying reasons for an addiction is required to develop more strategic, focused, and effective interventions. Understanding the ecology of a person's life, including their social environment, is critical for supporting sustained recovery from addictions (Morgan, 2019). As such, this review will look at how opioid use disorder is used for the self-regulation of the attachment system and of nervous system dysregulation.

Definition of Terms

Addiction

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM 5) does not include a diagnosis for addiction but outlines criteria for various substance use disorders. It describes a "pathological pattern of behaviour" related to the substance (American Psychiatric Association [APA], 2013, p. 483). The diagnostic criterion of the DSM is utilized throughout this paper as the primary definition of addiction for specificity and consistency with other research literature. This includes a loss of control over the use/ consumption of the substance, taking it in larger amounts over time; an intensive amount of time acquiring, using, or recovering from the effects of the substance; in severe cases, nearly all of the daily activities of the person revolving around their substance use; and an intense craving and desire for the substance; social impairment as a result of the substance use; use of the substance that may be physically hazardous or dangerous to the individual; and tolerance and withdrawal to the substance (APA, 2013). Addiction may be observed in a three-phase cycle (Koob & Volkow, 2016). The first phase involves a person using and binging a substance, followed by the second phase of withdrawal and negative affect, and in the third phase the person has a preoccupation with and craving for the substance. The cycle is repetitive and progressive.

Attachment (Patterns)

The patterns of how a person forms social connections and bonds with others throughout life. These patterns develop through the exchanges between an infant/child with a caregiver, which form the internal working models for how a person implicitly understands their identity and for how they engage in relationships later in life.

Autonomic Nervous System

(See definition under peripheral nervous system).

Central Nervous System

The part of the nervous system that includes the brain and spinal cord.

Defence Cascade

The term, ‘defence cascade’ was first coined by Lang et al. (1997). It refers to the activation of defensive and survival responses that are automatically elicited by the autonomic nervous system to promote survival. When a threat is detected, the first step is an orienting response, in which attention is directed to the perceived threat (Lang et al., 1997; Ogden & Fisher, 2017). This is accompanied by a mobilization of arousal through the sympathetic nervous system, followed by a significant down-regulation of arousal when it is not possible to fight or flee (Kozlowska et al., 2014).

Dissociation

Trauma-related alterations in consciousness that impact a person's subjective experience (Lanius, 2015); a person's sense of disconnection from their emotions, thoughts, body/ bodily sensations, memories, identity, or sense of connection to the present moment; alterations to the subjective experience of time, thought, the body, and emotion; broader definitions include flow states and absorption with a task.

Hyperarousal State

Hyperarousal are bio-behavioural responses that are mediated by activation of the sympathetic nervous system (Corrigan et al., 2010; Fisher, 2017b; Rothschild, 2017). Physiological signs of sympathetic activation may include tense muscles, increased heart rate, the release of adrenaline and cortisol, visual acuity, sweating. Behavioural signs may include pacing, posturing, self-destructive and self-harming behaviours, outbursts of aggression, and compulsive behaviours. Cognitive/ mental symptoms such as racing and intrusive thoughts/imagery, rigid thinking, flashbacks, nightmares, anxiety, and hypervigilance. Emotional symptoms may present as anger, rage, dread, and panic. Moreover, when there is chronic activation of the survival-stress response, the functioning of the autonomic, immune, and endocrine systems will be disrupted; as a result, people who experience chronic stress will have an increased vulnerability to mental and physical pathology and disorders (Porges, 2017).

Hypo-arousal State

Hypo-arousal is an arousal state of the autonomic nervous system and a bio-behavioural response, characterized by low overall arousal and mediated by the parasympathetic nervous system/ greater dorsal vagal tone (Brantbjerg, 2021; Porges, 2017). Some physiological symptoms are decreased heartrate/ bradycardia, decreased blood flow, shallow and slowed breathing, flaccidity in muscles and loss of muscle tone, the release of endogenous opiates, restricted pupils, drooping eyelids/ closed eyes, loss of energy, reduced visual clarity, and cold sweats. Behavioural symptoms might include slumped posture, withdrawal, substance use, slowed movements, and lack of social engagement. Cognitive/ mental symptoms can include depersonalization, dissociation or dissociative states, self-loathing, dysthymia, inability to think clearly, forgetfulness, depressive cognitions; and emotional symptoms such as feelings of worthlessness, apathy, excessive guilt, shame, depression, sadness, hopelessness, helplessness, or flat affect.

Opioids

Opioids include the body's naturally occurring endogenous opioids and exogenous substances that bind to the opioid receptors, such as fentanyl, diacetylmorphine (heroin), morphine, hydromorphone, codeine, and oxycodone.

Endogenous Opioids. The body has naturally occurring endogenous opioids with receptors throughout the body, largely in the central nervous system and gastrointestinal tract (Lanius, 2014). Endogenous opioids include enkephalins, dynorphins, and endorphins, which are neuropeptides that act at opioid receptors (Lanius 2014; McLaughlin & Zagon, 2013; Zagon & McLaughlin, 2017). Endogenous opioids are part of the pain management system in the body and are involved in learning to prevent future harm (Christie, 2021). As part of these two processes, endogenous opioids reduce physical and emotional pain, are released in the survival-stress response/ defence cascade, and in the experience of negative emotion or dysphoria after loss or rejection (Christie, 2021).

'Endorphins' is now a general term used to refer to multiple peptides with different functions including pain reduction and analgesia, euphoria, and have effects on respiration, immune and cardiovascular functions, and higher-order emotional and neurological systems, including attachment (Kyte et al., 2020; McLaughlin & Zagon, 2013; Zagon & McLaughlin, 2017). As part of the body's survival-stress response system, endogenous opioids are released to help cope with a variety of pain-related events, such as pain or anticipating pain, childbirth, social rejection/ conflict, and starvation (Lanius, 2014). The μ-opioids are of particular importance due to their role in the attachment system (Pellissier et al., 2018).

The long-term use of exogenous opioids can down regulate the mu-opioid system, which can disrupt the formation of social relationships and natural rewards (Christie, 2021). However, there is diversity and complexity in the endogenous opioid system; long-term use can also upregulate kappa-opioids, which is associated with maintaining problematic patterns of substance use through stress-related symptoms (Christie, 2021). Enkephalins are also involved in managing pain, social reward, and patterns of addiction (Christie, 2021). Dynorphins reduce movement, negative emotion, and long-lasting pain (Christie, 2021).

Exogenous Opioids are opioids that are not natural to the body and that are administered. This includes common substances, such as prescription opioids or other illicit opioid drugs.

Parasympathetic Nervous System

A branch of the autonomic nervous system, which is part of the peripheral nervous system that is responsible for a variety of involuntary physiological functions including cardiovascular functions, digestion, relaxation, and repair within the body.

Peripheral Nervous System

The part of the nervous system that connects the rest of the body and the central nervous system (the brain and spinal cord).

Somatic Nervous System. This is a branch of the peripheral nervous system that controls voluntary movement and sensory input from the skin, joints, and muscles.

Autonomic Nervous System. This is a branch of the peripheral nervous system that has two subdivisions: the parasympathetic nervous system and the sympathetic nervous system. It controls involuntary, automatic physiological functions, including cardiovascular functions, respiration, and digestion.

Regulation (Nervous system regulation)

Regulation is a broad term that refers to the modulation and capacity of the body to maintain stability and balance within the autonomic nervous system in response to external and internal cues; to remain within or return to high ventral vagal tone/ the window of tolerance; the modulation of activity in the autonomic nervous system so that the amount of arousal is neither too high nor too low but is within a range that feels tolerable and comfortable; a complex interplay between the sympathetic and parasympathetic nervous systems to maintain homeostatic and an array bodily functions; balanced and moderate oscillations between activation of the sympathetic and parasympathetic nervous systems.

Reward

Positive events, outcomes or experiences that promote, motivate and reinforce the repetition of certain behaviours.

Self-regulation

The capacity of an individual to maintain stability and balance within their nervous system

Sympathetic Nervous System

A branch of the autonomic nervous system, which is part of the peripheral nervous system that upregulates arousal within the body and modulates a variety of physiological functions, including the activation of the survival-stress response (fight-flight response).

Trauma

Trauma is an event within the nervous system that overwhelms a person's capacity to cope with an event or experience; the ongoing response to an event or events that resulted in chronic nervous system dysregulation; the somatic, emotional, psychological, and social *impacts* of one or multiple events; the chronic changes to the nervous system and other body systems that occurred in response to an event, rather than an event itself; something that results in chronic states of people living outside of the window of tolerance.

Window of Tolerance

The window of tolerance, by contrast to states of hyperarousal and hypo-arousal, can be characterized by ventral vagal engagement (Corrigan et al., 2010; Fisher, 2017; Rothschild, 2017). Physiological symptoms might include relaxed or engaged muscles, eyes and mouth are moist, eyelids toned or relaxed, blood pressure is in a normal range, digestion and immune functions are occurring normally, and repair in the body can occur. Behavioural presentations might include social engagement, compassionate actions and altruism, and prosocial behaviours.

Cognitive/ mental presentations might include the ability to plan, higher-level reasoning, moral reasoning, and innovative/ creative thinking. Emotional signs might include feelings of compassion, connection, empathy, excitement, enthusiasm, joy, calm, and other affect experienced as pleasant, tolerable or enjoyable.

Outline of the Capstone Project Chapters

Addiction does not happen in isolation, nor can it be properly treated without understanding the context in which it developed. Due to the severity of the opioid overdose epidemic in British Columbia, this paper will review research related to opioid use disorder. Chapter two will explore how interpersonal experiences of relationships and traumatic experiences impact neural systems in the brain that are related to addiction and how this impacts the formation and maintenance of opioid addiction. Specifically, research related to the attachment system, self-regulation systems and processes, and the survival-stress response system interact and how they intersect with opioid use disorder. Additionally, research literature is reviewed to explore how opioid addiction may be used as an attachment substitute, specifically in light of the brain opioid theory of social attachment (BOTSA). Chapter three will then discuss the research findings and offer practical recommendations for practitioners and recovery programs to better support people within recovery from opioid use disorder in light of dislocation theory, attachment theory, and polyvagal theory.

Chapter 2: Literature Review

This paper will review the literature on how interpersonal neurobiology interfaces with opioid addiction. Dislocation theory eloquently outlines how macro changes in the global political structures and free market economic changes have resulted in the experience of dislocation and a lack of belonging at an individual level. The science of interpersonal neurobiology and other relevant neurobiological processes associated with addiction provides a framework to understand how the concept of dislocation is integrated into or within a person and produces addiction. While every person grappling with addiction has a unique constellation of experiences that have led toward substance use, some common neurobiological processes can provide the scaffolding to understand the experience of addiction more generally.

First, I will provide a broad overview of the various neural systems involved in addiction and elaborate on them in greater detail throughout this paper. Next, I will provide an overview of three models that aim to explain the relationship between PTSD and opioid use before moving into a more comprehensive review of the defence cascade/ survival-stress response that becomes activated during a traumatic experience and then for those living with chronic nervous system dysregulation resulting from trauma. Finally, conceptualizing addiction and recovery through dislocation theory and attachment theory, I will review the literature on the role of the attachment system and attachment processes that influence the development of PTSD or nervous system dysregulation and opioid use disorder.

Overview of Neural Systems Implicated in Addiction

Understanding the neurobiological processes that organize the human experience when conceptualizing addiction is critical. While the human brain and nervous system are very complex, I will discuss several neural systems to briefly introduce some of the complex processes that help to organize the human experience and get interrupted by addiction or when people attempt to regulate through substance use. While neurobiology is not the complete picture of the etiology and progression of addiction, it provides insight into one of the moderating processes between many experiences, such as early neglect, abuse, violence, structural discrimination, and countless other adverse experiences that are correlated with substance use (Morgan, 2019).

The adaptability of the brain and these neural systems are designed to meet the complex, diverse, and varied needs of different environments in which people are immersed. The interlocking and interdependent relationship between nature and nurture shapes the brain and human experience, which the research calls interpersonal neurobiology (Morgan, 2019; Siegel, 2021). Interpersonal neurobiology is a large and multidisciplinary field of study that details how social interactions and the environment influence a person's internal experience and nervous system and vice versa (Siegel, 2021). Through interpersonal neurobiological processes, the social ecology of a person's life impacts their physical body, brain, and physiological systems. This change occurs through social attachment, neuroception, co-regulation, and the defence cascade (Schore, 2015; Porges, 2007). When the ecology of a person's life is supportive, responsive and safe, and they have access to all their basic and core needs, these neural systems will be healthy and have optimal functioning (Morgan, 2019). However, when the ecology of a person's life, including their social environment and access to resources to meet their basic physical and psychological needs are compromised, these neural systems will adapt to support survival rather than flourishing. These experiences of safety and responsiveness, or danger and lack, result in physical changes and adaptations in the brain to support the person to engage, survive or participate in their environment, whatever that may look like (Morgan, 2019).

In other words, the brain constantly changes through neuroplasticity through the interaction between the intrapersonal and interpersonal environment and the environment (Siegel, 2021). While change occurs across the lifespan, early attachment processes lay the foundation for other systems to adapt later in life (Schore, 2015). Through attachment processes, a caregiver can 'transmit' their blueprints of the world and self to the infant, which reflects safety and security or danger and lack. Although the most significant foundations are laid before a person is 25 years old when the brain fully matures, the brain is constantly creating new neuropathways through experiences, changes in the environment, the formation or extinction of habits, and interpersonal experiences (Morgan, 2019; Siegel, 2021). When considering the neurobiology of addiction, the most relevant neural systems include the reward and motivation system, the survival-stress response system, self-regulation circuits and processes, the social attachment system, and the pain response system (Morgan, 2019). These are briefly outlined below.

The Reward and Motivation System

The reward and motivation system is one of the most heavily researched and discussed neural systems in the literature on substance use and addiction. As such, this section will provide a brief overview of this critical system but will not elaborate further in this paper due to the breadth of existing literature on the role of the rewards system and addiction. The reward system is involved in the 'wanting' aspect of addiction, in which the brain reinforces behaviours relevant to survival through the release of dopamine (Morgan, 2019).

The reward system relies on the mesocorticolimbic dopamine system (MDS), which has projections between cortical regions of the brain and the limbic system and is implicated in the use of almost all drugs involved in problematic substance use (Koob & Volkow, 2016). In optimal functioning, the reward and motivation system reinforces survival-relevant behaviours through chemical signals- primarily dopamine (Koob & Volkow, 2016). However, psychoactive drugs involved in patterns of problematic substance use, such as heroin or fentanyl, trigger a very significant and unnaturally large release of dopamine in the reward system compared to other survival-relevant behaviours and naturally rewarding behaviours such as eating, social interaction, and sex (Koob & Volkow, 2016). While naturally rewarding activities still cause a release of dopamine and activation of the reward and motivation system, on a neurological level, are less 'important' or salient compared to other drugs, based on the flood of dopamine released through the psychoactive drug (Morgan, 2019).

However, over time the brain becomes more efficient in metabolizing the excess dopamine in the brain and other psychoactive components, such as exogenous opioids. As a result, the person builds a tolerance to the substance, and other survival-relevant behaviours such as eating and social interaction become less rewarding; that is, they have less of a hedonic reward since the neural threshold for what is rewarding is increased (Koob & Volkow, 2016; Morgan, 2019). As a result of increased tolerance, natural rewards no longer produce adequate dopamine rewards, resulting in a preoccupation with that which will produce a satisfactory flood of dopamine (i.e. substance use), resulting in the disruption to the neural circuits that inhibit impulsive behaviour.

Stimulus-Response Learning and Operant Conditioning. Learning through association is also a core process of the reward and motivation system. If the goal of the brain's reward-motivation system is to engage the person in survival-relevant behaviours, it does this by associating specific behaviours with pleasurable outcomes- that is, through the reinforcement of a dopamine release.

Classical and operant conditioning are part of behavioural learning in which a person associates a cue (such as seeing a heroin pipe) with a particular outcome (a feeling of euphoria or relief from distress). When the person is exposed to the cue (seeing the pipe), the behavioural response is activated (using heroin), the reward system of the brain becomes fully engaged, and processes that manage impulses are down-regulated (Koob & Volkow, 2016; Morgan, 2019). Dopamine and corticosteroids (which are involved in the survival-stress response) are also involved in classical and operant conditioning; both cues that elicit activation in the nervous system during a survival-stress response and stimulus for drug use form through stimulus-response learning (Lopez & Flagel, 2021).

Operant conditioning, otherwise known as stimulus-response learning, involves different cognitive processes and brain structures than goal-oriented behaviours. Stimulus-response learning involves "bottom-up" processes that draw upon limbic structures, whereas goal-directed behaviour involves "top-down" processes involving the cortical and hippocampal regions (Koob & Volkow, 2016; Lopez & Flagel, 2021). Stimulus-response learning and operant conditioning are involved with the development of trauma-related 'triggers' and are a necessary process involved in the formation of addiction, outlined in the three-stage model of addiction (Koob & Volkow, 2016; Lopez & Flagel, 2021).

The three-stage model of addiction proposes three distinct stages that make up the cycle of addiction (Koob & Volkow, 2016). First is the binge-intoxication phase, in which someone uses a drug and experiences a sense of pleasure, euphoria, and the desired "high." Second is the withdrawal/ negative affect stage, in which a person experiences distressing emotions and physiological symptoms of withdrawal. Lastly, the preoccupation and fixation phase involves the person experiencing an intense desire and craving for the drug and devoting significant time and effort to acquiring it. In short, a person comes to 'learn' through operant conditioning that using opioids removes or reduces distressing feelings and sensations, making the behavioural cycle of substance use challenging to abstain from, as drugs become a self-regulation mechanism.

Due to the centrality of stimulus-response learning in the reward-motivation system and its involvement in addiction, addiction recovery and treatment rely heavily on behavioural modification interventions. Principles of behaviourism and cognitive-behavioural interventions certainly have a meaningful role in the treatment of problematic substance use since the reward-motivation system is foundational in the development and maintenance of addiction. Utilizing targeted interventions for the reward and motivation system through behavioural interventions is useful, strategic, and even necessary. However, other neural systems impacted by addiction will be discussed below and further elaborated on throughout this paper. When considering interventions for addiction recovery, a holistic and balanced approach would consider multiple neural system interventions (Morgan, 2021; van der Kolk, 2014).

The Survival-Stress Response System

The survival-survival-stress response system and the corresponding defence cascade will be outlined in subsequent sections. The primary purpose of the survival-stress response system is to maintain safety through various biological responses. As previously noted, when the hypothalamic-pituitary-adrenal axis (HPA axis) excites the sympathetic nervous system, it mobilizes a person to fight or flee when faced with a threat (Porges, 2007; Rothschild, 2000). When it is impossible to fight back or escape, a parasympathetically-moderated down-regulation of the nervous system occurs to feign death and prevent further harm (Porges, 2007; Rothschild, 2000).

The survival-stress response, while adaptive when faced with acute danger, can become chronically or easily activated due to traumatic exposure, chronic stressors, and disrupted attachment patterns (Corrigan et al., 2010; Fisher, 2017a). When someone experiences chronic dysregulation of the nervous system, they may try to reduce activation when they experience chronic hyperarousal through substance use or other coping mechanisms that may result in harm (Corrigan et al., 2010).

Self-Regulation Circuits and Processes

Since the primary goal of the stress system and defence cascade is to ensure survival through nervous system dysregulation and survival responses, then on a subconscious and physiological level, people's primary goal is to achieve regulation (Morgan, 2019). Regulating the nervous system through self-regulation or co-regulation keeps the nervous system within the tolerable range of experience (Corrigan et al., 2010). The self-regulation circuits are inextricably linked with the survival-stress response and social attachment system. These processes will be outlined in greater detail throughout this paper.

In summary, attachment processes in utero, throughout infancy and childhood, shape the brain's right hemisphere, which develops earlier than the left hemisphere and is involved in emotion processing and social cognition (Schore, 2015). The capacity for affect regulation first develops through a secure relationship with a caregiver, which instills a sense of security and safety. Later when the brain develops further and there is a connection between the right and left hemispheres, the person learns to self-regulate emotional states.

The quality of the relationship with the caregiver and their capacity for attunement with the infant/child can have a lifelong influence on the child's capacity to regulate their emotions. In addition, non-verbal communication (such as facial expressions and coordination of movements), para-verbal communication (such as prosody and tone), and accurate reflection and identification of affective states are also involved in the quality of the relationship; that is, how well the caregiver can coordinate and attune their response to that of the child and to support them to regulate their affective states.

When the caregiver is responsive and attuned, the child's system is primed to anticipate safety, to quickly or more easily regulate distress (as they have been given a model of the world as a safe place through the interaction with their caregiver), and is primed for social interaction and secure relationships throughout the lifespan (Schore, 2015). However, in experiences of neglect, abuse, misattunement, or unresponsive caregiving, the infant misses the first step in regulating affect through a secure relationship with the caregiver. Additionally, the right hemisphere develops so that the survival-stress response/ HPA axis is quickly activated (as they have received an inner working model of the world and people as unsafe/ unresponsive). This paradigm can leave a person more vulnerable to other mental health challenges and addiction later in life, as they may seek to regulate the affective and nervous system states through other means when the capacity for self-regulation (and co-regulation) was not fully developed in infancy.

The Social Attachment System

As discussed in the section on self-regulation processes and circuits, attachment relationships with caregivers are foundational in establishing a person's capacity to self-regulate their nervous system and the reactivity of their survival-stress response (Fisher, 2017a; Schore, 2015). The attachment system and its relationship with the endogenous opioid system will be discussed in greater detail throughout this paper. In short, the attachment system is the innate system through which people build relationships, connections, and affiliations with other people

(Seigel, 2012). Beginning in infancy, when a caregiver is responsive and attuned to the infant, this attachment develops the blueprints for how the infant later understands themselves in an interpersonal context (Seigel, 2012).

Intricately intertwined with the social attachment system is a person's capacity for regulation of affect and the nervous system in infancy, the development of the window of tolerance, and later in life through processes of co-regulation (Corrigan et al., 2010; Fisher, 2017a; Porges, 2017). For example, when an infant experiences secure attachment, they are primed to expect trust, responsiveness, care, and safety in interpersonal relationships (Seigel, 2012). In contrast, when insecure attachment patterns are developed in infancy, the child later is primed to self-protect, be distrustful, or withdraw in relationships for the sake of self-preservation and safety. Disruption in early patterns of caregiver attachment can have significant implications for a person's ability to create secure relationships later in life, resulting in a further lack of connection (Ainsworth, 1989). However, as discussed within dislocation theory, being integrated into meaningful relationships and a social community is a core human need, and addiction is a logical response to the experience of dislocation and disconnection (Alexander, 2008).

The Pain System

The pain system will be discussed indirectly throughout this paper. First, it is essential to note that people may use opioids for relief from physical pain. Opioids are an analgesic and part of the body's natural pain relief system (Christie, 2021). It is important to note that the neural pathways for physical pain and social rejection overlap (Eisenberger et al., 2003). In fact, the brain experiences social rejection similarly to physical pain (Eisenberger et al., 2003; Pellissier et al., 2018). It is hypothesized that the neural pathways for physical pain and social attachment systems evolved to have overlapping pain pathways since social connection and attachment is critical to humans' survival in infancy and later in life (Loseth et al., 2014; Panksepp et al., 1994).

Additionally, endogenous opioids are hypothesized to be the vehicle through which social contact alleviates the distress of isolation, and that isolation (resulting in the deprivation of endogenous opioids) would stimulate attachment-seeking behaviours (Loseth et al., 2014). The endogenous opioid system has important implications in the pain system, as well as the attachment system. As previously noted, the attachment system and self-regulation processes overlap with the survival-stress response system. However, the specific role of pain in the formation and maintenance of addiction is beyond the scope of this paper.

All these systems that are involved in addiction have a complex interconnection. However, despite the complexity of these systems, notably when altered through exposure to trauma, danger, or insufficient environments, they share the common basis of becoming organized through secure, responsive relationships, and safety. The remainder of this paper will explore these addiction-related systems and how they are affected by trauma, social relationships, and opioid use.

The Interconnection of Opioid Dependence & Trauma

When supporting people with co-occurring PTSD and substance use disorders, it is helpful to understand the interconnection between both disorders to improve treatment outcomes (Dass-Brailsford & Myrick, 2010). The proposed models that attempt to explain the relationship between PTSD and substance use highlight the role of various neural systems discussed in the previous section, including the reward-motivation system, the survival-stress response/defence cascade, the social attachment system, and self-regulation processes. These related neural systems overlap and intersect in complex ways making an etiological understanding of opioid use disorder complicated to delineate.

Three specific models aim to explain the relationship between opioid use disorder and PTSD. Firstly, PTSD results in a distressing activation of the survival-stress response and chronic symptoms of hyperarousal; people may use opioids to regulate these symptoms. As such, symptoms of PTSD can increase the risk of developing an opioid use disorder, as people may be more likely to use opioids to self-regulate. Secondly, the neurochemical changes that occur during withdrawal from opioids and the increased exposure to dangerous or traumatic events via substance use and a high-risk lifestyle may increase the risk of developing PTSD (Dass-Brailsford & Myrick, 2010). Third, overlapping processes from the previous two models may contribute to the development of opioid use disorder. As a result, recovery becomes more difficult because these somatic cues may lower the threshold for relapse. The section below will outline these three models in greater detail that aim to explain the unique relationship between PTSD and opioid use disorder.

Opioid Susceptibility Model: The Self-Medication Hypothesis

The "Self-Medication Hypothesis" is predicated on the assumption that people living with PTSD and opioid use disorder first use opioids to reduce symptoms of the survival-stress response, which over time escalates into addiction (Danovitch, 2016; Dass-Brailsford & Myrick, 2010). Furthermore, opioids may have unique properties that are more reinforcing to people with PTSD symptoms compared to other drugs. Findings from multiple studies support this hypothesis and are based on three tenets, which include: that stress causes opioid use to be more reinforcing and can intensify the distress of withdrawal; that PTSD can amplify the development of opioid use disorder; and that there are overlapping somatic cues between opioid use and PTSD (Danovitch, 2016; Lopez & Flagel, 2021). These processes are described in depth below.

Amplification Opioid Use Disorder & Reward. PTSD and substance use disorders have overlapping pathways in the brain that can reinforce patterns of substance use (Dass-Brailsford & Myrick, 2010). The overlapping pathways in the brain involve both the reward and survival-stress response systems (i.e., the fight-flight response) (Dass-Brailsford & Myrick, 2010). Additionally, stress can make the effects of opioid use more reinforcing (Danovitch, 2016).

The limbic system is part of the overlapping neurocircuitry of the survival-stress response and the reward system. The limbic system includes the following areas: the amygdala (involved in fear and emotion), hippocampus (involved in memory), various hypothalamic nuclei (involved in maintaining homeostatic functions), the olfactory cortex (involved in smell), septal nuclei and nucleus accumbens (which are involved in reward and reinforcement), cingulate cortex (involved in emotion formation and memory processing), the basal ganglia (involved in reward learning and the cognition), the ventral tegmental area (involved in drug and natural reward systems) and the limbic midbrain (including the periaqueductal gray matter, which is involved in autonomic function, motivation, and behavioural responses to threat) (Moini et al., 2021). In short, the limbic system processes emotion and fear, the brain's reward-motivation system, which is the basis of the 'wanting' aspect of addiction, and the stress-response/ fight-flight response. It is heavily activated by the survival-stress response and reward/ addiction processes involving stimulus-response learning (Lopez & Flagel, 2021).

Researchers have also suggested that PTSD might prime the reward pathways in the mid-brain/ limbic system (Lopez & Flagel, 2021; Piazza & Le Moal, 1997). This process happens with the release of stress hormones (glucocorticoids) during the survival-stress response in PTSD. There are glucocorticoid receptors in the nucleus accumbens and mesencephalic dopaminergic neurons; these pathways are involved in the dopamine reward system, which is implicated in the development of addiction (Danovitch, 2016; Lopez & Flagel, 2021). As stress increases, more corticosteroids and dopamine are released, making these pathways more sensitive to the reinforcing effects of substance use (Lopez & Flagel, 2021). The glucocorticoids also regulate endogenous opioids in these areas, and there are mu-opioid (endogenous opioids) receptors in these pathways. (Danovitch, 2016). Both beta-endorphin and adrenocorticotropic hormone (ACTH) are released together, and ACTH will then stimulate the release of glucocorticoids (Lanius, 2014). As a result, these reward pathways are more sensitive to exogenous opioids, and interestingly, the same sensitization does not occur with stimulants (Danovitch, 2016; Piazza & Le Moal, 1997). Simply put, the survival-stress response causes a release of hormones that sensitize the brain's reward center in the mid-brain/ limbic system to be more sensitive to exogenous opioids and susceptible to opioid dependence, even in comparison to other drugs.

In relation to the three-phase model of addiction, the basal ganglia is implicated in the first binge-intoxication stage, followed by the amygdala in the withdrawal and negative affect stage, and then the prefrontal cortex during the third phase of preoccupation and craving (Koob & Volkow, 2016). The limbic system is involved in both reward systems involved in addiction and during traumatic activation (Fisher, 2017a; Koob & Volkow, 2016). Early life stress or trauma can change how dopamine and glucocorticoids are expressed in the brain, increasing the propensity towards dopamine-contingent stimulus-response learning. The significance of this is that early life stress/ trauma or chronic stress later in life can increase "bottom-up" learning or what might be colloquially called an "addictive personality."

Similarly, there are overlapping neurocircuitry/ neurochemical circuits between opioid use disorder and PTSD that are interlocking and mutually reinforcing (Upadhyay et al., 2022). Opioid use disorder and PTSD overlap through the loss of executive function and cortical modulation of lower brain regions. Essentially, there is a loss of top-down control from negative affect arising from traumatic activation in PTSD or negative affect that is associated with opioid use in which the person is less able to regulate impulsivity and cravings.

Overlapping Somatic Cues of Hyperarousal. PTSD may worsen the symptoms of withdrawal from opioids, as people will often experience an intensification of rebounding high arousal symptoms when they withdraw from opioids (Danovitch, 2016; Koob & Volkow, 2016). Since PTSD also results in hyperarousal, the symptoms of hyperarousal and withdrawal may exacerbate the desire to use via negative reinforcement (Dass-Brailsford & Myrick, 2010). In other words, using opioids is rewarding as it reduces the anxiety-like symptoms and high arousal states associated with PTSD and withdrawal. When a person withdraws from opioids, their nervous system will experience a rebound from the opioid-induced low-arousal state to a high arousal state, mimicking feelings of anxiety and the survival-stress response. However, PTSD symptoms may intensify these feelings during withdrawal, making opioid use more desirable and rewarding (Danovitch, 2016; Lopez & Flagel, 2021). The extended periods of hyperarousal and anxiety-like symptoms during withdrawal may also contribute to feelings of malaise and boredom when a person is not using the substance (Koob & Volkow, 2016). Additionally, a person may use substances to reduce re-experiencing symptoms, such as nightmares, flashbacks, or intrusive thoughts and memories (Dass-Brailsford & Myrick, 2010).

Somatic cues may trigger someone to use opioids during periods of abstinence (Danovitch, 2016). As noted, opioid withdrawal is also characterized by hyperarousal symptoms. Since withdrawal symptoms contribute to drug-seeking and are a form of negative reinforcement, symptoms of hyperarousal in PTSD may also be a stimulus to use. In other words, nervous system dysregulation from trauma may mimic opioid withdrawal symptoms and vice versa; both dysregulation and withdrawal symptoms in opioid addiction become paired with opioid use through negative reinforcement/ the desire to remove unpleasant symptoms. As such, opioid use becomes a method of self-regulation to avoid trauma responses and withdrawal symptoms, both of which can be a potent stimulus for opioid use.

Attachment and Self-Medication. Attachment theory has been understood as a theory of regulation (Schore & Schore, 2007). Therefore, if addiction can be understood as an attempt to self-regulate, then addiction-related disorders can be hypothesized as attachment disorders (Flores & Mahon, 1993). In other words, addiction is used to self-regulate emotional dysregulation resulting from insecure attachment patterns (Thorberg & Lyvers, 2010). Cross-sectional research with people using substances has supported this hypothesis; participants in substance use recovery programs had higher levels of insecure attachment, scored lower on their capacity for mood regulation abilities, and reported higher fear of intimacy than the general population (Thorberg & Lyvers, 2010). The interconnection between attachment and opioid use will be discussed more thoroughly in subsequent sections.

PTSD Susceptibility

An alternative hypothesis suggests that using opioids may increase a person's risk of developing PTSD (Danovitch, 2016; Dass-Brailsford & Myrick, 2010). This may occur through exposure to traumatic events or incidents and increased exposure to violence or accidents among people using opioids. For example, in the context of Vancouver's Downtown Eastside, someone may not be able to maintain stable work and housing due to patterns of addiction and opioid use, resulting in homelessness and increased exposure to violence and danger; someone may need to engage in the survival sex trade, gang involvement, or illicit activity to acquire money to procure drugs; or they may have increased exposure to violence and harm while under the influence of opioids.

Additionally, endogenous opioids are released naturally in a survival-stress response to provide an analgesic effect and promote a sense of well-being. However, using exogenous opioids will down-regulate the body's naturally occurring endogenous opioids. As a result, there can be an increased risk of developing PTSD since the body's natural survival-stress response may be disrupted by using exogenous opioids. Therefore, PTSD susceptibility can occur because using exogenous opioids suppresses glucocorticoid release, an essential part of the survival-stress response (Danovitch, 2016).

After a stressful event, cortisol (a type of glucocorticoid) will help the body to return to homeostasis by inhibiting the defensive reaction and the release of epinephrine and norepinephrine (NE) (Tsigos et al., 2020). Research has found that some people that develop PTSD compared to controls have lower levels of cortisol; the reason for this is because, on a biological level, the body is not receiving the chemical signal that the traumatic incident ended, vis-à-vis cortisol dampening the defensive reaction (Rothschild, 2017). As such, using exogenous opioids can increase the susceptibility to developing PTSD by impairing the body's natural survival-stress response, and in a sense, inhibiting the hormone that signals to the body that the traumatic event has ended. Chronic exogenous opioid use may result in low levels of glucocorticoids and high levels of CRF and NE circulating, which contribute to the development of PTSD symptoms; in essence, CRF and NE are contributing to the upregulation of arousal in the nervous system without the cortisol to signal for the survival-stress response to end (Danvoich, 2016; Tsigos et al., 2020). Furthermore, the oscillation between use and withdrawal when someone is using opioids in active addiction will simulate symptoms of the survival-stress response that is characteristic of PSTD, which further sensitizes the stress system (Danovitch, 2016).

Common Factors Hypothesis

The Common Factors Hypothesis suggests that a confluence of elements from the previous two models contributes to the development and intensification of PTSD and opioid use disorder and that both disorders share common factors, such as difficulty with emotion regulation (Danovitch, 2016; Upadhyay et al., 2022). This model suggests genetic factors may also increase the likelihood of developing PTSD and opioid use disorder (Danovitch, 2016). In support of this model, Wolf et al. (2010) found that heritable components accounted for approximately 40% of the variance in internalizing/ affective components of PTSD (such as depression/ anxiety) and 58% of the variance in externalizing behaviours (such as substance use) in a twin study. An alternative explanation for these findings is that nervous system dysregulation (as seen in anxiety and depressive disorders) can be ‘transmitted’ through attachment processes between a caregiver and an infant (Corrigan et al., 2010). Similarly, psychological traits, such as emotion dysregulation, a lack of distress tolerance, and challenges with impulse control, may increase susceptibility to developing PTSD and opioid use disorder (Danovitch, 2016). Rather than suggesting that opioid use disorder is heritable directly, other moderating factors, such as attachment processes/ patterns interpersonal neurobiology, might be ‘the common factor’ between the likelihood of developing PTSD and opioid use disorder.

Early environments may also contribute to the development of PTSD and opioid use disorder through exposure to a traumatic environment, substance use, or a lack of caregiver support (Danovitch, 2016; Fisher, 2017b; Koob & Volkow, 2016). The environment may also influence the expression of these genes through epigenetics and alter the functioning of the neuroendocrine system. Endogenous opioids, norepinephrine and oxytocin, are all part of the natural attachment system, in which the brain releases these neurotransmitters to reinforce the caring of a mother to the child (Inagaki et al., 2016; Maté, 2010; Nelson & Panksepp, 1998). Disruptions to attachment patterns early in life due to an unavailable, inconsistent, or frightening caregiver can change the endogenous opioid system (Kyte et al., 2020).

These models that aim to explain the relationship between opioid use and PTSD are a helpful framework for understanding the interconnection of these complex disorders. The following section will review the literature on the body's survival-stress response and defence cascade. The survival-stress response is a cascade of bio-behavioural responses to actual or perceived danger and threat, which intersects with the risk of developing addiction and cycles of addiction. Additionally, there is much research from different fields of study, including medicine, psychotherapy, and various subfields of biology that use different terminology to describe a variety of survival responses. These responses graft well onto the overarching states described in polyvagal theory; that is, the dominance of the ventral vagus in regulated states, the dominance of the sympathetic nervous system that moderates responses with high arousal (such as fight or flight responses), and the dorsal vagus that moderates hypo-responses. Each of the different responses in the defence cascade described below adds nuance to these three states described in polyvagal theory. Research on the survival-stress response/defence cascade will be reviewed first, followed by research on the endogenous opioid system/ attachment system.

Subsequent sections will discuss the complex interaction between the social attachment system, self-regulation processes and the survival-stress response system.

The Survival-Stress Response and Defence Cascade

To ensure survival, humans and animals have natural, biological defence systems that are activated. These are intimately intertwined with all social interaction, are subconscious, and involuntary. From an attachment perspective, the early experiences with a caregiver will prime the blueprints (inner working model) of how a person's understanding of themselves in an interpersonal context and will shape the patterns of interpersonal interactions (Fishbane, 2019; Schore, 2015). These early attachment experiences also shape how reactive the nervous system is to threats and stimuli; in other words, attachment experiences prime people to either have a wide window of tolerance (a greater capacity to remain in a ventral vagal state) through experiences of responsiveness and safety with a caregiver or to have a narrow window of tolerance and to have a quick activation of their defence cascade (Corrigan et al., 2010). From infancy, interpersonal neurobiology has an essential role in determining if the environment is safe and if needs will be met through the responsiveness of a caregiver and then later in life through neuroception and co-regulation (Porges, 2017). This has potent implications for recovery programs, as practitioners working with clients can provide corrective experiences of safety, co-regulation, support, responsiveness, attunement, availability, and acceptance (Corrigan et al., 2010).

From the perspective of Dislocation Theory, addiction occurs and in fact, is a logical response to disconnection from a sense of purpose and identity and disconnection from other people and the community (Alexander, 2008). While changing the wider macrosystems that support dislocation, such as transnational capitalism, is beyond the scope of individual recovery programs, practitioners can support clients to engage in meaningful connections with themselves and others (Alexander, 2008). However, chronic activation of defensive responses can interrupt a person's capacity to engage in meaningful, intimate connections by reducing their access to their social engagement system and ventral vagal engagement (Corrigan et al., 2010; Porges, 2017).

Traumatic reactions resulting from dysregulation in the autonomic nervous system can recur long after the initial event in response to cues and stimuli associated with the traumatic event. Although the quick activation of defensive responses is adaptive in dangerous environments when a quick response is required, people may live with chronic dysregulation in their autonomic nervous system, which is no longer adaptive and is distressing in a safe environment (Fisher, 2017a). Benign cues become encoded as signs of danger that elicit the defence cascade (Lang et al., 1997; Fishbane, 2019). Quick activation of defence responses can become habitual behavioural patterns that undermine relationships, goals or violate a client's values or self-concept, potentially resulting in shame, relational damage, and regret (Corrigan et al., 2010; Fishbane, 2019).

Understanding what 'safety' means on a physiological/neurobiological level has significant implications for therapeutic practice in a recovery-based setting. In the same way, understanding unsafety, trauma, and threat through a neurobiological framework gives context to potentially confusing manifestations and presentations in a therapeutic context. Neurobiological safety is required for people to experience empathy, compassion, creativity, moral reasoning and many more outcomes associated with human flourishing and well-being (Porges, 2017). Therefore, supporting clients to be able to access a felt sense of safety through ventral vagal engagement (the capacity to remain in or return quickly to their window of tolerance) is an essential aspect of helping clients to engage in safe relationships and toward psychosocial recovery (Corrigan et al., 2010; Fisher, 2017a). While the capacity to regulate nervous system activation is one aspect of recovery from addictions, alongside many other required external resources such as housing, medical care, food, and financial security, etc., the capacity for social engagement and belonging is a core root of addiction as proposed by Dislocation Theory (Alexander, 2008).

The defence cascade provides the best context to understand the diverse symptoms, phenomena and disorders described and observed among trauma survivors in the research literature. Therefore, it is essential for practitioners working with trauma survivors to understand how the defence cascade can manifest as a biobehavioural state (Lang et al., 1997). Extensive work has been done in developing praxis to support people living with the impacts of trauma, mainly when manifested in hyperarousal symptoms and the fight-flight-freeze response (Brantbjerg, 2020; Fisher, 2017a; Rothschild, 2017). However, the impacts of trauma will also manifest in different forms of hypo-responses, which can be harder to identify and regulate (Brantbjerb, 2012; Fisher, 2019). Due to the sometimes more passive and discrete presentation of hypo-responses, people seeking help from social service agencies may not receive appropriate care, or the presentation of distress may not be identified at all (Brantbjerg, 2020).

While sympathetic activation results in increased arousal and more obvious presentations of distress, hypo-arousal and hypo-responses can be challenging for clients and practitioners to work with therapeutically. In a sense, practitioners are trying to work with what is not present and ‘too little’ rather than ‘too much’ in the case of hyperarousal (Baldwin, 2013). This section will provide a literature review on the manifestation and psychophysiological foundations of trauma-related hypo-responses for counsellors working with clients recovering from trauma, opioid use disorder and chronic autonomic nervous system dysregulation. This will be expanded by outlining the defence cascade, a series of physiological responses that enable a person to respond to actual and perceived threats through different levels of brain-body defence systems.

The Defence Cascade: Increase in Arousal

Lang et al. (1997) first coined the term' defence cascade.' It refers to the activation of defensive responses to promote survival. When a threat is detected, the first step is an orienting response, in which attention is directed to the perceived threat (Lang et al., 1997; Ogden & Fisher, 2017). A mobilization of arousal accompanies the orienting response (Kozlowska et al., 2014). The hypothalamus increases activation of the sympathetic nervous system, which increases the tone of the smooth muscles in the viscera; the somatic nervous system, which increases the tone of the striated muscles that are involved in voluntary movement (skeletal muscles); and in cardiac function (Akinrodoye, 2020; Shadrin et al., 2016). The physiological changes prepare the body to respond quickly and for action. For example, the mobilization of the sympathetic nervous system may result in the person experiencing a dry mouth as the blood flow to the salivary glands decreases, digestive process slows, sweat increases and the heartbeat quickens (Rothschild 2000, 2017).

Practitioners working with people experiencing an increase in arousal may also notice a higher pitch in their voice as the proximal laryngeal muscles constrict, a stiffening of posture, increasing respiration, a less rosy tone in the skin (despite skin colour) and an increase in muscle tone (Kozlowska et al., 2014; Rothschild, 2017). Associated feelings may include anger, shame, disgust, anxiety, excitement, and sexual climax (Rothschild, 2017). Rothschild (2017) asserts that when the client is presenting with this level of activation, the counsellor should assist the client to down-regulate to moderate arousal levels, and the frontal cortex should be accessible to the person before proceeding with therapy.

Fight-Flight Responses. The fight-flight responses are active defensive responses in which a person or animal will fight back or flee to escape harm (Kozlowska et al., 2014). The fight-flight response includes activating the skeletal muscles, the autonomic nervous system, and a non-opioid analgesic response to mitigate pain (Kozlowska et al., 2014). In addition to commonly known expressions of the fight responses, such as aggressive behaviour and hostility, Fisher (2017) notes that the fight response may present in trauma survivors as patterns of self-criticism, judgment, self-blame, self-destructive behaviour, suicide/ ideation, mistrust, and a need to control. She also notes that a flight response may present as strong ambivalence, avoidance, addiction, disordered eating patterns, and distancing behaviours.

Differentiating Freeze Responses. This section will discuss the progression of the defence cascade in which the parasympathetic nervous system is dominant. Additionally, it will tease apart the different types of "freeze" responses identified within research literature, differentiating freeze responses with sympathetic and dorsal vagal dominance. Lastly, although dissociation is not necessarily part of the defence cascade and the construct is widely disputed, depersonalization and derealization will be briefly reviewed as forms of hypo-responses. It should be noted that people often emerge from various states in the defence cascade in the reverse order that they enter them (Kozlowska et al., 2015). Bringing awareness to this process can help the counsellor anticipate how to support the client therapeutically and prepare clients so that they are not surprised or alarmed by shifts they experience in their nervous system during therapy.

Hyper-Freeze: Attentive Immobility. While the freeze response is commonly conceptualized as a hypo-response (Corrigan et al., 2011), researchers and therapists have distinguished two types of freeze responses (Rothschild, 2017). As described earlier, a Polyvagal

Theory perspective describes a freeze response characterized by a state of collapse, muscle flaccidity, and low nervous system arousal (Porges, 2011). However, another variation of the freeze response involves co-activating both the sympathetic and parasympathetic nervous systems; the person/animal is primed for action but is frozen in place (Kozlowska et al., 2015). This type of freeze response involves high levels of sympathetic arousal rather than only a collapse of cortical processing and hypo-arousal (Bracha, 2004; Kozlowska et al., 2014; Rothschild, 2017). A hyper-freeze response is a fight-flight response put on standby, in which the heart rate momentarily slows until the fight-flight response reactivates (Corrigan et al., 2011; Kozlowska et al., 2015). In the literature, this has also been referred to as hyper-vigilance (Bracha, 2004), hyper-freeze (Rothschild, 2017), attentive (Volchan et al., 2017), alert immobility (Scaer, 2004), freeze-alert (Ataria, 2015; Baldwin, 2013), freeze-fright (Bracha, 2004), and reactive immobility (Kozlowska et al., 2015).

Freezing is adaptive for several reasons when faced with a threat. It enables the person or animal to continue scanning their environment for signs of threat while maintaining the level of arousal required to quickly transition into fight or flight (Kalin & Shelton, 1989; Kozlowska et al., 2014). In carnivores, the visual cortex and retina are primed to detect movement rather than colour (Bracha, 2004). Considering this, freezing increases the chances of survival by decreasing the likelihood of detection by allowing the mammal to momentarily avoid detection (Bracha, 2004; Scaer, 2001). Subsequent attempts to fight or flee typically follow a hyper-freeze response (Bracha, 2004). Additionally, when the mammal is far/ further away from the predator, the hyper-freeze response is more likely to be activated (Marx et al., 2008). The endogenous opiate system is also activated to inhibit a pain response.

Research literature makes a distinction between a freeze response that occurs before and one that occurs after a fight-flight response by using different terminology, although the phenomena are similar. For example, Volchan et al. (2017) make a distinction between a hyper-freeze response (or attentive immobility response) and what they define as "immobility under attack." They suggest that attentive immobility is elicited when the predator/ perpetrator has not detected the prey/ victim. In contrast, immobility under attack is elicited when the escape route is blocked, or the prey/ victim has been detected. Similarly, Baldwin (2013) differentiated what they call freeze-alert and freeze-fright. Like Volchan et al. (2017), they suggest that freeze-alert occurs when a threat is first detected and is associated with the orienting response and precedes the fight-flight responses. Freeze-fright, in contrast, is activated after the fight-flight response and is differentiated from freeze-alert by dorsal vagal activation. Freeze-fright is the first step in transitioning into tonic immobility. Similarly, Bastos et al. (2016) suggest that 'immobility under attack' states occur just before tonic immobility when there is a gross loss of motor control, and the prey is subdued.

Research evaluating the hypothesis of two types of freeze responses (one with higher sympathetic activation and one with dorsal vagal activation) simulated conditions that would elicit both types of responses in human participants (Bastos et al., 2016; Volchan et al., 2017). Researchers then measured the body sway/ movement to measure the sympathetic or dorsal vagal activation; more movement is associated with higher sympathetic tone and vice versa for dorsal vagal tone. Under conditions meant to simulate a situation that would elicit attentive immobility, Volchan et al. (2017) noted that there was more body sway (suggesting a higher sympathetic tone). In contrast, there was less body sway/ movement and slowed heart rate among people who experienced a simulated condition of danger with a low possibility of escape (to simulate a situation that would elicit an immobility under attack state). The findings of this study suggest the onset of a dorsal vagal state and potentially early transition into tonic immobility (Bastos et al., 2016; Volchan et al., 2017). Despite the usefulness of this information in understanding the defence cascade, it is worth highlighting the obvious ethical concerns in conducting this type of research in both human and animal studies.

Although freeze responses are often brief, counsellors can support clients in developing tools to manage these states (Kozlowska et al., 2015). They can do this by inviting clients to notice body sensations, breathe into them, and then track/ notice any movement or changes. Counsellors can direct attention away from emotions, memories, and thoughts and towards noticing impulses to move or complete a specific action. Additionally, they can help clients to expand the narrowed field of attention that occurs in a freeze response by attending to details and features in their surrounding environment, guided imagery, or sounds/ vocalizations.

The Defence Cascade: Decrease in Arousal

Tonic Immobility. When the attempts to fight or flee are unsuccessful, tonic immobility is activated. The research literature also refers to tonic immobility as freeze-fright (Ataria, 2015; Baldwin, 2013), rape-induced paralysis (Burgess & Holmstrom, 1976), hypo-freeze (Rothschild, 2017), immobility reflex (Galeano et al., 1978), feigning death (Porges, 2011), playing possum (Beach & Stern, 2011), catalepsy (Janet et al., 2022), or the ‘freeze’ response (Haenaars et al., 2014). When nerves in muscle tissue, joint muscles, or viscera reach a critical threshold, these afferent nerve signals can trigger tonic immobility (Kozlowska et al., 2015). If the animal/ person does not fight back, it increases the chances of escape by potentially being temporarily released (Bracha, 2004). Among humans, tonic immobility may be activated during contact with a perpetrator, while being restrained, during rape/ sexual assault, in combat, animal attacks, car crashes, or when the person perceives that escape/ fighting is not possible (Kozlowska et al., 2015).

Symptoms of tonic immobility include involuntary movement (being unable to move and shaking without control); periods of eye closure and unfocused gaze; repressed vocalizations/speech; rigid/waxy flexibility; and possible defecation (Bovin et al., 2008; Rothschild, 2017). In addition, tonic immobility elicits an opiate-mediated analgesic response in which the body releases endorphins to numb pain (Marx et al., 2008). In this state, a person may experience potentially fatal arrhythmias; there is first an increase in heart rate during the onset of tonic immobility, and there may be a rapid decrease in heart rate and respiration once it is instated (Kozlowska et al., 2015). As noted in previous sections, the initial increase in heart rate and respiration is freeze-fight, which appears to be a step that occurs after a fight-flight response and just before a more intensive increase in dorsal vagal tone/ tonic immobility (Baldwin, 2013). People experiencing tonic immobility may report being unable to yell out or move, feeling cold, being paralyzed, experiencing numbness, shaking without control, dissociation, and feeling hopeless and trapped (Kozlowska et al., 2015; Marx et al., 2008). These responses are part of the dorsal vagal branch of the autonomic nervous system and occur when the limbic mid-brain is offline/ sympathetic nervous system tone reduces, resulting in the dominance of phylogenetically the older defence system (Baldwin, 2013; Kozlowska et al., 2015).

Tonic immobility differs from a hyper-freeze response, which promotes alertness, vigilance, sensitivity to stimuli, and mobilization of energy to quickly move into action, despite immobility (Marx et al., 2008). Tonic immobility, by comparison, results in a loss of postural alertness even when subjected to painful stimuli and attack to which the person remains unresponsive (Marx et al., 2008). Rather than avoiding detection, tonic immobility is a feigned death response; it reduces the likelihood that a predator would complete the attack-kill response and that the animal might be mistaken for dead meat and not be eaten (Marx et al., 2008).

Experiencing restraint in combination with high levels of fear elicits a tonic immobility response (Bovin et al., 2008; Marx et al., 2008). While restraint without fear is insufficient to elicit tonic immobility, the intensity of fear and how safe/ unsafe the environment is perceived will impact the onset and duration of the tonic immobility (Marx et al., 2008). Although there is a substantial body of animal research on tonic immobility based on mimicking a predator-prey relationship (Hagenaars et al., 2014), human participant research has obvious ethical concerns limiting experimental research. However, comparable naturalistic conditions in humans occur in circumstances with high fear and restraint, such as sexual assault and rape (Volchan et al., 2017). For example, Bovin et al. (2007), in their research with people who experienced sexual assault, found that tonic immobility mediates the following relationships: the severity of PTSD symptoms/ avoidance/ re-experiencing symptoms and the perceived inescapability, fear and re-experiencing symptoms; and it partially mediated the relationship between fear and PTSD symptom severity. These research findings suggest that tonic immobility may determine whether someone develops PTSD and the nature of trauma symptoms after the assault. Furthermore, it supports the hypothesis that the co-occurrence of fear and restraint elicits tonic immobility.

Since people have verbal and cognitive faculties to appraise, represent, and make meaning of their environment, these representations add complexity to the fear component in eliciting tonic immobility (Marx et al., 2008). Unlike animals that respond only to the cues in their present environment, the magnitude of fear experienced by people is mediated by their personal/ family history, cultural context, genetics, and perceptions that will result in different responses to potentially the same circumstance (Marx et al., 2008). In this context, it is essential to recognize that structural systems of power and oppression, history of abuse/ trauma, and a person's intersectional identity and cultural locations may impact the level of fear and duration/ intensity of a traumatic response due to the appraisal of safety (such as the belief that someone will come to their aid when attacked or if other people in the environment are benevolent). These contextual factors may significantly affect a person's appraisal of safety or danger.

Counsellors can support clients to upregulate from a state of tonic immobility by using somatic, bottom-up approaches (approaches that engage sub-cortical brain regions) in conjunction with mindfulness practices (Kozlowska et al., 2015). To do this, counsellors can support clients by directing awareness to sensations through touch (such as noticing the feeling of touching something cold or the texture of clothing); through interoceptive awareness, the awareness of internal body sensations (such as noticing the feeling of the breath in their lungs or the feeling of warmth in their skin); or by proprioceptive awareness, the noticing the position and movement of the body (such as noticing the feeling of wiggling their toes and the activation of muscles as they press their feet into the floor). Directing attention to an area of the body increases blood flow to that region, which can increase the afferent signals to the brain. Mindfulness helps to increase brain activity, and when the counsellor can foster mindful acceptance and noticing of bodily sensations, it can activate the prefrontal cortex. For clients unable to move, supporting them to notice bodily sensations and gently experimenting with very small movements can help regain motor control. Additionally, other grounding techniques such as tapping, humming, chanting, stepping, stomping, engaging in mutual gaze, prosodic vocalizations, walking, moving various types of self-touch, or tactile interventions (such as touching something cold or fuzzy) and then pairing these with interoceptive/ proprioceptive awareness and mindfulness can be helpful tools to prevent or come out of states of tonic immobility.

Collapsed Immobility. Collapsed immobility is similar to tonic immobility and operates on the same neuropathways but with a more rapid slowing of the heart rate or asystole (Kozlowska et al., 2015). Research literature also refers to collapsed immobility as collapse (Baldwin, 2013; Fisher, 2017b), flaccid immobility (Bracha, 2004), faint (Bracha, 2004), fear-induced fainting (Bracha et al., 2005), and vasovagal syncope (O'Hare et al., 2017). Collapsed immobility presents as the client fainting (Kozlowska et al., 2015). The more rapid and dramatic onset of parasympathetic dominance and disruption to cardio functioning and vasodilation leads to brain hypoxia and subsequently interrupted signals from the brainstem to the muscles (Kozlowska et al., 2015; O'Hare et al., 2017). As a result, a person may faint, lose postural tone, have disrupted/ loss of consciousness, or lose inhibitory control, which may result in crying, intense panic, or moaning (Kozlowska et al., 2015; O'Hare et al., 2017). While fainting may occur when there is exposure to blood or when there is a fear of needles (Bracha et al., 2005), there is a higher rate of collapsed immobility (vasovagal syncope) among people with early childhood physical and sexual abuse, dissociative symptomology (O'Hare et al., 2017). When other medical conditions are ruled out as the cause of fainting, the counsellor could support the client in becoming aware of cues that signal the onset of collapsed immobility, such as blurred vision, nausea, dizziness, or sweating (Kozlowska et al., 2015). Developing awareness of activators and triggers and then using some of the interventions outlined in the section on tonic immobility will also be supportive in preventing the onset of collapsed immobility.

Quiescent Immobility. Quiescent immobility is a state of hypo-arousal that occurs in response to pain in the viscera, bones, muscles, or joints (Kozlowska et al., 2015). The hypostate allows the person or animal to recover and heal after pain, injury, illness, or exhaustion. After experiencing a painful stimulus from which they cannot escape, animals exhibit reduced motor function and engagement with other animals and are less responsive to their environment (Depaulis et al., 1994). Kozlowska et al. (2020) suggest that this might be an underlying facet of some chronic pain and fatigue conditions when the body's stress system has been activated and engaged for too long. However, there is a lack of literature on this subject and little other research.

Dissociation

The term 'dissociation' is frequently used to refer to states of hypo-arousal and forms of hypo-responses. A brief overview of different phenomena associated with dissociation is reviewed below for clarity. An underlying thread across phenomena referred to as dissociation includes a fragmentation of the present moment experience in some way, including a fragmentation of experience, thoughts, emotions, and the personality/'mind.' The interconnection of the endogenous opioid system and dissociation will also be reviewed below.

The term 'dissociation' in academic literature refers to an array of trauma-related symptoms and psychological and somatic phenomena, with little consensus on a specific definition (Nijenhuis & van der Hart, 2011). More narrow conceptualizations of 'dissociation' can be defined as trauma-related alterations in consciousness that impact a person's subjective experience (Lanius, 2015). Broader definitions include flow states and absorption with a task (Nijenhuis & van der Hart, 2011). While dissociation includes many somatic and psychological constructs, dissociation occurs across four dimensions: time, thought, the body, and emotion (Lanius, 2015).

Structural Dissociation. Structural dissociation is a more comprehensive and specific model to define dissociation as a construct (Nijenhuis & van der Hart, 2011). When dissociation occurs in the context of trauma, there is a structural fragmentation of the personality, in which two or more dissociative parts develop to meet practical needs in the environment (Nijenhuis & van der Hart, 2011). These practical needs include attachment (via the social attachment system), safety (via the survival-stress response/defence cascade), and self-regulation. Each fragmented/ dissociative part of the personality has different functions and emerges to meet practical needs. Nijenhuis & van der Hart (2011) assert that subcortical action systems or emotional systems mediate the functions of each of the dissociative parts; the most essential action systems include attachment, defence/ safety, procreation, sociability, energy management, exploration, and play (Nijenhuis & van der Hart, 2011).

People can dissociate from the overwhelming external stimuli in their environment and the overwhelming internal experiences and body sensations resulting from the traumatic experience (Shore, 2001). However, it is adaptive for infants and children to dissociate from the corresponding internal survival-stress responses when their caregiver is the source of terror or distress since they depend entirely on them for survival (Shore, 2001). As a result, when the caregiver is the source of distress, it is adaptive for the child to suppress the internal distress cues to maintain an attachment bond. However, this fragmentation process enables a child to dissociate from the internal experience of distress to maintain attachment. While it is automatic, adaptive and unconscious, this process is costly. It results in a fragmentation of the 'self' in which the Parts of the personality seen as acceptable, adaptive, or valued, can continue to grow and mature. In contrast, other Parts of the personality that are adaptations to unsafe situations are fragmented off/ disintegrated and bear the sensations, implicit memory and pain of early experiences (Fisher, 2017a).

For example, suppose anger was not tolerated within a family. In that case, a child may have had to suppress their experience of anger when they felt disrespected, violated, or abused while being sweet, helpful and high achieving were praised (Fisher, 2017a). The ‘helpful and sweet Parts’ of the personality would continue to be reinforced and have the opportunity to develop. In contrast, the person subjectively experiences anger as unsafe or ‘bad.’ However, although the ‘helpful and sweet Parts’ might be more developed and elaborated, the ‘angry Part’ remains and carries the associated implicit and somatic memory and the defensive fight responses that could not be safely expressed at the time.

Structural dissociation is a natural compartmentalization that occurs in which different ‘Parts’ form patterned ways of responding that are functional and emerge to meet practical needs (Fisher, 2017a). While parts carry various types of memory, they are also functional, patterned ways of responding; they involve emotional, cognitive, and behavioural adaptations that help someone to survive an unsafe environment with as little damage as possible (Fisher, 2017a). Unsafe environments may also include an environment that is intolerant of all aspects of the client’s experience, preventing them from being safely expressed, tolerated, and supported (such as a young boy derided for crying). Attachment-related needs strongly influence the development of Parts, as people will subconsciously disown or fragment off the elements of their experience that disrupt attachment bonds.

This fragmentation occurs along natural ‘fault lines’ such as the divide between the left and right hemispheres, behavioural action systems, and attachment processes (Fisher, 2017a). Although children have both the right and left hemispheres, the right hemisphere is dominant for most of childhood (Fisher, 2017a). In fact, the corpus callosum that enables connectivity between the hemispheres is only fully developed by age 12 (Schore, 2001). The left brain encodes verbal, autobiographical, and narrative memory (ex. "I went here and then did this"), whereas the right brain encodes more visual, implicit, and episodic memory (ex. feelings of shame, fear, terror, anger, flashes of imagery and sensation; Fisher, 2017a).

While a person may be able to give a narrative description of events that happened to them, including traumatic memory, which is the focus of many talk-based therapies, it does not necessarily mean that the implicit memory of the right brain has been integrated (Fisher, 2017a). The non-verbal memory of the right brain is not forgotten and may remain uninterpreted. Associated cues (i.e. triggers) still activate the Part's patterned responses. In a sense, therapy might reinforce the adaptive responses of the 'good Part.' However, the client's dissociated and fragmented parts and non-verbal memories are left unaddressed or unintentionally activated but not integrated during therapy.

Additionally, the structural dissociation model is a helpful way to understand the defence cascade responses and work therapeutically with clients. Parts form as an adaptive response to an unsafe environment and, as a result, are often associated with an autonomic state within the defence cascade (Corrigan et al., 2010; Fisher, 2017a). An unsafe environment activates the defence cascade with all associated adaptive responses that promote survival; Parts include the somatic, cognitive, affective, and procedural elements of these responses that become patterned over time (Fisher, 2017a). According to the Trauma-Informed Stabilization Treatment (TIST) model, Fisher (2017a, 2017b) suggests that clients may present with fight, flight, freeze, submit, and attach-cry Parts. In this conceptualization, the fight-flight parts are associated with sympathetic nervous system activation, and submit, attach and sometimes freeze parts are moderated by dorsal vagal/ parasympathetic nervous system activation (Corrigan et al., 2010).

Within this model, dissociation may not refer to a specific state of hypo-arousal but a phenomenon resulting from traumatic adaptations in which a person may experience both hyper- and hypo-aroused states (Ogden & Minton, 2000). In states of hypo-arousal, dissociation may result in interruptions to a person's ability to detect danger, feel emotion, think clearly, evoke motivation; and loss of sensation in parts of the body, depersonalization, and derealization (Ogden & Minton, 2000). Additionally, dissociative symptoms are conceptualized as manifestations of dissociative parts of the personality (Nijenhuis & van der Hart, 2011). The dissociative symptoms that might present within the various dissociative parts can include negative symptoms (e.g. functional losses, amnesia, paralysis), positive symptoms (e.g., intrusions, flashbacks, voices), psycho-form symptoms (e.g. hearing voices), or somatoform (e.g., loss of sensation or tics).

Depersonalization & Derealization are Hypo-responses. People with the dissociative subtype of PTSD, including depersonalization and derealization, show more activation of brain regions associated with dorsal vagal activation (Harricharan et al., 2016). Both people with PTSD who do and do not meet the criteria for the dissociative subtype of PTSD show connectivity with brain regions associated with sympathetic activation and hyperarousal; that is, the dorsolateral and lateral periaqueductal gray (DL-PAG and L-PAG). In contrast, only people with dissociative PTSD had greater functional connectivity under an fMRI scan in the ventrolateral periaqueductal gray (VL-PAG), which is associated with parasympathetic defence responses (hypo-arousal), compared to controls and people with PTSD and no dissociative symptomology. These research findings suggest that the DL-PAG and VL-PAG are the brain structures that mediate high and low arousal defence strategies and also suggest that depersonalization and derealization are forms of hypo-responses.

Dissociation, Opioids and Attachment. The endogenous opioid system is important in the defence cascade and is involved in initiating dissociative responses (Kozlowska et al., 2014; Lanius, 2014). Opioid-mediated dissociative responses are part of a parasympathetic state of hypo-arousal. Numbing/ analgesic effects also accompany these dissociative states due to a significant release of natural opioids, which is outlined in greater detail below (Lanius, 2014).

Dissociation is one type of peritraumatic reaction that can occur while a person is experiencing states of hypo-arousal (Lanius, 2014). The natural opioid system is essential in initiating dissociative processes and shaping the attachment system; the natural opioid system may also be involved in the formation of dissociative responses, particularly in early childhood abuse (Lanius, 2014; Shore, 2001). Traumatic abuse results in the nervous system being overwhelmed and having insufficient resources to cope with the experience. Schore (2001) explains that a person will dissociate from both the overwhelming external stimuli in their environment along with the internal experiences and body sensations that result from the traumatic experience.

When the caregiver is the source of terror or distress, it is adaptive for the infant to dissociate from the corresponding internal survival-stress responses (Schore, 2001). There are overlapping neural pathways between social separation/ rejection and physical pain (Eisenberger et al., 2003), which are rooted in the attachment processes (Schore, 2001). MacLean asserts that “nature appears to have ensured that maternal-offspring separation in mammals results in distress comparable to pain” (1987, p. 136). Since maintaining attachment is critical to the infant’s survival, a response that neurologically equates to pain (via the endogenous opioid system) is adaptive in that it will provoke the infant to cry out to the caregiver to elicit care and response (Schore, 2001). If the caregiver, however, is the source of distress, it is adaptive for the child to suppress the internal cues of distress so that they can maintain an attachment bond. However, in situations of abuse, neglect or attachment trauma, the pain system of the infant may be reorganized and alter the pain response in adulthood and their endogenous opioid system (Schore, 2001).

When healthy, the orbitofrontal cortex in adults can regulate both states of hyper- and hypo-arousal and can monitor sensory signals from throughout the body (Schore, 2001). However, cortical modulation is lost when the defence cascade is initiated (first through the sympathetic nervous system and subsequently through dorsal vagal collapse) (Porges, 2007). Since the orbitofrontal cortex is involved in the conscious processing and recognition of body sensations, reduced activation in these areas will suppress conscious pain identification (Schore, 2001). Sensory input is disrupted and can result in depersonalization and derealization (the out-of-body) effect when the sensory information is sorted incorrectly and attributed to someone else (Lanius, 2014).

People with early childhood trauma or PTSD may use self-injurious behaviours to self-regulate, particularly when they have an altered pain response (Fisher, 2017a; Shore, 2001). Self-injury releases a flood of opioids, creating a sense of well-being, reducing pain and stimulating the endogenous opioid system. Scaer (2001) highlights that since the opiate-mediated analgesic response is activated in hypo-responses/ dissociation, the opiate reward system may also reinforce procedural memory in trauma. The reinforcing nature of the opiate system/ endorphins may result in traumatic reenactments and have a bidirectional and mutually reinforcing relationship between dissociation and self-injury/ traumatic reenactments. Moreover, using exogenous opioids would have a similar effect as self-injury- it increases the amount of bioavailable opioids in a person's system, reducing pain and increasing feelings of euphoria and well-being.

Self-Regulation and the Attachment System

The previous section reviewed the interconnection of opioid use disorder and PTSD and the survival-stress response/defence cascade. The following section will review the literature on the social attachment and self-regulation systems. The development of these two systems impacts how reactive a person's survival-stress response is and their capacity for self-regulation once activated. Additionally, to expand upon an additional layer of complexity, the endogenous opioid system has a formative role in developing attachment bonds. Therefore, research on how the endogenous opioid system impacts attachment will also be reviewed.

Attachment, Self-Regulation System & the Implicit Self

The concept of the 'window of tolerance,' proposed by Siegel (1999), provides a helpful framework to understand further how a physiological perception of safety/ threat, self-regulation through substance use, and attachment are interconnected. While there is a breadth of complex cross-disciplinary publications on how the nervous system responds to a threat, as described above on the defence cascade, the window of tolerance is a simple illustration accessible to both clients and practitioners.

The window of tolerance is the range (or window) of arousal, emotion, and experience that a person experiences as tolerable or optimal (Corrigan et al., 2010; Siegel, 1999). Concerning Polyvagal Theory, the window of tolerance is a ventral vagal state. Therefore, it can be used as a framework to understand how a person may attempt to self-regulate and return to their window of tolerance by engaging in substance use or other behaviours to moderate hyper-/

hypo-arousal. Above the upper edge of the window of tolerance are states of hyperarousal (sympathetic nervous system activation) and accompanying behavioural responses (Corrigan et al., 2010; Ogden et al., 2006). Below the lower threshold of the window of tolerance are parasympathetically mediated states of hypo-arousal/ dorsal vagal state (Corrigan et al., 2010; Ogden et al., 2006).

Formation of the Window of Tolerance. The primary caregiver's ability to attune, respond, and co-regulate with the infant has significant implications on how the infant develops the ability to self-regulate their nervous system states and emotions later in life or if they form social-emotional adaptations in order to maintain attachment bonds which are required for their survival (Fisher, 2017a; Schore, 1994). Exchanges between a caregiver and infant that support the development of secure (or insecure) attachment shape the window of tolerance; the caregiver acts as a safe base from which the infant/child can explore their environment, and they act as a safe haven that the child can return to be soothed by when they are distressed (Ainsworth, 1989; Fisher, 2017a; Inagaki et al., 2016). When the infant is startled or expresses needs, and the caregiver responds to their needs in a soothing and non-frightening or confusing way, the caregiver supports the development of secure attachment in the infant (Siegel, 1999). The infant's nervous system releases endogenous opioids that reinforce the attachment bonds and alleviates distress (Inagaki et al., 2016). Through the development of secure attachment and the parent acting as a secure base and safe haven for the infant, the infant experiences a felt sense of safety and security, developing their tolerance window (Ainsworth, 1989; Fisher, 2017a). Additionally, the experience of co-regulation with a caregiver is the first step in developing the capacity for self-regulation (Morgan, 2019).

As the primary caregiver co-regulates emotion and dysregulation through attachment communication, they draw the blueprint for the infant's central and autonomic nervous systems (Schore & Schore, 2007). Attachment communication includes coordination of eye contact, vocalizations, body movement, gestures, shared gaze, facial expressions, posture, and tone of voice (Feldman, 2007; Trevarthen, 2001). These attachment exchanges develop synaptic connections in the right orbitoprefrontal cortex, the connections between the cortex and limbic structures, the neuroendocrine system (including the endogenous opioid system), and the autonomic nervous system (Schore, 1994). As synaptic pruning occurs, particularly between the first year and second year of life, important links between the cortex and limbic system are established (Schore, 1994).

Polyvagal theory and the concept of neuroception provide a useful framework to explain how these attachment communications are 'understood' by the infant's nervous system as communications about the safety of the environment and their security in the relationship (Porges, 2007). Neuroception is a subconscious process in which the nervous system scans the environment for cues of safety or threat to determine whether to activate or suppress the defence cascade. Biological movements (such as gestures and facial expressions) and vocalizations are 'read' by the temporal cortex to identify safety or threat (Porges, 2007). The myelinated vagus nerve connects the heart and lungs in a two-way relationship, in which the muscles that regulate the upper portion of the face, facial expressions, the vocal tone, the mid-ear/ hearing, and sight through the nuclei in the brainstem (Porges, 2007, 2017). When the environment is perceived as safe through neuroception, the body will enter a state of repair, growth, and healing. The myelinated vagal pathway will cause the heart rate to slow, will hinder the sympathetic fight-flight reactions, reduce a survival-stress response that results in the release of cortisol through the

HPA axis, and regulate immune reactions (Porges, 2007). Infants need the caregiver to regulate their nervous system, as infants cannot do this independently (Trevarthen, 2001).

Researchers found that the level of synchrony (attunement and coordination of physiological stimuli) between the mother and infant at three and nine months was directly related to the child's capacity for self-regulation at two, four, and six years of age (Felman, 2007). Specifically, the level of synchrony predicted the child's IQ at age two and four years of age; fewer behavioural problems at two years; the language the child uses to communicate internal states at two years and elementary skills for theory-of-mind; and the ability to empathize at 13 years (Feldman, 2007; Feldman & Greenbaum, 1997). In addition, Feldman (2007) asserts that "synchrony sensitizes infants to the emotional resonance that underlies human relationships across the lifespan" (p. 343). This highlights the formative role of attachment communication in developing emotional regulation, social engagement and behaviours, and cognitive development.

However, in the absence of secure attachment and a regulated/ responsive caregiver, or if the infant/ child is subjected to trauma, abuse, or neglect, they are more likely to experience chronic states of hyperarousal and hypo-arousal and have a narrower window of tolerance since they are entirely dependent on the caregiver to soothe and regulate their nervous system (Corrigan et al., 2010; Siegel, 2012). The chronic dysregulation of the nervous system primes the developing child to respond quickly to threats, which is adaptive if they are in an unsafe environment. However, the subjective experience of distress from chronic dysregulation gets encoded as preverbal, sensorimotor memory (Schore, 2015). In summary, exchanges between the caregiver and infant/ child that support secure attachment produce a felt sense of safety (Schore, 2015; Siegel, 2012). These experiences are the precursor to a person's capacity for self-regulation and also sculpt a person's implicit sense of self, which will be described below.

Formation of the Implicit Self. The implicit self is the aspect of a person's identity that is formed during early developmental periods, particularly the first two years of life, through attachment experiences with a caregiver (Schore, 2001; Schore & Schore, 2007; Schore, 2015; Trevarthen, 2001). It includes the embodied, subconscious, and non-verbal aspects of a person's sense of self and influences their emotions, behaviour, sense of worth, and motivations at a subconscious level. Additionally, early attachment experiences with a caregiver form the implicit self and social attachment system, which impacts a person's capacity for empathy, social connection and affect regulation later in life. While a person may not be consciously aware of their implicit self, it can be inferred through patterns of emotion and physiological responses in the nervous system.

If the child has prolonged states of dysregulation, distress, disconnection and fear, these somatic and sensorimotor states are imprinted in the right brain and form the basis of the unconscious internal working models for the child (Schore & Schore, 2007). The internal working models formed during the infant attachment process are then carried throughout life and impact the way the person engages in interpersonal relationships, interprets cues from others, and their capacity for self-regulation later in life (Schore & Schore, 2008). However, the corpus callosum that bridges the right and left hemispheres is not fully developed until roughly age 25 (Schore, 2015). Therefore, these sensorimotor memories are detached from narrative/ declarative memories, which rely on left brain processes (Schore, 1994). As a result, people have a felt sense of self that is formed before a conscious and cognitive sense of sense is developed (Fisher, 2017a; Trevarthen, 2001).

Depending on a person's attachment experiences, a person may have a felt sense of security and worthiness if the interactions with the caregiver support secure attachment (Fisher, 2017a; Trevarthen, 2001). Conversely, they may continue to experience a felt sense of insecurity and unworthiness emerging from the sensorimotor memories of the right brain despite later developing a positive self-concept that relies on left brain processes (Fisher, 2017a; Trevarthen, 2001). Although they may have a genuine positive self-concept and self-esteem based on later experiences, these early preverbal memories may still arise and influence the implicit, felt sense of self (Fisher, 2017a).

Emotion-Regulation and Opioid Use. Some research has found that opioids might be used for self-regulation and to regulate negative emotional states. In one study, 67 people with a history of opioid use disorder who were on methadone maintenance therapy at the time of the study reported using opioids to cope with difficulties in emotion regulation (Gold et al., 2020). Other research looking at the use of opioids among people with mood disorders found that 18.7% of Americans with mental health disorders use prescription opioids (an estimated 38.6 million people) compared to 5% of people without mental health disorders (Davis et al., 2017). Additionally, 51.4% of the opioids prescribed in the US annually are prescribed to people with mental health conditions; that is, people with a mental health condition are twice as likely to use prescription opioids (not including the people who also use illicit, non-prescribed opioids) (Davis et al., 2017). Although these studies do not examine the specific function of opioid use in the lives of people with mental health disorders, it may be possible that opioids are used for emotional regulation, as emotional distress is a common symptom across many mental health disorders. Some researchers suggest that the endogenous opioid system is directly involved in regulating emotion and is dysregulated among people with major depressive disorder (Peciña et al., 2019). There are endogenous opioid receptors in the limbic regions that are involved in modulating emotion, hormonal and survival-stress responses, and motivation (Peciña et al., 2019).

Attachment styles are part of how a person manages distress and connection, and as previously discussed, is a first step in developing a person's capacity for self-regulation. Understanding the link between attachment styles and opioid use is another way of understanding the role of opioids as a form of emotion regulation (Schindler et al., 2009; Schore, 1994, 2015). The following section will review research on how patterns of opioid use overlap with attachment styles. Then research on the role of the endogenous opioid system will be reviewed.

Attachment Style and Opioid Use

Attachment styles have significant implications for and interaction with opioid use disorder. Secure attachment patterns are a protective factor against the development of opioid use disorder, as it is associated with flexible and healthy coping (Schindler, 2019). In contrast, insecure attachment patterns are associated with higher levels of emotional dysregulation and difficulties in emotional coping (Fisher, 2017b). The implications of attachment on opioid use disorder include the strategies that a person employs to cope with distress, how the attachment system shapes the brain and endogenous opioid system and the corresponding behavioural patterns, and how a person experiences either comfort or distress later in life in social situations.

Attachment Styles and Coping. Interactions with a caregiver through critical development periods shape attachment patterns, which are ways a person copes with distress and affect regulation by up or down-regulating their attachment and/or defence systems (Schindler et al., 2009; Schindler, 2019). Dianna Fosha summarizes coping strategies of each attachment style succinctly: people with secure attachment are "feeling and dealing while relating"; people with anxious attachment are "feeling but not dealing"; people with dismissing attachment are "dealing but not feeling"; and people with disorganized (fearful-avoidant) attachment are "not feeling and not dealing" (Fosha, 2000, pp. 42–44).

People with preoccupied attachment experience a strong activation of the attachment system, which can present as the pursuit of closeness and proximity in relationships (Schindler et al., 2009). This results in activation of the attachment system/ pursuing behaviours paired with high levels of emotional activation; the person is emotionally distressed and copes by pursuing attachment relationships. In contrast, when faced with attachment-related distress, people with dismissing attachment deactivate their attachment system, dismiss attachment needs, and may create distance in interpersonal relationships (Schindler et al., 2009). The downregulation of the attachment system and dismissal of attachment needs may present as withdrawal, social isolation, low bonding, and a 'lone wolf' mentality. They experience a deactivation of the attachment system and low emotional activation; they cope with attachment distress by deactivating both the attachment system/ withdrawing and toning down emotional distress. People with avoidant attachment who use substances may do so to self-medicate or reduce distress. However, they may already be able to deactivate their attachment system (and distress) without using substances (Schindler et al., 2009).

In relevant studies, the strongest correlation exists between disorganized (fearful-avoidant) attachment and substance use (Schindler et al., 2009). While people with dismissing attachment may suppress attachment needs and deactivate their recognition of threatening cues, people with disorganized attachment both desire proximity in attachment relationships while feeling unable to trust them (Shaver & Mikulincer, 2002). Like people with preoccupied styles who desire proximity and attachment, people with disorganized attachment experience a similar desire for attachment but do not view attachment as a possibility due to the internal working models established in infancy, unlike people with a preoccupied style (Shaver & Mikulincer, 2002). This results in neither using the deactivating strategies of people with dismissing styles nor the pursuing behaviours of people with preoccupied attachment, leaving them with high levels of affective distress but without coping by pursuing or deactivating as the other styles do. As a result, people with disorganized attachment styles may not have an attachment strategy to respond to affect dysregulation or attachment distress, making substance use a potentially desirable and highly reinforcing option, considering the lack of other patterned attachment responses (Schindler et al., 2009).

Research on patterns of opioid use, insecure attachment, and disorganized attachment support the link. In a study with 84 Swedish participants, researchers found a statistically significant difference in attachment insecurity among people using opioids compared to the comparison group (Hovelius et al., 2021). More people using opioids had insecure attachment styles compared to the comparison group. A recent review of 37 studies showed a clear relationship between insecure attachment and substance use disorders (Schindler, 2019). Moreover, this review found a pattern of opioid use among people with disorganized attachment. In a study comparing 75 Iranian men who use opioids to 75 men who use stimulants, researchers found that more participants that used opioids had more insecure attachment patterns (avoidant and ambivalent styles) than people who use stimulants (Hosseinifard & Kaviani, 2015). However, the measure used in this study did not assess for disorganized attachment. Since other research has reflected that people who use substances, in general, have a more insecure attachment style (such as Schindler, 2019), the higher mean score for insecure attachment among people using opioids could reflect the measure detecting disorganized attachment, which includes elements of both avoidant and ambivalent attachment styles. A study of 56 married Israeli men who used substances (53% used heroin) demonstrated similar results; 60.7% had avoidant attachment styles (Finzi-Dottan et al., 2003).

Attachment & Neurodevelopment. Attachment patterns also impact the opioid system and exogenous opioid use. For example, research on rats that were isolated in adolescence (four to five weeks of age) revealed that the isolation reduced the rat's motivation in adulthood (seven to eight weeks of age) to seek social contact and to drink sugar water (Van den Berg et al., 1999a). In other words, isolation/ disrupted attachment in specific developmental periods reduces the motivation of adult rats to seek social contact and motivation for other naturally rewarding stimuli.

Further research examined how isolation in adolescent rats impacted adult social behaviour and the endogenous opioid system (van den Berg et al., 1999b). Findings corroborated the previous study in that social isolation in adolescence in rats resulted in less social exploration in adulthood. Interestingly, giving morphine to the isolated rats reversed the effects of isolation- the morphine increased social exploration. The opposite effect was also observed in non-isolated rats; giving an injection of morphine to non-isolated rats that could participate in social play in adolescence reduced their social exploration. Additionally, the researchers found a 58% increase in mu-opioid receptors in the amygdala and a 33% increase in the bed nucleus of the stria terminalis. However, giving morphine to isolated rats reversed the increase of mu-opioid receptors in both brain regions. As a result of the lack of social interaction in adolescent developmental periods, isolated rats engaged in less social engagement behaviours in adulthood, which might be mediated by the changes to the endogenous opioid system (the opioid receptors in the amygdala) that result make the social interactions reinforcing. This research shows that social interactions during critical developmental periods shape the endogenous opioid system and directly impact social behaviour later in life.

Additionally, the rats that were isolated in adolescence engaged in more non-social exploration and self-grooming when they were later housed with another rat (Van den Berg et al., 1999b). Self-grooming is a behaviour in rats associated with stress reduction and decreases in arousal. The researchers suggested that the increase in grooming behaviours might have been an attempt to reduce stress from the lack of ability to respond socially to the other rat. This research highlights how exogenous opioids directly impact the social engagement/ attachment system, mainly when there has been a lack of social contact in critical developmental periods. Additionally, the increase in self-grooming behaviours to self-soothe an activated survival-stress response when in a social setting may also suggest that exogenous opioids are reinforcing for people with social anxiety; the exogenous opioids would downregulate the anxiety and simultaneously interact with the social engagement/ attachment system. These research findings may be particularly pertinent regarding attachment patterns and opioid use.

Social Behaviours and Opioid Use. In rodent research, when there were high amounts of morphine or heroin given to mice, there were social deficits observed, which lasted up to seven weeks after detoxification (Pellissier et al., 2018). Additionally, in animal research, high doses of opioids interrupted social-sexual behaviours, social play, and long-term social memory (Pellissier et al., 2018). Opioid agonists increased social-sexual and sexual behaviours in rodents, increased social play and improved social memory; the opposite was found when mu-opioid receptors were blocked, and rodents were in a neutral environment (Pellissier et al., 2018). These findings suggest that mu-opioids have a functional role in controlling social behaviours, which the balance model of mu-opioids summarizes succinctly. Pellessier et al. (2018) proposed a balance model of mu-opioids role in controlling social behaviour, including several hypotheses:

1. They suggest social behaviours occur along a bell curve, with sociability along the Y axis.
2. Mu-opioid deficiencies can activate social avoidance systems, resulting in social withdrawal.
3. Excess mu-opioids can result in social indifference and low sociability.
4. Optimal social behaviour occurs in a narrow window with neither too much nor too little stimulation of mu-opioid receptors and high/ adaptive sociability.

Rejection, Exclusion, and Isolation

Human survival has depended on social networks for protection, gathering resources, attachment processes, caregiving during early life, reproduction, and support (Gunther Moor et al., 2010). Survival for humans from early attachment through to adulthood necessitates social connectedness; therefore, it is adaptive for people to be socially and physiologically sensitive to threats of social exclusion (MacDonald & Leary, 2005). Interestingly, the pain of social rejection, exclusion and ostracism activate neural networks similar to those of physical pain (Eisenberger et al., 2003; MacDonald & Leary, 2005). In fact, from an evolutionary perspective, some researchers posit that the social pain system co-opted the same neural networks as physical pain in the brain to alert the person to repair their 'social injury' as one would adjust to avoid physical damage when experiencing physical pain (Eisenberger et al., 2003; Eisenberger & Lieberman, 2005; Nelson & Panksepp, 1998).

Some researchers suggest that discrete neural circuits support' social homeostasis' to evoke people to the absence of connection and to seek reconnection (Matthews & Tye, 2019). From an evolutionary perspective, isolation could be a threat to survival. As such, it is adaptive to have short-term neurophysiological processes that stimulate a person to restore the social connection. The social homeostasis model proposes that loneliness functions similarly to hunger in that it incites a person to seek connection to restore social homeostasis, similar to how eating would restore physical homeostasis. They identified three parallel and overlapping circuits maintaining social homeostasis: hypervigilance, social motivation, and passive coping. These circuits include the activation of the survival-stress response and HPA axis to produce hypervigilance; the endogenous opioid system, reward-motivation system, and oxytocin system to stimulate social motivation; and changes to stress hormones, oxytocin and opioid release to reduce pain and further emotional distress when there are prolonged periods of loneliness.

As previously discussed, pain and threat to survival activate the defence cascade to promote adaptive survival responses. In physical injury, a minor wound may stimulate the person or animal to initiate a response that would promote their survival through action (Porges, 2017). However, hypo-responses are activated when there is a more intense flesh wound or severe threat to survival to reduce pain and further injury (Bovin et al., 2007). Since physical and social pain activates similar brain regions, social pain may activate the defence cascade similarly to physical pain, depending on the intensity. For example, researchers found that when participants experienced low-intensity social exclusion through an online game (Cyberball) that has been demonstrated to elicit feelings of social exclusion in players, it evoked an increased sensitivity to pain (Bernstein & Claypool, 2012) and produced an increase in sympathetic arousal measured through an increase in heart rate, as well as an increase self-reported in anger (Iffland et al., 2014).

In another study using the Cyberball paradigm, researchers compared the heart rate variability (HRV) as a measure of emotion dysregulation in 23 people using non-medical opioids to 29 people not using opioids after a game of Cyberball to elicit feelings of social exclusion (Kroll et al., 2019). People craving opioids had the highest HRV signalling the highest level of emotion dysregulation. There was also higher activation of the HPA axis among people who experienced social exclusion, indicating an activation of the survival-stress response. However, although people using opioids reflected that they were aware of the social exclusion during the game, they reported lower levels of emotional distress than the control group. These findings suggest that using opioids moderated the emotional distress resulting from social exclusion and can regulate emotional and social distress in natural contexts.

In contrast, research designs that elicit a high-intensity experience of social exclusion and/or rejection resulted in a lowering of the heart rate (Gunther Moor et al., 2010) and a decreased sensitivity to pain (Bernstein & Claypool, 2012). For example, in one study, participants provided a picture of themselves and then received feedback from someone whom they expected acceptance (Gunther Moor et al., 2010). This person rejected them, and the participant had a more pronounced decrease in heart rate (signaling activation of the parasympathetic nervous system) than when they experienced rejection from someone, they anticipated would reject them. In another study, participants took a personality test and were then given randomly assigned feedback on the test suggesting they would either have a fulfilling marriage and friendships or likely be socially isolated later in life; participants that experienced the social isolation condition had a decreased sensitivity to painful stimuli (Bernstein & Claypool, 2012). When this same design was modified to simulate a low-intensity form of social isolation by informing participants that they are still predicted to have social relationships, but they will be less fulfilling than they hoped, participants had an increased sensitivity to painful stimuli (Bernstein & Claypool, 2012).

These findings are consistent with the pattern of activation of the defence cascade via injury, suggesting that social pain in humans may function similarly to physical pain. Both physical and emotional pain mobilize a person to act in order to reduce harm when the injury is less intense. In contrast, hypo-responses are activated when there is more severe physical or emotional injury to prevent additional injury from literally or figuratively ‘fighting back’ and reduce pain.

Social Exclusion and Self-Regulation. Some research has also found that social exclusion affects a person’s capacity for self-regulation (Baumeister et al., 2005). They suggest rejection interferes with a person’s capacity to moderate their responses and behaviour, partially through a disruption in executive control as the survival-stress response/defence cascade is activated and the corresponding neural systems become dominant. Rejection also results in less altruistic and empathetic behaviours, particularly among people with deficits in the amount of opioids in their system (i.e. non-intoxicated opioid users) (Carlyle et al., 2020).

Baumeister et al. (2005) conducted several studies that demonstrated that people performed worse on tasks requiring them to self-regulate when they experienced social rejection or exclusion. In a series of six experiments, researchers told participants in five of the experiments that they would likely end up alone in life. In the other experiment, researchers told participants that no one in their group wanted them as a partner. Participants were less able to compel themselves to drink a bad tasting but healthy drink; they were more likely to eat unhealthy snacks; quicker to give up solving a difficult puzzle; and more easily distracted when trying to identify a specific word amongst a flurry of other words. In one of the experiments, researchers offered participants a cash incentive if they could complete the task requiring them to self-regulate. Participants successfully self-regulated in this acute task, suggesting that people still may be able to self-regulate when there is a reasonable incentive do so (at least for a brief time) but may be unwilling to direct the extra effort without a clear incentive. Interestingly, when participants completed the task with a mirror in front of them, they self-regulated more effectively.

The researchers suggested that self-regulation may require a person to self-reflect to moderate and change impulsive, unwanted or selfish behaviour (Baumeister et al., 2005). However, without a reward, someone may not be willing to endure the discomfort of self-regulating or self-reflecting on an undesirable aspect of themselves. However, these findings were in an acute task with a relatively short duration. People recovering from addiction frequently need to self-regulate to deal with cravings and triggers for use. Creating an environment where they can experience belonging, and acceptance may support self-regulation and serve as an incentive. Fostering an inclusive community and addressing stigma can be particularly salient due to the additional systemic discrimination that they may endure.

Considering that many people in the DTES face systemic discrimination such as racism, colonialism, and sexism, externalizing the associated narratives that may have become internalized could be helpful. However, systemic discrimination would result in a person continually being exposed to rejection and exclusion of some aspect of themselves, which could make it even more challenging to self-regulate. For example, in the experiments by Baumeister et al. (2005), research participants were exposed to rejection in a research setting and were required to practice self-regulation in a task for a relatively short period. However, in natural settings, people recovering from addiction may be experiencing rejection and exclusion by more valued and personal social relationships such as family, friends, workplaces, and other social settings, which structural discrimination may amplify.

Additionally, the finding that people who experience rejection and social exclusion have a reduced capacity for self-regulation has important implications for people recovering from opioid use disorder (Baumeister et al., 2005; Carlyle et al., 2020). Specifically, they may be more likely to experience social exclusion due to stigma around addiction, socioeconomic status, and other intersecting systems of power and oppression. These contextual factors may result in a person having a reduced capacity to self-regulate and impaired executive functioning. Consequently, this could impede their capacity to refrain from substance use, making sustained recovery more complex. Additionally, self-regulation is a crucial skill for maintaining social relationships, delaying gratification, and making health-oriented decisions when the healthy option is less gratifying (Baumeister et al., 2005). Deficits in self-regulation can perpetuate cycles of addiction, social exclusion and dysregulation. It is, therefore, essential to support people in recovery from opioid use disorder to find ways to experience social inclusion, develop social skills necessary to initiate and maintain relationships, and alternative skills to self-regulate without using substances.

Brain Opioid Theory of Social Attachment (BOTSA)

The Brain Opioid Theory of Social Attachment (BOTSA) suggests that endogenous opioids are a foundational part of relational and attachment processes (Panksepp et al., 1994). Specifically, endogenous opioids foster social attachment and are released during interactions that build attachment (Kyte et al., 2020). BOTSA hypothesizes that endogenous opioids are the vehicle through which social contact alleviates the distress of isolation and that isolation or deprivation of endogenous opioids would stimulate attachment-seeking behaviours (Loseth et al., 2014). Endogenous opioids, norepinephrine and oxytocin, are all part of the natural attachment system; the brain releases these neurotransmitters to reinforce the mother's caring for the child

(Inagaki et al., 2016; Maté, 2010; Nelson & Panksepp, 1998). When a caregiver nurtures that infant and acts as a secure base and safe haven from which the child can engage with and explore their environment and experience comfort, the infant's brain then releases endorphins which provide a sense of well-being and safety, and this builds the attachment bond (Kyte et al., 2020; Panksepp et al., 1994). This process in which the caregiver builds the attachment bonds also establishes the neurological foundations of the window of tolerance for the child (Corrigan et al., 2010). As previously discussed, the window of tolerance is the range of nervous system arousal states that a person experiences as tolerable and optimal (Corrigan et al., 2010; Siegel, 1999).

Researchers identified similar patterns between opioid addiction and social dependence with a period of developing attachment, euphoria, tolerance, and withdrawal signs when separation occurs (Machin & Dunbar, 2011; Manduca et al., 2021; Nelson & Panksepp, 1998). Research in support of the brain opioid theory of social attachment has also found that opioids reduce distress when social separation occurs; endogenous opioids are released when there is social interaction/ engagement; and when there are low levels of endogenous opioids, people/ mammals show motivation to engage and search for social contact (Kyte et al., 2020; Nelson & Panksepp, 1998). BOTSA has several predictions, which include: Agonists that of endogenous opioids would promote feelings of social well-being, which would reduce connection-seeking behaviour and motivation to seek proximity to others; conversely, endogenous opioid antagonists that block opioids would increase motivation to seek social connection and proximity but would decrease the reinforcing nature of the connection (Panksepp et al., 1994).

When people experience attachment trauma, adverse childhood events, or traumatic events early in life, the natural neurochemical systems related to these neurotransmitters may result in deficits in these areas later in life (Felitti et al., 1998; Kyte et al., 2020). Taking opioids will act on the brain system that affects attachment, which has profound reinforcing effects since social attachment is one of the most foundational and powerful organizing processes in human life and can help with emotion regulation and pain reduction (Kyte et al., 2020; Maté, 2010). If a person was deprived of safe attachment or experiences trauma, which occurs in the context of a relationship, opioids could provide a synthetic substitute that allows the person to regain a sense of regulation, connection, and restoration (Kyte et al., 2020; Maté, 2010). Due to the opioid crisis in the DTES and Canada, understanding the role of attachment systems and BOTSA is particularly relevant for practitioners working in addiction recovery programs.

Moreover, disruption in early patterns of caregiver attachment can have significant implications for a person's ability to create secure relationships later in life, resulting in a further lack of connection (Ainsworth, 1989). The emotional suffering experienced in isolation activates the same neuropathways as physical pain. In other words, the brain experiences physical and emotional pain through the same pathways and in the same way (Pellissier et al., 2018). In fMRI scans, researchers found that the same neurocircuitry is activated when a person experiences social rejection as when a person experiences physical pain (Eisenberger et al., 2003). The authors suggest that the role of social pain is like physical pain in how it mobilizes a person to initiate repair in relationships and respond to social injury. In the context of problematic substance use, opioids can provide the felt experience of connection, reduction in pain, and relief from distress that someone might experience via safe relational repair and restoration of connection (Kyte et al., 2020; Pellissier et al., 2018).

Opioids also have an analgesic effect on physical pain and are some of the most common forms of prescription painkillers; since physical and emotional pain both act on the same neural pathways, the analgesic effects can provide rich insight into the role of opioid use disorder in the lives of people who cope with opioids. They relieve social, emotional and physical pain, all of which the brain experiences similarly (Kozlowska et al., 2014; Kyte et al., 2020). The anterior cingulate cortex, anterior insula, periaqueductal gray, and amygdala are all activated when a person experiences physical pain or social rejection (Pellissier et al., 2018). Additionally, social interaction activates brain regions implicated in both reward pathways and activating reward regions (the ventral tegmental area and dopaminergic raphe neurons), eliciting social behaviours and engagement in rodents (Pellissier et al., 2018). Although addiction and substance use are counterfeits of genuine safety and connection, given the intensity of pain of these unmet needs and the desire for relief, substance use is a logical response in the absence of being able to authentically meet these needs safely elsewhere (Christie, 2021).

Research on the Brain Opioid Theory of Attachment

A robust body of literature supports BOTSA, particularly in animal models (Machin & Dunbar, 2011; Manduca et al., 2021). The most developed body of research investigating the relationship between endogenous opioids and attachment is in non-primate animal studies, with substantial evidence supporting the theory (Machin & Dunbar, 2011; Manduca et al., 2021). However, the generalizability of the research to humans may be limited, as rodents and non-primate animals are less cognitively complex, and humans have a much more significant reliance on cortical functioning, particularly in social interaction (Machin & Dunbar, 2011). For example, rodents, which are most researched, rely more heavily on hormonal and sensory stimuli in their social processes, including attachment, bonding, sexual behaviour, and nurturance (Machin & Dunbar, 2011). Nonetheless, non-primate animal research offers rich insight from experimental manipulations that cannot be done in humans into the role of the endogenous opioid system in attachment processes.

In summary, from the research in humans and animals, it appears that endogenous opioids play an essential role in the social reward aspects of attachment and bond formation, motivation to seek social connection, attachment behaviours between young and their mothers, and pair bonding. Disrupting the endogenous opioid system affects maternal caregiving behaviours; it provokes an increased desire for connection and proximity and interrupts the formation of partner preference. In contrast, increasing the amount of opioids in the system (through administering exogenous opioids) decreases proximity-seeking behaviour, as animals appear to be ‘socially satiated’ through the exogenous opioids. Rather than seeking out social connection, animals appear to be satiated through the opioids, whereas blocking the opioids system stimulates animals to increase the level of opioids in their system via social connection.

These findings have important implications for recovery from opioid addiction; if the endogenous opioid system is implicated in motivation to seek social connection and social attachment, exogenous opioids could meet a need for social connection. Similarly, social community, relationships, and therapeutic support may have a particularly salient role in recovery from opioid use disorder due to the natural stimulation of the opioid system. These findings are consistent with the Recovery Oriented Systems of Care and Dislocation Theory model, which emphasizes the central importance of a sense of connection and belonging in either recovery from addiction, or the formation of addictions when they are lacking (Alexander, 2008).

Non-Primate Animal Studies. In non-primate animal research, blocking endogenous opioids and administering non-sedating doses of opioids disrupts maternal nurturing behaviours and increases attachment-seeking behaviours. More specifically, reducing the amount of available opioids in the animal’s system by blocking endogenous opioid receptors reduces how well the mother can care for the pup. For example, when researchers blocked the endogenous opioids of dogs with naloxone and separated the puppies from the mother, the naloxone did not change the mother’s motivation (the mother seeking out the puppies). However, it affected her competence in caring for the puppies (Panksepp et al., 1980). Although she sought out the puppies (displayed motivation), she would not return them to the nest areas as reliably and would more frequently drop them partway (impacted competence).

Additionally, blocking endogenous opioids through naloxone in rats increases the motivation for proximity among both rat pups and mothers; however, blocking endogenous opioids appeared to reduce the rewarding effects of receiving maternal nurturance in rat pups (Panksepp et al., 1980). Similarly, when researchers gave newborn sheep naltrexone to block endogenous opioid receptors (an opioid antagonist), they found that the control group spent significantly more time near the mother than those given the opioid antagonist (Shayit et al., 2003). This finding suggests that endogenous opioids may have a role in developing a preference for the mother.

In contrast, administering low doses of opioids reduces gregariousness but does not reduce the competence of maternal nurturing behaviour (Panksepp et al., 1994). In studies that investigated how increasing opioids would impact attachment behaviours, researchers administered low levels of opioids so that it would interact with the endogenous opioid system but not overwhelm the animal with sedating effects. When researchers gave morphine to rats, it reduced the responsiveness of the mother and her nurturing behaviours towards pups; when they reversed effects of the morphine through naloxone (an opioid antagonist), the maternal nurturing behaviour returned to baseline and was identical to that of the control rats that were injected with a saline solution (Bridges & Grimm, 1982). Among young animals, administering low doses of opioids reduces distress related to separation in puppies, rodents, and chicks (Grimm & Bridges, 1983; Panksepp et al., 1980).

Vocalizations of distress are how young humans and animals elicit maternal care. Opioids also impact the vocalizations of distress among young non-primate mammals. When researchers gave 3- and 7-day-old rat pups low doses of morphine, it reduced vocalizations of distress in pups during separation from the mother, suggesting that opioids have a role in attachment-related behaviours and systems (Carden & Hofer, 1996). Interestingly, morphine had a more substantial impact in reducing distress vocalizations in older pups (10 days). Similarly, the presence of a companion rat pup reduced the distress vocalizations in pups that were 14 days old more than they did among the younger rats. These findings may indicate that the endogenous opioid system may modulate behaviour differently in various developmental stages. Another study tested the same effects by looking at the vocalizations of distress among rodent pups lacking mu-opioid receptors that are made to provoke the mother to search for the pup (Moles et al., 2004; Oddi et al., 2013). They found that mice that lacked the μ opioid receptors had fewer vocalizations of distress (Moles et al., 2004) and that they were less robust (shorter calls and more constricted range of sound frequency) than the controls (Oddi et al., 2013). Similarly, when puppies were isolated, administering a low dose of oxymorphone reduced movements and vocalizations associated with distress (Panksepp et al., 1978).

Assessing behaviours related to the formation of pair bonds is another way of understanding the role of endogenous opioids in attachment behaviours, particularly in non-parental relationships. To evaluate the role of opioids in pair bonding, researchers focused on pair bonding in prairie voles with monogamous and stable mating patterns. Research looking at partner preference and pair bonding found that administering naltrexone (an opioid antagonist) disrupted partner preference among female prairie voles (Burkett et al., 2011). Further research also reflected that endogenous mu-opioids are involved in partner preference among prairie voles through hedonic preference; that is, the opioid system reinforces and is neurologically rewarding to mark the partner as preferable (Resendez, 2013). In summary, these findings suggest that endogenous opioids, specifically mu-opioids, have an essential role in the formation of pair bonding and that the opioid antagonists (such as naltrexone) can disrupt attachment formation (Furay & Neumaier, 2011).

Additionally, these findings have important implications for people recovering from opioid addiction. Naltrexone is a commonly prescribed pharmaceutical used to reduce recurrences of opioid use among people in substance use recovery. However, given the role of opioids in facilitating attachment bonds, naltrexone may disrupt the development of relationships and social networks, which are crucial to sustained recovery from substance use (Alexander, 2008; Furay & Neumaier, 2011).

One interpretation of these findings suggests that endogenous opioids may be one of the essential neurochemical components that contribute to the development of attachment bonds and facilitate maternal nurturing behaviours and proximity-seeking behaviours in young animals (Machin & Dunbar, 2011). These findings support the predictions of BOTSA; that opioids induce feelings of well-being and reduce the motivation to seek out similar effects through social connection, whereas, suppressing endogenous opioids increase the motivation to seek social contact. Although opioids have an essential neurochemical role in developing and expressing attachment behaviours, the cascade of other neurochemicals released concurrently and their confounding or supportive role must also be considered (Machin & Dunbar, 2011). Other important neuropeptides are involved in attachment and social bonding, such as oxytocin and vasopressin (Dunbar, 2010). These different neuropeptides are often released in cascades, making isolating each neuropeptide's specific effects more complex (Dunbar, 2010). However, a more thorough review of other neurochemical processes is beyond the scope of this paper. Although endogenous opioids may be one of many other neuroendocrine processes, considering their role is essential to support people recovering from opioid use disorder.

The importance of supporting the development of social relationships in opioid use recovery is supported by research on rats evaluating how social interaction with other rats can reduce heroin craving behaviour and self-administration (Venniro et al., 2019). Researchers trained rats to self-administer 60 seconds of social contact with other rats by pressing a lever. They then trained them to self-administer heroin by pressing a different lever. They looked at relapse rates of self-administration of heroin after one or 15 days of abstinence from heroin use. Rats self-administered heroin more after 15 days of abstinence than after one day of abstinence. However, when they were abstinent as a result of choosing to engage in social interaction rather than administering heroin, there was a reduction in the heroin craving effect; in other words, rats sought heroin more after more extended periods of abstinence, but they did so less when they were abstinent due to choosing to have social contact rather than having forced abstinence.

Supporting people in recovery to develop meaningful relationships and social relationships may have a two-fold benefit. First, having regular, meaningful social contact may naturally upregulate the amount of endogenous opioids in a person's nervous system via the attachment system and its interconnection with the endogenous opioid system. The natural increase in endogenous opioids may make the person less likely to crave exogenous opioids due to a deficit in their system. Additionally, having interpersonal connection, or better yet, a meaningful social community in which a person has membership and a role supported and appreciated by other community members, could address some of the underlying elements of dislocation (Alexander, 2000).

Dislocation theory proposes that the lack of psychosocial integration is one of the underlying causes of addiction and in fact, that addiction is a natural response to dislocation (Alexander, 2008). While dislocation theory has a very broad definition of addiction- that is, a truncated focus on a particular thing- it also emphasizes that addiction, as it presents in the Downtown Eastside of Vancouver, is a product of intense levels of dislocation. In contrast, psychosocial integration is defined as the living network of supportive relationships that a person has and the person's experience of belonging and engagement with a group of people who also accept and understand the person (Alexander, 2000).

Primate Studies. Comparatively, there is less research on primates (excluding humans). However, the findings suggest that endogenous opioids may play a more significant role in attachment and social behaviour in primates, and presumably humans (Machin & Dunbar, 2011). In humans and primates, cortical processes (rather than sensory, hormonal, and limbic processes) have a much more significant role in social processes and behaviours (Machin & Dunbar, 2011). As a result, primate research has important implications for understanding the role of opioids in attachment behaviours because the more complex social behaviours/ relationships and brain structure are more comparable to humans. Some researchers suggest that "endogenous opioids might be the neurochemical 'glue'" that helps humans to maintain complex social relationships over time in tandem with other cognitive and developmental processes (Machin & Dunbar, 2011, p. 1002; Dunbar, 2010).

One way of testing the role of endogenous opioids in social bonding and attachment behaviours is by evaluating their effects on grooming behaviours in primates. Grooming is an important social behaviour that promotes the development of social bonds and social alliances among primates (Dunbar, 2010). Grooming often occurs after mating to reinforce social affiliations between mother and infants, to reestablish peace after aggression, and to maintain social cohesion (Fabre-Nys et al., 1982). Social bonding in primates involves cognitive and neurochemical processes; the neurochemical processes underlie the cognitive processes and provide the physiological context for social relationships to form (Dunbar, 2010). Additionally, grooming stimulates the release of endogenous opioids- that is, mu-opioids/ beta-endorphins (Keverne et al., 1989; Loseth et al., 2014).

Studies in primates suggest a strong link between endogenous opioids and grooming behaviours. An early study found that administering naloxone and naltrexone to block endogenous opioids in male talapoin monkeys increased behaviours to seek grooming from other monkeys (Meller et al., 1980). However, these behaviours were not associated with self-grooming, and suggest that the motivation to seek grooming may be socially motivated; the researchers suggest that the deficit in available endogenous opioids via the opioid antagonist may have led the monkeys to seek social assurance to compensate (Meller et al., 1980). Further studies with a larger sample size, including male and female talapoin monkeys, replicated these findings; naloxone and naltrexone increased grooming invitations and behaviour 15 minutes after administration without other significant changes to their behaviour (Fabre-Nys et al., 1982). Other studies have corroborated these findings that opioid antagonists increase grooming behaviours and administering opioids decreases it in primates pointing to the possible neurochemical role of opioids in social attachment (Graves et al., 2002; Keverne et al., 1989). These findings support the hypotheses of BOTSA in that blocking endogenous opioids would increase the motivation for social attachment.

Another way to understand the impact of endogenous opioids on attachment behaviours is to evaluate their impacts on vocalizations of distress during separation, in which young primates call for their mother when separated. In one study, when researchers separated infant rhesus monkeys from their mothers, and a human walked into the room, they observed the differences in the activation of the defence cascade and implications of the endogenous opioid system (Kalin & Shelton, 1989). First, if the person did not look at the monkey, it would become silent and motionless, suggesting the first activation of the defence cascade- a hyper-freeze response in which a freeze response occurs with high levels of sympathetic activation. When they looked at the monkey, it would start barking (an aggressive and defensive behaviour), suggesting the activation of the sympathetic nervous system and a fight response. When researchers gave the monkey a low, non-sedating dose of morphine, the vocalizations of distress decreased. In contrast, when researchers administered naloxone, an opioid antagonist, to reverse the effects of the morphine, the barking increased. Similarly, administering naloxone, an opioid antagonist in young rhesus monkeys, resulted in more distress vocalizations, more time close to the mother, and attempts to suckle among infants (Martel et al., 1995). Similarly, mature females sought and received more grooming from other monkeys when naloxone resulted in fewer available opioids.

Additionally, the motivation for social contact via the endogenous opioid system may change depending on whether a person or animal is in a state of homeostasis or distress (Loseth et al., 2014). For example, for social animals like primates, and humans, isolation and separation can result in greater levels of distress. In this case, they may seek social contact for comfort, stimulating the release of endogenous opioids. In contrast, when a social animal/ person is in a state of homeostasis, social contact for other purposes, such as pleasure, relational maintenance or play, which also stimulates the endogenous opioid system. Researchers suggested that the social nature of different animals might account for the differences in findings between rodent and primate studies; when the rats were given non-sedating doses of morphine after social isolation, there were increases in social play (Trezza & Vanderschuren, 2008a, b). In contrast, the opposite was found among primates which are more social animals (Loseth et al., 2014).

Human Research. The most limited research exploring the relationship between endogenous opioids and social attachment is among humans, largely because of ethical challenges in methodology (Machin & Dunbar, 2011). Several ethical complications in facilitating human research include disrupting the attachment process, exposing people directly to opioids, and inhibiting endogenous opioids to alter attachment processes. As a result, research has focused on alternative methods of garnering data, such as evaluating proxy measures like serum levels of endogenous opioids or pain thresholds. PET scans have also been used in studies but are expensive, making them less accessible and less feasible to have robust sample sizes (Machin & Dunbar, 2011). Human research is also early and thus far has not focused on validating BOTSA. More research explicitly focused on testing BOTSA is needed.

In studies with humans, it appears that opioid use interferes with social behaviour. In one study, researchers observed impaired emotion perception and capacity to make correct inferences about social situations among people on opioid maintenance therapy compared to controls matched for age, sex, IQ, and psychological distress (McDonald et al., 2013). Research on rejection, exclusion and isolation in humans, such as the literature reviewed in previous sections, is one way of understanding the relationship between the attachment system and the opioid system. Proxy measures such as pain thresholds are also used to measure the interaction of social connection and the endogenous opioid system.

Discussion on Findings of Animal Research & Implications for Recovery

There is a clear relationship between social connection and social motivation with the endogenous opioid system. The findings reviewed on primate research, and the findings previously discussed suggest that a deficit in bioavailable endogenous opioids increases attachment-seeking behaviours, and exogenous opioids can replace the need for social contact and alleviate attachment distress during separation. These conclusions have important implications for recovery from opioid addiction when people are regularly experiencing alterations to their opioid systems and have higher rates of attachment trauma (Kyte et al., 2020; Manduca et al., 2021). Supporting people in recovery to develop and access supportive social networks, develop meaningful relationships, address intrapersonal and interpersonal barriers to relationship development, and increase their recovery capital may increase the likelihood of sustained recovery from opioid use disorder.

Although, the exact reason for addiction likely differs for every person. For some, exogenous opioids may have been sought for comfort when social support was unavailable. If there was a deficit in the endogenous opioid system as a prior lack of social connection (or disrupted attachment), using exogenous opioids may have been particularly reinforcing as they would have increased the level of opioids in the person's system (and which the system may have been 'craving'), as seen in the animal research reviewed. Suppose substance use was common in a person's environment and was normalized. In that case, substance use may have also provided a way to build social connections, which naturally would upregulate the amount of opioids released in their nervous system. In this case, the stimulation of the opioid system by both social connection and the corresponding natural release of endogenous opioids and through the rewarding properties of exogenous opioids would reinforce opioid use. Alternatively, someone may also have been prescribed opioids for medical reasons and then experienced ongoing cravings and developed patterns of problematic substance use, whereas other people may be able to discontinue the medication without problem; in this case, the individual differences in a person's endogenous opioid system may account for at least some of the differences in patterns of addiction and continued drug seeking.

Additionally, since opioid use stimulates the mu-opioid receptors, this reduces the slow release of dopamine neurons in the brain, results in the intense stimulation of the mesolimbic dopamine system and a feeling of euphoria (Martinez et al., 2022). In other words, using exogenous opioids stimulates the mesolimbic dopamine system, which is the brain's 'wanting' and reward pathway (Trezza et al., 2011). While social contact would activate the reward system in a healthy and more subdued way, exogenous opioids would activate the reward system in an unnaturally intense way. So, if there was a deficit of endogenous opioids due to a lack of stable social connection, using exogenous opioids (whatever the original and individual reasons were), the exogenous opioids could satiate the neurochemical 'hunger' for social connection but also powerfully activate the addiction reward center in the brain that reinforces the behaviour. While much of the animal research reviewed above focuses on social attachment in infancy, other animal research has demonstrated the reinforcing nature of social interactions across the lifespan, specifically in maternal-infant behaviour, social play, and sexual behaviour (Trezza et al., 2011). Although it may not be possible to determine the nature of the relationship between the opioid system and problematic substance use, meaningful social connection may have an essential role in developing opioid use disorder and recovery.

Chapter 3: Discussion, Implications, Recommendations and Conclusion

The severity of the opioid crisis in Vancouver has intensified over the last 10 years with increasing overdose-related deaths. Among people living with opioid use disorder, a disproportionate number are also living with PTSD and have high rates of adverse childhood experiences compared to the general population. Given this context, the purpose of this capstone is to provide a conceptual understanding of opioid use disorder, particularly considering the human attachment and survival systems and how they interact with the development and maintenance of opioid use disorder. A conceptual understanding of opioid use disorder in light of interpersonal neurobiology can provide health practitioners working in substance use recovery services with insight to develop more specific and strategic therapeutic interventions to support people in recovery from opioid use disorder and trauma.

Discussion

We are profoundly wired for connection, interdependence, and attachment with other people from the first moments of life. Attachment Theory details how attachment and relational interdependence are formed and persist over the lifetime. The need for safety and attachment is so essential for human life that the corresponding systems that regulate safety and attachment (the survival-stress response/defence cascade and the social attachment system) essentially organize the human experience. Through the thousands of attachment exchanges that promote secure attachment and the repair of relational ruptures in which a caregiver regulates the nervous system and emotions of an infant/ child, a child develops the capacity for self-regulation later in life (Schore, 2016). In other words, secure attachment exchanges regulate the survival-stress response of the infant/ child, which shapes their self-regulation circuits and processes. These experiences of attunement, soothing, responsiveness, predictability, and delight (or lack thereof) from the caregiver draw the blueprints/ inner working models for the infant/ child's understanding of themselves in relation to other people and their environment and if they can expect safety or danger, responsiveness or lack.

While secure attachment primes an infant's nervous system to expect safety, caregiver responsiveness, and that their needs will be met, early attachment injury/ insecure attachment primes the nervous system to expect the opposite. An unresponsive, inconsistent, or frightening caregiver prepares the infant's nervous system to engage the defence cascade quickly; to anticipate danger; and expect that their caregiver/ people in their lives will be unresponsive, unsafe, or unpredictable. Oliver Morgan (2019) eloquently articulates this reality:

> Our neural machinery anticipates, indeed expects, these [supportive attachment] interactions; without them, there is over time an experience of pain and loss. The absence of attuned connection betrays an existential promise woven into our human fabric. As we have seen, without these interactions- or with abusive, traumatic, or neglectful interactions- a troubled future becomes more likely. (Morgan, 2019, p. 99)

We are hardwired for connection and interdependence; without secure and responsive connection, people do their best to adapt to a disordered social ecology.

Moreover, the undeveloped nervous system of the infant draws upon the mature nervous system and capacity for affect regulation through interpersonal neurobiological processes (Siegel, 1999). In other words, the infant's undeveloped nervous system synchronizes with the caregiver's developed nervous system. One way that intergenerational trauma is transmitted between generations is through these interpersonal neurobiological processes; essentially, the caregiver's dysregulated nervous system can prime the infant's nervous system to anticipate danger. While many other factors contribute to the transmission of intergenerational trauma, including relational, sociological, behavioural, and structural elements, this is one facet that should be considered when supporting recovery among survivors and communities.

If nervous system dysregulation is a biological signal of danger or life threat, then the regulation of emotion and the ability to stay within the window of tolerance essentially becomes a primary biological imperative. In light of this, anything that aids a person in returning to the window of tolerance and managing dysregulation may be associated with supporting their survival, even when it has other negative consequences. Exogenous opioids hijack the related neural systems meant to support safety, survival, and attachment, including the reward-motivation system, the survival-stress response, the social attachment system, the pain system, and self-regulation processes and circuits. On a neurochemical level, opioids satisfy the biological imperatives for self-regulation, which essentially become equated with survival and social attachment.

People also form adaptations to help them engage and survive in environments where they experience unsafety, disconnection, and a disordered social ecology. These adaptations can be helpful to survive in an unsafe environment and cope with relational malnutrition. However, they can become barriers and stumbling blocks in a healthy, safe social context, providing further challenges to people developing the meaningful social connections they need. Adapting to an unsafe environment or disordered social ecology evokes painful emotions and feelings of dysregulation, which usually requires a person to disown or fragment off part of their experience, including the thoughts, emotions, or desires that are unsafe or not tolerated within the environment. This fragmentation of the internal experience can happen through structural dissociation and/or substance use. While addiction and substance use is often understood as an intrapersonal issue, it reflects a more significant social reality: a suboptimal or unhealthy social environment that fails to provide the 'nutrients' required for human flourishing.

Opioids, Attachment and Self-Regulation

The addiction field has primarily focused on the reward-motivation system in the brain, resulting in heavy use of behavioural or cognitive-behavioural interventions to treat addiction. While the reward-motivation system is an essential neural system involved in forming and maintaining opioid addiction, several other critical neural systems are involved, many of which are strongly influenced and shaped by interpersonal neurobiological processes. Understanding the other neural systems can inform more well-rounded therapeutic interventions and approaches.

Opioids are one element of a cascade of other naturally occurring neurochemicals that orchestrate and reinforce attachment bonds. The endogenous opioid system interlaces the attachment system and reinforces attachment in healthy, supportive, and dependable relationships. In contrast, within the context of insecure attachment, the endogenous opioid system is unsatiated and under-stimulated by meaningful social connection, resulting in an increased vulnerability to problematic substance use to regulate the experience of disconnection. Moreover, since natural social interactions are not satiating the endogenous opioid system, exogenous opioids are extra reinforcing, as they meet the internal craving and neurobiological 'appetite' for opioids.

Within the context of attachment insecurity, trauma, or abuse, the role of substance use, and specifically opioid use, could be viewed as a means to ameliorate a deeper issue of disconnection, a lack of attachment security, or as a tool to self-regulate intolerable nervous system states and the impacts of trauma. Morgan (2019) proposes that addiction is an attachment disorder; he suggests that a substance must provide any of the following to fulfill the role of an attachment substitute: it provides a sense of comfort, relief, reward, analgesia, or diversion. As highlighted in the research reviewed in this paper, opioids have direct access to the attachment system and facilitate all these effects.

Without the experience of secure attachment exchanges during key developmental periods, a person misses the first ingredient to develop the capacity for self-regulation; co-regulation must occur before the capacity for self-regulation can mature. For example, a person may not have experienced co-regulation with a caregiver who could regulate their emotions and subsequently did not develop the capacity to self-regulate. In addition, traumatic experiences compound the impact of an underdeveloped self-regulation system compounds. A person is then left with overwhelming and intolerable internal states and without the capacity to organize their experiences, and further barriers to connection and co-regulation due to insecure social attachment patterns. In this context, substance use is a logical response to self-regulate these intolerable internal states, experiences of social disconnection, and self-alienation emerging from structural dissociation.

Moreover, exogenous opioids tap into the endogenous opioid system, which is the neurochemical foundation of the formation of social attachment. Using opioids satiates the neurochemical ‘hunger’ for social attachment by artificially stimulating opioid receptors in the brain, which may already be under-stimulated because of a lack of secure relationships. Additionally, opioids depress the central nervous system; if someone is experiencing frequent nervous system dysregulation, stress, anxiety and hyperarousal, opioids will also soothe these feelings of dysregulation. Opioids mimic a secure attachment relationship in these ways- they stimulate the same neurochemical attachment-related pathways and soothe dysregulation and distress.

Furthermore, PTSD/ nervous system dysregulation from trauma and opioid use can be mutually reinforcing. The symptoms of opioid withdrawal mirror the same symptoms of hyperarousal which a person may experience if they have PTSD or nervous system dysregulation due to traumatic experiences (Danovitch, 2016; Piazza & Le Moal, 1997). If a person uses opioids to regulate hyperarousal symptoms, having concurrent PTSD can make it more challenging to sustain recovery. This is because the symptoms of PTSD may be a primary trigger to use opioids and then become secondarily associated with symptoms of withdrawal, reinforcing patterns of opioid use. A person may be more likely to be exposed to harmful or unsafe environments that could result in trauma and the formation of PTSD because of their opioid use. Additionally, the survival-stress response causes a release of hormones that sensitize the brain's reward-motivation pathways to be more sensitive to exogenous opioids and susceptible to opioid dependence, even in comparison to other drugs (Piazza & Le Moal, 1997).

In summary, from the literature reviewed on the neurological systems implicated in the development and maintenance of addiction, it appears that everything comes down to a need for safety and attachment. When these two fundamental needs are unmet, people do their best to adapt to a disordered social ecology and need for safety. It appears to be a slippery slope: attachment processes regulate the stress system in infants/ children, which develops their later capacity for self-regulation, their implicit sense of self, and relational blueprints. All these systems then influence a person's capacity to engage in secure relationships later in life, their repertoire of coping with distress, their susceptibility to developing PTSD, and how primed their reward-motivation system is from exposure to stress. A cascade of adaptations occurs when these two fundamental needs for safety and attachment are unmet, making addiction or other problems more likely. This is not to say that addiction is inevitable, but the experience of addiction is better understood in light of these neural systems and processes.

The good news is it appears that the roots of the issue are simple: there is a need for safety, regulation of the nervous system, and social attachment that lay the foundations for other purpose-oriented and existential questions. However, the ecology of human life and the inner world is complex. Safety has many different meanings and implications, particularly in complex social worlds full of symbolic threats to safety and survival; for example, a social conflict at work becomes a possible threat to employment, which could result in a person no longer being able to pay rent and meet their basic needs, and thus a threat to survival. Moreover, unlike infants and children who are just drawing the blueprints for their implicit sense of self, sense of safety and patterns of relating to others, adults in addiction recovery already have formed these patterns. Recovery requires a repatterning of ingrained, subconscious/ subcortical, and automatic processes reinforced over years to ensure survival. Repatterning these processes is a complex task that requires significant vulnerability, nurturing and supportive relationships, and a safe environment. Additionally, even while it may be possible to support a person to change internal ways of relating to themselves and others, all people still exist in a broader social ecosystem that may be disordered and have generated the need for substance use and adaptation within the person in the first place.

This evokes the question: where do we go from here? This is a huge question beyond the scope and work of any single person. In fact, it requires a response from all people that make up a wider local and global community. Developing a social ecology that does not facilitate addiction necessitates a response on a personal and macro level, as the social, economic, political, and familial structures impact everyone, benefiting some and marginalizing and excluding others. In subsequent sections, I offer only a few practical recommendations considering the three theoretical models used to frame the research reviewed throughout this paper: Dislocation theory, attachment theory, and polyvagal theory. The recommendations below are not intended to be comprehensive or exhaustive but offer additional insights in addition to the existing cognitive-behavioural therapeutic approaches that dominate the addiction field. Furthermore, these recommendations are intended to be implemented alongside existing models and publications and local community knowledge, such as that from indigenous communities, churches and other spiritual groups, and countless other communities. These non-academic and professional communities have supported people long before social care became professionalized and have important wisdom from which to learn.

Dislocation Theory: Recommendations and Opportunities for Intervention

Recovery-Oriented Systems of Care & Recovery Capital

Dislocation Theory and a recovery-oriented system of care (ROSC) can help orient the therapeutic process and goals of counsellors supporting people in recovery. They emphasize the importance of understanding the broader context of people living with addiction. Since many relationships are damaged or lost during active addiction, such as relationships with natural social connections, cultural and spiritual communities, employers, and medical and mental health professionals, it is essential to help people reconnect with these supports in recovery. Access to many other vital resources during addiction, including financial security, housing, and medical services, is also lost, in addition to new problems that may arise, such as debt, legal concerns, custody issues, and medical/ psychiatric concerns. Any of these issues can be stressful, even in the absence of other concurrent problems or addiction. However, many people living in the

DTES of Vancouver who are in recovery from substance use may need to address multiple or all these challenges during their time in an addiction recovery program. Learning to manage all these challenges can be overwhelming; people may not know how to access relevant resources or may be unable to sustain long-term recovery from addictions without a support network when they leave a residential recovery program.

While it may appear evident that supporting the recovery of the broader context of a person's life is an essential part of the recovery process, particularly if the context contributes to and sustains the process of addiction, often acute addiction treatment programs fail to support these elements. The medical model of addiction has profoundly shaped how addiction is understood and treated over the latter part of the twentieth century (Alexander, 2008). The medical model treats addiction like any other medical disease; it conceptualizes addiction as a medical problem within a person, which professionals then diagnose and treat the acute symptoms (Sheedy & Whitter, 2013). Addiction has primarily been conceptualized as a disordered reward-motivation system and problematic behavioural patterns. Corresponding treatment interventions have then focused on pharmacological interventions and problematic psychological and behavioural patterns within the person during a short-term 30 to 90-day residential treatment program. While these treatment interventions are helpful, they are insufficient to produce long-term recovery from addictions and have meagre success rates for long-term recovery (Hubbard et al., 2001).

In recognition that the acute treatment model is not producing sustained recovery for people accessing care, a paradigm shift has occurred over the last 20 years in the addictions and mental health field (Kourgiantakis et al., 2020). As an alternative treatment model, 'recovery-oriented systems of care' (ROSC) were introduced (Substance Abuse and Mental Health Service

Administration [SAMHSA], 2010; White, 2008). A ROSC is a fulsome network of supports, including a microsystem, mesosystem, and macrosystem of supports that support a recovery-oriented lifestyle for the person in recovery. The microsystem includes a person's daily support network and personal relationships and either facilitates or interrupts the maintenance of their recovery (White, 2008). The mesosystem includes community, peer-based, spiritual, indigenous, and professional support and relationships that help people and their families sustain long-term recovery (White, 2008). The macro-system involves policy, governance, available funding, professional associations, education, laws, media, recovery-related organizations, businesses, and cultural attitudes; within this context, the person in recovery continues to live and through which their recovery is sustained (White, 2008). The ROSC is the entire system at a one-to-one level up to the federal government level that supports the ongoing recovery of the person (Sheedy & Whitter, 2013).

A complete review of this topic and the implications of a ROSC for addiction treatment programs is beyond the scope of this paper. However, supporting people in recovery to create sustained support networks is essential. The focus of addiction recovery programs should be supporting people to recreate meaningful connections, recover a sense of purpose and identity, and self-regulate without the assistance of substances (Fisher, 2017a).

Implications for Recovery Programs

Case Management, Assertive Linkages & Partnership Development. Providing intensive case management support and assertive linkages with a network of other supports becomes essential to the recovery process (Best, 2019). This process should be a person-centred and collaborative process directed by the person in recovery in collaboration with any other support persons they choose to involve and requires all professionals to collaborate. It also requires the development of relationships and strategic partnerships with other community groups and agencies to form a collaborative circle of support for the people in recovery so that case managers and clinicians can make appropriate referrals specific to the person they are working with. Case managers can bridge relationships with other communities, cultural and spiritual supports, interest groups, employment and education services, primary and mental health services, and care professionals to support the person in building a community of care. Additionally, involving recovery coaches or peer navigators/ peer support can provide support to provide support and bridge the relationship.

Community Asset Mapping. Community asset mapping identifies community assets and resources that people in the recovery program could connect with (Best, 2019). A variety of people should be included within the process, including professionals, volunteers, and people from within the recovery community who are aware of different resources and have diverse interests. Community assets can include services, such as primary and mental health services, but should also include groups where people in recovery can form natural, reciprocal relationships. These natural supports may include sports and recreational groups; education and employment resources; arts and culture groups; volunteering and community engagement; support and recovery groups; other informal social groups and associations; and cultural and spiritual groups.

Recovery Capital. Recovery capital is a succinct model that integrates the primary tenets of a ROSC into an easily accessible model for recovery programs to implement (Cloud & Granfield, 2008). It is the quality and extent of a person's internal and external resources to support them first to enter and maintain recovery from addiction (Cloud & Granfield, 2008). Using Recovery Capital as a framework can support a well-rounded, holistic, and integrated model to guide the case management process.

In a meta-analysis of research on recovery capital, Hennessy (2017) identified eight primary domains of recovery capital, which include physical capital, human capital, health capital, growth capital, social capital, family capital, cultural capital, community capital, and negative capital. These aspects of recovery can inform case management services and assertive linkages made within an addiction recovery program and programs that offer a continuum of care. By providing recovery services that include these domains, service providers can provide more holistic care by addressing the ecology of a person's life in which they are embedded. Just as a plant in unhealthy soil does not thrive, a ROSC and recovery capital model treats the person and the environment in which they live to promote sustained and long-term recovery.

Meaningful Social Connections & Social Inclusion

When people experience rejection and social exclusion, researchers observe deficits in self-regulation (Baumeister et al., 2005). People in addiction recovery regularly need to practice self-regulation to manage cravings and triggers. Considering that many people in the DTES face systemic discrimination such as racism, colonialism, sexism, and classism, people in recovery may be continually exposed to rejection and exclusion, which could make it even more challenging to self-regulate. In research on social rejection, participants are exposed to rejection by strangers or in an unnatural setting and then are required to practice self-regulation for a relatively short period. However, in natural settings, people recovering from addiction may be experiencing rejection and exclusion due to their addiction in far more emotionally charged settings in relationships with much higher stakes, such as with spouses/ partners, children, friends and workplaces. This may be in addition to experiencing systemic discrimination.

Additionally, the capacity for self-regulation is an essential skill for maintaining social relationships, delaying gratification, and making health-oriented decisions when the healthy option is less gratifying (Baumeister et al., 2005). However, a lack of self-regulation can perpetuate cycles of addiction, social exclusion, and dysregulation. It is, therefore, important to support people in recovery from opioid use disorder to find ways to experience social inclusion, develop social skills necessary to initiate and maintain relationships, and alternative skills to self-regulate without the use of substances.

Membership within a social community shapes a person's identity and self-concept (Best, 2019). Among people in recovery from substance use, people with more extensive social networks with people who do not use substances and who had more frequent contact were found to have better treatment outcomes (Zywiak et al., 2009). A person's social identity and sense of self are shaped by interactions with other people, both at an implicit attachment level and through explicit social exchanges and conscious membership within groups. Membership within a social group that shares values of a recovery-oriented lifestyle is important because the group influences the values, norms, and goals and subsequently influences the individual (Best, 2019). Groups provide support and a sense of belonging which is essential for all the attachment-related needs discussed throughout this paper. Additionally, they confer social identity and roles, influence their members' behaviours and values, affirm their members' views and beliefs, and provide a sense of understanding for unique challenges.

Social Development Plans and Case Management. Practitioners and case managers can support people in recovery by intentionally working on social development plans. Considering that social connectedness and belonging is an essential aspect of sustained recovery from addiction, case managers should intentionally work with participants in recovery to access and develop social networks, just as they would work with people to develop plans to manage health concerns. This can include identifying possible relationships to invest in or places to build social connections, along with some practical goals/ steps that they can take to rebuild social connections. This work should be coordinated with the counsellor, who can support the person in navigating issues of social anxiety, negative self-perceptions, or other related challenges. Additionally, case managers should develop relationships with other community groups, such as cultural, recreational, or spiritual communities, so that they are aware of the resources available in the community and can make personalized referrals.

Advocacy, Public Education and Stigma Reduction. Developing and facilitating public education and family education around the nature of addiction to reduce stigma and promote inclusion may reduce the amount of rejection that people in recovery face regularly. Specifically, targeting groups that people in recovery regularly interact with can increase the impact, such as providing education to health care, public services, spiritual communities, and families. This promotes recovery-oriented systems of care at the micro- and meso-level to improve the receptivity and support for the person in recovery. Interventions to improve the quality of relationships within a family system can improve recovery outcomes and the well-being of all members. Additionally, support and education programs for family members, partners, or other personal supports of people in recovery that address stigma and provide insight on how strategies to support someone in recovery can be helpful.

Developing Inclusive Communities. While people with lived experience of addiction or who are members of the DTES often experience additional stigma related to poverty and addiction on top of other forms of systemic discrimination, recovery programs can begin to address this issue by facilitating inclusive peer-led communities as part of their continuum of care. Creating inclusive communities in which people in recovery can experience belonging and acceptance may support self-regulation and serve as an incentive for maintaining sobriety (Best, 2019). These communities are places where people can find mutual, reciprocal supportive relationships accessible outside of typical business hours. Practitioners in recovery programs can work with participants in programs to develop leadership skills and provide resources and opportunities for participants to facilitate social events and opportunities for social engagement. Programs should facilitate activities that encourage the development of these natural and cultural communities among participants.

Peer Leadership. Supporting peer-led communities can also provide opportunities for leadership and meaningful roles in which people can contribute to their community (Best, 2019). Dislocation Theory highlights how addiction is a natural response to lacking belonging and social roles. Therefore, recovery programs can intentionally provide meaningful roles that people can fill to contribute to their community. This may include supporting other people who are in earlier phases of recovery than they are to connect with external resources or to co-facilitate some of the programming with staff. Additionally, practitioners can look for opportunities for participants with specific skills, such as culinary training to teach others or contribute their skills uniquely. Peer models are supportive for the person receiving support and the peer leader may also receive as many benefits as the recipient. Additional benefits include creating a recovery culture within the program in which recovery-oriented social norms can develop and powerfully shape values, behaviour, and a sense of empowerment among participants.

Peer Social Navigators. Like peer leadership opportunities, peer social navigators are individuals who are in recovery, and have actively participated in and attended multiple social groups and communities identified in the asset mapping process described above (Best, 2019). They help connect newer participants with these social groups and can attend/ explore new groups with other participants to bridge community connections. Peer Social Navigators receive training on how to provide peer support and are taught expectations on how to provide support safely and transparently. They have regular check-in meetings with staff members for support and supervision and to ensure that their recovery needs are met and supported.

Attachment Theory: Restoring Connection and Recommendations

As discussed throughout the research reviewed on BOTSA, the endogenous opioid system is part of the neurochemical foundations of the formation of attachment bonds. While opioids are only one neurochemical in a cascade of many others that support the formation and maintenance of attachment bonds, they are one reason that using exogenous opioids can powerfully impact a person with trauma and insecure attachment patterns. People with disorganized attachment had the highest rates of exogenous opioid use compared to all other attachment styles (Hovelius et al., 2021). People with disorganized styles may not have an attachment strategy to manage emotions or attachment distress, making substance use a potentially desirable and highly reinforcing option, considering the lack of other patterned attachment responses (Schindler et al., 2009). Opioids also can satisfy the neurochemical 'appetite' for social connection that would trigger the release of endogenous opioids by using exogenous opioids. While using exogenous opioids is a counterfeit for genuine, meaningful relationships, it can function as an attachment substitute. It helps the person calm/ regulate emotional distress and provides a (neurochemical) sense of connection and well-being.

Attachment Related Interventions

Although providing new tools for coping and self-regulation is an essential part of the process, more than these tools are needed to sustain long-term recovery in the absence of meaningful connections. Similarly, while skill development and goal-oriented programming are helpful and arguably essential, the quality of presence among the staff in how they can attune to clients and each other is foundational if practitioners hope to foster change at a nervous system and attachment level among the people they serve. This provides a corrective experience for the people seeking care through the services; it is through the relational exchanges that demonstrate to a client that people are available to them when they are in distress, these people are predictable and safe, and they will not abandon the client that the client's internal working models/ attachment style begins to shift. Given this, the relational fabric of the people that make up a program cannot be understated.

The Therapeutic Relationship. The therapeutic alliance between a therapist and client can be a powerful tool for providing a corrective experience and supporting people with insecure attachment patterns to experience attachment security in the therapeutic relationship (Wallin, 2007). The goal of the therapeutic relationship is to provide the client with a new experience in relationships in which the counsellor (or helping professional) acts as an attachment figure that is consistently available and safe (Morgan, 2018). Rather than focusing primarily on the explicit verbal content of psychotherapy, without denying its importance, the most profound transformative therapeutic work occurs in the attachment-based, non-verbal, affective exchanges (Schore & Schore, 2008).

Building a strong therapeutic relationship should be prioritized, and practitioners should use the principles of Attachment Theory and Person-Centered Therapy. David Wallin suggests that 'we are the tools of our trade' (Wallin, 2013). Considering this, it is important for mental health workers to work from an attachment-oriented perspective. Staff and counsellors in recovery programs enact secure base and safe haven behaviours, which supports relational safety. The relationship can afford the opportunity for the client to have new attachment and relational experiences. For example, if a person is becoming dysregulated as a result of a conversation, when staff are attuned to the client and can notice that there is dysregulation, they can initiate relational repair. This is an attachment interaction that can provide the experience of positive relational repair, which the client may not have experienced (Wallin, 2007). All interactions in this sense are therapeutic; from speaking about the hobbies of a client while preparing dinner to working through complex relational ruptures after a positive drug screen, staff have the opportunity to provide a positive attachment experience for the client through their actively attuned and attentive presence (Wallin, 2007).

Counsellors and recovery staff should focus on having attuned, compassionate, empathetic, curious, and accepting interactions with the people they are working with. This promotes the experience Daniel Siegel (2010) describes as, 'feeling felt'. Feeling felt involves allowing our internal experience to attune and become resonant with another person's internal experience, which is needed to feel connected to another person. Children need the experience of 'feeling felt' throughout development to form a secure attachment and the capacity to feel connected and close to other people. However, when they do not experience this, it is possible to develop earned secure attachments in adulthood through corrective experiences and safe relationships. This provides a sense of emotional resonance, feeling understood, connected and safe within the relationship.

Additionally, there is more potential for people accessing a live-in recovery program to develop supportive attachment relationships between the client and staff. However, live-in recovery programs should also be mindful that when a client transitions from the program, they would be losing one or multiple new attachment relationships. As such, it is important for recovery programs to intentionally support clients in the program to develop a supportive network beyond the live-in program.

Meta-Processing the Therapeutic Relationship. The attachment style of the counsellor will implicitly influence and shape the relationship and interactions with the client in the therapeutic context (Wallin, 2007). Wallin (2007) asserts that neither therapeutic objectivity nor counsellor neutrality is possible, and he emphasizes the importance of the client and counsellor's attachment style in the therapeutic work. The author notes that the counsellor's role is to become an expert in identifying the attachment-related enactments and meta-processing them in session to provide a corrective attachment experience for the client.

The counsellor will attend to the attachment exchanges between themselves and the client throughout the therapeutic process. Specifically, they will look for the moments of attunement, misattunement/ ruptures, and re-attunement/ repair and then bring these moments to conscious awareness with the client to meta-process within the session (Morgan, 2018; Wallin, 2007). Drawing mindful attention to states of defensive activation while maintaining enough self/co-regulation to be present and then simultaneously bringing conscious awareness to a new, corrective experience supports the process of memory reconsolidation (Morgan, 2018).

Memory reconsolidation reprocesses subcortical, implicit memories and affective states underlying insecure attachment and the implicit self. In other words, bringing mindful attention to new experiences of secure relationships at the moment (when there is some level of activation of old internal working models) supports clients in developing new, secure internal working models and metabolizing the distressing feelings associated with old internal working models. In addition, this process of memory reprocessing helps clients update their beliefs about themselves and their relationships and supports psychological integration, particularly for clients with structural dissociation.

Attachment-Oriented Approaches. Attachment-oriented counselling approaches should be the foundation of therapeutic work with people in recovery (Morgan, 2018). From an attachment perspective, exploratory behaviours (i.e. secure base behaviours) require a child to know that they have a dependable, accepting and secure relationship that they can return to and provides the base and sense of security needed to explore their environment. Exploration is a significant part of addiction recovery. People need to make tremendous amounts of change to nearly all aspects of their lives, which involves both internal exploration and creating new life habits. Moreover, if substance use was functioning as an attachment substitute, people will need to experience alternative relationships that are safe, secure, and supportive resources to draw on instead.

Specifically, mentalization-based therapy supports clients in developing the capacity to mentalize, which is the ability to explore their inner state and those of others (Schindler, 2019). internal family systems (IFS) is an alternative approach that works with clients in individual therapy to integrate fragmented 'Parts' of the personality into the 'core self' (Schwartz, 2019). Janina Fisher's trauma informed stabilization treatment (TIST) is a similar approach that works with 'Parts' of the personality and is adapted to work with trauma survivors in early stabilization (Fisher, 2017a, b). In other words, through present-moment-focused and internally oriented work, IFS and TIST aim to help a person to integrate the somatic, cognitive, and affective elements of a person's experience and attachment memory into a cohesive sense of self. It is a transformative approach that helps clients 're-parent' 'Parts' of themselves and their experience and provides a corrective attachment-like experience for the parts carrying affective, somatic, and cognitive memories.

These approaches can be powerful because rather than simply overwriting patterns, addressing cognitive distortions, or addressing behavioural sequences, they can help clients to process and metabolize the affective and body-based memories stored in sub-cortical regions/ the right hemisphere that cannot be accessed through purely cognitive and behavioural approaches (Fisher, 2017a). For clients with early attachment injury or trauma, before they were verbal, these memories are encoded as sensations, feelings, and emotions detached from the declarative and narrative memory stored in the left hemisphere due to their stage of neurodevelopment (Fisher, 2017a). Therefore, somatic approaches or internal therapies (like TIST or IFS) are required to support clients in accessing and processing these forms of memory.

Development of Interpersonal Skills. The psychoeducation curriculum should integrate psychoeducation to promote the development of interpersonal skills, teaching skills to regulate anxiety in social situations, and opportunities to practice social engagement (Hayes & Hoffmann, 2018). Additionally, developing interpersonal skills and building and maintaining relationships should be considered as one of the therapeutic goals/ outcomes of recovery programs.

Practitioners can support interpersonal skill development by identifying and simplifying elements of social skills (such as verbal and nonverbal communication, paralinguistics, etc.), teaching the program participants, modelling them, and roleplaying with participants (Hayes & Hofmann, 2018). Additionally, practitioners can debrief and offer feedback to participants to help hone the development of the skill. Participants are then directed to practice in other natural situations and can debrief these interactions with counsellors or other practitioners.

A Parallel Process. A safe environment requires relational safety through all levels of the organization, both between the clients and frontline staff, and at peer, supervisory, and administrative levels, which supports a parallel process (Bennet, 2008). Supervisors and management can promote attachment-oriented approaches by facilitating a parallel process with their staff. If staff do not trust their supervisor or feel safe enough to discuss issues they are encountering in their work, the supervisor may not be able to support them in developing related competencies and may risk staff not raising ethical concerns or other issues that jeopardize client safety. Additionally, Fredricks (2018) found that relationship-specific attachment to a supervisor (rather than the person's general attachment style) predicted client interpersonal outcomes. As such, the relationship between the supervisor and staff is a critical element of clinical supervision. Centering the relationship between the supervisor and staff can increase the psychological well-being of staff.

From a management level, organizational leaders should consider what creates a safe or unsafe environment, including the workload of staff, team dynamics, and leadership styles, and also consider a relational approach in their leadership that supports a parallel process between staff and supervisors (Bennet, 2008).

Polyvagal Theory: Recommendations and Opportunities for Intervention

Concurrent Treatment of Trauma and Addiction

Research on substance use treatment programs has highlighted the need for trauma and problematic substance use to be treated concurrently (Kelly & Daley, 2013; Roberts, 2021). Among people receiving treatment for opiate use, people with PTSD and co-occurring opioid use disorder had poorer outcomes, including occupational functioning, continuing substance use, overdose and physical and mental health despite receiving the same services (Mills et al., 2005). This suggests that people with concurrent opioid use and PTSD require specialized services to treat PTSD and that treatment for opioid use disorder alone is insufficient. However, trauma and substance use are often treated separately, staff in substance use recovery programs feel unequipped, under-resourced, or were reluctant to provide concurrent treatment due to concerns that PTSD treatment would lead to recurrences of substance use (Gielen et al., 2014). There is a lack of integrated addiction and trauma treatment programs in Canada, and researchers have recommended that recovery programs assume, based on the volume of research identifying the link between trauma and addiction, that people receiving services have experienced a traumatic event (Dass-Brailsford & Myrick, 2010; Shier & Turpin, 2017). They suggest that having a trauma-informed program provides a therapeutic context that supports trauma recovery indirectly without necessitating participants to disclose detailed trauma history and risking re-traumatization (Shier & Turpin, 2017).

Additionally, approaches to trauma treatment vary significantly, and cognitive behavioural approaches dominate the therapeutic field (Fisher, 2017a). However, PTSD and opioid use disorder both have significant physiological components that are not holistically integrated into therapy by approaches, such as cognitive behavioural, that rely on top-down, cortical processes (Corrigan et al., 2010). During traumatic activation and addiction cycles, people often lose cortical control, and limbic processes dominate (Corrigan et al., 2010). Therefore, trauma-informed approaches to addictions and trauma recovery must include an understanding of the neurophysiological impacts of trauma that continue to be reexperienced by survivors (Fisher, 2017a). This requires practitioners to recognize and understand traumatic activation, including more inconspicuous forms, such as hypo-responses, and to support clients in differentiating traumatic activation and actual signs of danger and reestablishing a sense of felt safety (Fisher, 2017a). As such, this paper has focused heavily on reviewing the literature on the activation of defensive responses in the nervous system to provide insight to practitioners working in addictions recovery settings to identify the activation of these responses in their clients and so that they can support them therapeutically to develop self-regulation skills without the use of substances.

For people who have experienced trauma, nervous system dysregulation is common; people may experience sharp fluctuations between hyper/hypo-arousal states (Corrigan et al., 2010). Although the traumatic events may have occurred years before, people who have experienced trauma continue to experience anxiety, shame, nightmares, flashbacks, dissociation, and bodily sensations of dysregulation and distress (Fisher, 2017b; Ogden et al., 2006). Many of these states are well characterized by the states of hyper/hypo-arousal. Multiple mental health diagnoses, commonly diagnosed concurrently with PTSD, such as various forms of anxiety, borderline personality, and depressive disorders, can be understood better in light of the window of tolerance (Corrigan et al., 2010). For example, a clinical level of depression could be characterized by chronic states of hypo-arousal; they suggest that this may be further evidenced if the person takes an anti-depressant and afterwards experiences a spike in anxiety symptoms. In this instance, the anti-depressant is upregulating the state of hypo-arousal, though not resolving the underlying issue of nervous system dysregulation and an inability to reenter a ventral vagal state/ the window of tolerance. Similar conceptualizations can be made for borderline personality disorder, which has high correlations with early childhood trauma and difficulty activating a state of ventral vagal regulation to engage the social engagement system and connect and feel safe with others (Corrigan et al., 2010).

Opportunities for Intervention

Embodied Therapeutic Approaches. Offering embodied therapeutic approaches is an important component of supporting trauma recovery in combination with other approaches. While other cognitive and behaviourally oriented approaches, like cognitive behavioural therapy, dialectical behavioural therapy and narrative therapy, are important, empirically validated approaches, offering some embodied therapeutic approaches alongside these modalities that can support holistic recovery. For example, counsellors can use dance and movement therapy, expressive art therapies, and somatically oriented talk therapies (such as somatic internal family systems, sensorimotor psychotherapy, somatic experiencing, and somatic transformation) to support clients in transforming implicit, non-verbal, traumatic memory.

Attuned and Grounded Staff. Co-regulation is the easiest and quickest way to re-regulate nervous system dysregulation, which requires another grounded, attuned person (Porges, 2017). It is important for all staff who interact with clients to recognize signs of regulation and dysregulation in the nervous system so that they can attune to the person, support them in managing the traumatic trauma responses, and support co-regulation (Rothschild, 2017). Staff need to be able to recognize signs of regulation and dysregulation within themselves and to be able to respond to these states. This is important for the longevity of the staff within the organization, in addition to being a safe and grounded presence for the people in the recovery program. Awareness of their own nervous system will also offer deeper insight into the client's experience through the processes of neuroception and kinesthetic empathy. The counsellor will also act as an auxiliary cortex to help clients to regulate their emotions in therapy (Fisher, 2019).

Since safety is a biological state that is perceived through the nervous system, practitioners should pay particular attention in creating a sense of safety and safe environments for their clients. The nervous system constantly scans the environment for signs of danger and safety through neuroception (Porges, 2007). Neuroception, as previously described, utilizes afferent information through nerves in the inner ear, the facial muscles, the viscera, and other visual/ auditory cues to determine if an environment is safe (Porges, 2017).

When people cannot detect or 'read' safety cues in their environment, it is a function of an arousal state (Porges, 2017). That is, when people are in a state of immobilization or dissociation, they cannot ingest the environmental cues that signal safety (Porges, 2017). Given this information, the clinician should pay particular attention to creating safety through these channels and what is occurring within their nervous system. If staff and practitioners are regulated within themselves, they can support co-regulation at a nervous system level with the people accessing services. However, if the staff are also dysregulated, they may support co-dysregulation, as human nervous systems are designed to pick up signs of safety and danger through neuroception. One person in the relationship must be grounded and regulated, and that onus should never be on the client.

Mindfulness. Mindfulness brings conscious awareness with acceptance and without judgement to internal states, thoughts, feelings, and experiences in the present moment. Research shows that mindfulness-based interventions effectively reduce substance use and cravings (Chiesa & Serretti, 2014). In addition, bringing attention to building blocks of the present-moment experience (Ogden & Fisher, 2015), including thoughts, emotions, five-sense perception, movement, and body sensations, can help clients to become aware of how these internal cues associated with traumatic activation impact their felt sense of safety, feelings of distress, and ways of managing this discomfort.

In bringing attention to these experiences and automatic thoughts and reactions, the client can work with the counsellor to develop new ways of managing distress, regulate the nervous system states, understand the physical sensations, and address narratives that traumatic experiences have shaped. Additionally, mindfulness creates space for the person between the stimulus and the response, offering room for conscious choice. Finally, mindfulness activates the orbitofrontal cortex and supports regulation; in other words, using mindfulness to identify emotions engages the prefrontal cortex and supports the integration of brain regions associated with survival-stress responses (Creswell et al., 2007; Schore, 2016).

Counsellors can help clients to become aware of different ‘landmarks’ or memories that exemplify different nervous system states or responses within the defence cascade (Dana, 2020). This can help clients recognize when they are dysregulated or a trauma-related response is shaping their present experience. Counsellors can do this by verbally discussing the stories, encouraging clients to use art to illustrate or process each state creatively, or drawing out a spectrum of cues they notice between social engagement and dorsal vagal collapse.

Dual Awareness. Dual awareness is a mindfulness-based skill that counsellors can support clients in developing in therapy. As the client recalls past events, the counsellor helps them notice sensations and emotions arising and that they are only emotions (Fisher, 2019). In addition, counsellors help clients to notice that these feelings and sensations are no longer giving relevant cues about their present-moment safety but are associated with former traumatic responses. With practice, the sensations become less intense and overwhelming, with the goal of the client being able to tolerate the activation and to practice dual-awareness on their own.

Resourcing. Counsellors and recovery programs should support clients in developing various new resources to support grounding and regulation of the nervous system that clients can use for self-regulation. This can include various somatic grounding techniques, diaphragmatic breathing, meditation practices, mindfulness, visualization practices, and creative processing by engaging the five-senses or engaging positive memories (Dana, 2020). While there are many different options within these categories, each person will have individual preferences. The counsellors and recovery staff can introduce new tools to clients, practice and model the tools with clients, speak with the client about which resources work for them, and encourage them to integrate them into daily practice.

Sound. When people look at another person, smiling and speaking, they contract their inner ear muscles (Porges, 2017). The contraction of the inner ear muscle allows them to better hear the human voice and distinguish it from other background noises. However, this reduces their ability to hear lower-frequency sounds, which are biologically associated with predators. When the person is smiling or speaking, and their inner ear muscles are contracted, the social engagement system is activated and reduces sympathetic arousal in service of their ability to connect with others and detect human voices. The higher-frequency sounds in human voice will move through the structures within the middle ear and be transmitted to the brain via the auditory nerve when the middle ear muscles are tensed. The lower-frequency sounds associated with predators and threat will bounce off the eardrum since the eardrum will tighten when the muscles in the middle ear are contracted. However, when lower-frequency sounds get through to the brain, the social engagement system is downregulated, the person's ability to distinguish higher-frequency sounds is dampened, and defensive systems are activated. This occurs when there is a lower tone of the muscles in the middle ear, resulting in the eardrum being softer, allowing more of the low-frequency sounds to be transmitted to the auditory nerve and relayed to the brain. In this state, the person has less access to their social engagement system. They physiologically feel less safe through the activation of defence responses and will be less likely to benefit from therapy.

Considering this, the practitioner should reduce low-frequency sounds in the therapeutic environment, such as the low rumble from centralized air systems (Porges, 2017). They can play soft vocal music and use prosodic vocalizations. Prosodic vocalizations involve the use of intonation in a voice that communicates emotion. They should be conscious of vocal volume variation as this could signal threat and use modulation in intonation instead. The vocal intonation can cue and facilitate the activation of the social engagement system in the client, promoting a sense of felt safety and connection.

Additionally, having options for people to engage in signing can be a helpful tool to support the regulation of the nervous system (Porges, 2017). It requires people to consciously regulate their breath and coordinate and attune to other people in the room. Additionally, signing contracts the inner ear muscle, which, as previously noted, supports the activation of the social engagement system. Music therapy or even recreational choirs, karaoke, or singalongs could be a creative way to support clients.

Psychoeducation. Providing psychoeducation is important for clients to understand the role of the defence cascade and how this is part of an involuntary biological imperative for survival. Since much of psychotherapy has conceptualized behaviour as a conscious decision, understanding their adaptive behaviours in light of the biological defence systems can provide important context, reduce shame, and promote self-empathy (Porges, 2017). Porges (2017) urges practitioners to encourage their clients to celebrate their body's survival responses that helped them survive and reduce physical harm. He noted that when therapists started doing this, he received reports that their clients started to improve spontaneously. Psychoeducation supports the client's identification of the physiological processes occurring. It can reduce the shame of being unable to respond or engage in situations in the way they otherwise would hope to. Additionally, in a pilot study of people receiving treatment to prevent suicide in an inpatient mental health unit who were hospitalized for two to 10 years, six of the eight participants demonstrated significant improvement after receiving psychoeducation-based treatment that helped them to understand structural dissociation and link unsafe behaviour to parts (Fisher, 2017a).

Play & Engaging the Social Engagement System. Play is a psychologically and physiologically sophisticated process that promotes therapeutic regulation of the nervous system and engagement of the social engagement system. From a Polyvagal perspective, play must involve face-to-face interaction that provides the cues that communicate safety and keep the social engagement system online (Porges, 2017). This would include sports, social banter, reciprocal humour, in-person imaginative games, drama, and dance involving multiple people. However, isolated activities such as video games would not be included due to the lack of involvement of the social engagement system. Typically, play will involve the ventral vagal system regulating phylogenetically lower-level defensive processes. That is, a person will modulate their sympathetic arousal, which is needed for mobilization. They will do this in play vis-à-vis the process of neuroception that detects and interprets biological movements (prosody of voice, facial expressions, gestures) as safe through activating their social engagement system (Porges, 2017). These social cues that activate the social engagement system support the myelinated ventral vagal pathway to down-regulate the sympathetic nervous system (Porges, 2017). Play, in this sense, is an activity that can be used as a neural exercise to support the regulation of nervous system states. This has the additional benefit of supporting the formation of social relationships and stimulating the endogenous opioid system.

Concluding Thoughts

Addiction does not happen in isolation, nor can it be properly treated without understanding the context in which it developed. Addiction is better understood as a symptom of a deeper challenge, rather than the core ‘problem’ to treat. Considering the research reviewed in this paper on different neural systems and processes that intersect with addiction, addiction largely hinges on the need for safety and attachment; whether someone had access to physical or a felt neurobiological safety and secure attachment throughout life or not can increase the probability developing an addiction. In the context of the DTES, the central issues to be addressed include access to a healthy context that people are embedded within, including meeting basic needs (such as food security, safe housing, and safety), safe and meaningful social connection, a sense of purpose, the capacity for self/ co-regulation so that people can engage in relationships and their community without the role of substances. Exogenous opioids may be used as an attachment substitute to meet these basic core needs; thus, substance use recovery programs should take a holistic approach to addressing the multifaceted needs of people in recovery. People may also live with chronic states nervous system dysregulation making it difficult to create and sustain meaningful connections and to develop a felt sense of belonging and wellbeing, which can be a significant barrier to maintaining long term recovery from substance use. It is therefore important to have practitioners to be attuned to clients, to support a sense of neurobiological safety, to support clients to develop skills for self-regulation, and to provide new experiences of safety, attachment, and connection through the therapeutic relationship.

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