Nature-based regenerative healing: Nature and neurons

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Abstract

This is a follow-up article to a longitudinal case study involving the same nature-based healing model for healing, using the natural world as the primary context. One of the critical findings of the first study was that the individual involved described herself as being "a different person" as a consequence of the long-term treatment and daily exposure to the natural world.

In the current study, two more longitudinal case studies that utilized this nature-based healing model will be examined. Both of these individuals have cognitive impairment as a consequence of post-concussive syndrome (PCS). The results of the current study will be compared with the findings from the previous study in order to demonstrate consistency.

After the findings are reviewed, I utilize grounded theory methodology in order to develop a working model in an attempt to explain how I believe healing occurred, based on the relationship humans have with natural processes. I use the concept of a "working model" to imply an ongoing process to constantly refine the components and their relationships, rather than a fixed, definitive end-point. I further postulate that the resulting well-being of the participants may be a synthesis of nature-based healing interventions deliberately chosen to be congruent with the healing capacity of nature. This congruence is centrally organized around evolutionary processes that resulted in the human brain. I suggest that the efficacy of the nature-based healing model is based on a nexus of three interdependent, converging influences: 1.emotion; 2. cognitive restoration; 3.memory, all influenced by daily relationships with natural processes. Utilizing the research literature in each of these areas, a working theory will attempt to synthesize these various influences in order to suggest how they might augment each other; and that nature-based healing is greater than the sum of the individual parts. My belief is that being in nature may amplify and synchronize the benefits that each influence would provide if applied in isolation. I also discuss my role of working with the participants in weekly meetings as a 'guide' rather than that of a 'therapist'.

Keywords: nature-based healing; human/nature relationship; regenerative healing; amplifying synchrony; neurons; emotion.

Introduction

"…For I have learned to look on nature…" (1799). Wordsworth's words simply yet humbly acknowledge that natural, non-human processes are the alpha and the omega of life and that we are but passengers inside this protective cloud. That early homo sapiens evolved over time largely due to their constant immersion in natural processes and "our adaptive synergy with nature" (Seymour, 2016, p. 4) has perhaps been mostly forgotten in today's predominately urbanized, "outtree" experience, at least in the industrialized countries (Puk, 2021a). And yet it was in that constant and immediate exposure to sun, air, water, soil, flora and fauna that resulted in the health of modern humans. Post World War Two however, people in the industrialized world have become more and more distanced from the influences that helped shape their very being. As a consequence of this distancing, one might argue that physical, emotional and mental stress has become the defining characteristic of modern life.

Much has been studied and written about the benefits of nature-based interventions in the pursuit of human well-being (Corazon et al., 2010; Corazon, et al., 2011; Corazon et al., 2019). Some studies generalize the benefits of nature by simply being exposed to the aesthetic aspects of nature rather than identifying the specific influences within this exposure and the corresponding specific mechanisms within the human psyche that are affected. "Rather, nature therapy relates to the environment as a live and dynamic partner in the shaping of the setting and the process" (Berger, as cited in Berger and McLeod, 2006, p. 81). In the current study I will attempt to provide a working theory regarding the nexus of these synchronous, amplifying influences through an nature-based healing model. I use the term "nature-based healing" (Puk, 2022; 2024) to signify that in the "nature-based regenerative healing model (NBRH)" featured in this study, nature provides the primary influences in the healing process rather than the intervention of a human therapist. This NBRH model consists of three main interventions: a. moving in nature b. memorizing poetry and repeating affirmations and c. weekly debriefing between the author as 'guide' and the participants (more on the nature of these interventions is provided later in the article).

As such, this is a follow-up article to a longitudinal case study involving the NBRH model, using nature as the primary context (Puk, 2021b). One of the critical findings of this first study was that the individual involved suffering from Lyme disease described herself as being "a different person" as a consequence of the long-term treatment and daily exposure to the natural world. A number of agents and mechanisms were identified as having a probable influence on this healing.

Method

In the current study, two more longitudinal case studies that utilized this nature-based healing model with individuals suffering from post-concussive syndrome, are examined. These case studies allow for longitudinal rather than cross-sectional , one-time examination of the phenomenon involved, resulting in a "thick description" of the human behaviors experienced (Creswell, 2009; Savin-Baden and Major, 2013). In addition, case studies allow for the exploration of context in which these behaviors are embedded (Saven-Baden and Major, 2013) and better suit the understanding of complexity rather than through a clinical lens.

Observational notes were made by myself as the guide and researcher (more on this role later in the paper) during weekly meetings lasting 30-45 minutes per session, rather than risk making the participants feel self-conscious of being digitally recorded. These weekly observation notes provide depth and breadth of information over a period of time. Symptom assessment instruments (Puk, 2021b) were completed at the beginning of the study and then again after significant improvement was observed. Participants were asked how much their symptoms interfered with various aspects of their lives (see further below), 10 meaning total interference and 1 meaning no interference. Both of these individuals had cognitive impairment as well as emotional distress that affected their jobs and social interactions, as a consequence of PCS. The results of the current study will be compared with the findings from the previous study (Puk, 2021b) in order to demonstrate a consistency of results of the nature-based regenerative healing model utilized in these case studies.

After the findings are reviewed, I provide a working theory in an attempt to outline how healing may have occurred with these participants.

Grounded theory

Attempting to hypothesize why healing occurs and how the complexity of the interplay between brain, mind, body and nature are influenced during the NBRH process, is challenging. There is a historical practice found in the literature of studies in ecopsychology in which researchers hypothesize and speculate in order to develop a working theory to explain the results of their study (Koch, 2019; Milton & Corbett, 2011; Tudor, 2013; Wolsko & Hoyt, 2012). In the discussion section, grounded theory methodology (Strauss & Corbin, 1994) was utilized to help coalesce this working theory by utilizing the data described in these three case studies. "GT takes qualitative inquiry beyond descriptive studies into a realm of explanatory theoretical frameworks, by the construction of theories or conceptual models through inductive analysis grounded in the data" (Naor & Mayless, 2021, p.286). More specifically, constructivist grounded

theory (Charmaz, 2006, p.286) was utilized as the researcher was the interpreter of the data and constructed the working theory (Noble & Mitchell, 2016). "[T]theories developed in CGT are described as "working models" rather than pragmatic conclusions and are suggestive, inconclusive, subject to further development" (Naor & Mauless, 2021, p.287).

Three intertwined characteristics of grounded theory helped me shape the working theory: a. in depth reading of the literature; b. professional and personal experience; and c. the analytic process (Noble & Mitchell, 2016). From professional and personal experience, I tapped into the working model of the first published study using the nature- based regenerative healing model (Puk, 2021a).

Thus the current working theory in this paper is a tentative framework meant to provide a springboard for further studies and refinement, in nature-based healing. I suggest that the psychological well-being and mental health benefits of daily nature-based experiences may be a result of a synthesis of deliberate interventions as opposed to simply being exposed to nature. The efficacy of the nature-based healing model is based on a nexus of three converging, interdependent influences: 1. emotion; 2. cognitive restoration; and 3. memory.

Utilizing the research literature in each of these areas, this working theory will attempt to synthesize these various influences in order to suggest how they might amplify each other so that the resulting healing is greater than the sum of the individual parts. Nature provides the "liquid" in which these other influences can thoroughly mix and enhance each other, producing a "different person" than the one who existed prior to the NBRH process. Natural processes may help augment exponentially the benefits that each influence would provide if applied in isolation. Fortunately for us, nature has provided this synchronous energy.

Review of Previous Study

As described in Puk 2021b, Jesse (a pseudonym) had been diagnosed with lyme disease and had been off work for approximately 1.5 years prior to the beginning of the nature-based regenerative healing process . She had been taking six different kinds of antibiotics multiple times every day during this period. She began the NBRH process (described below) by walking each day in a rural area with little human influence while memorizing poetry (one of her main symptoms was brain-fog and memory impairment) and repeating affirmations created just for her. She started walking at ten minutes per day and progressed to one hour within the first three months by adding one minute to her walking per day. At the beginning of the study Jesse was quite somber, often breaking out into tears when describing her situation . By the end of the third month, Jesse described herself as feeling like she was a "different person". Now she was quite upbeat and joyful

at times. By seven months she started back to work part-time and full-time by the end of nine months. During her previous convalescence she had come to the conclusion that she probably would never be able to return to her job because of her lack of progress in healing. During the second year of her nature-based healing, Jesse described herself as being happier, enjoying her job and doing her job better, than she had prior to becoming ill. She had seventeen consecutive weeks of describing her previous week as "fantastic". As of the submission of this current article, she experienced very minor occasional symptoms.

The natured-based regenerative healing model

The main phases of the current model consist of Regenerative Interpretation and Barometric Adaptation (a diagram of the Nature-based Regenerative Healing Model can be found in Puk 2021b). There are two contexts in which the healing occurs: a. natural processes and b. walking in nature. Nature settings ideally minimize human influence, especially noise and sight in order to maximize "cognitive restoration" (Berman, et al., 2008; Kaplan, 1995; more on this later in the paper). The first phase of Brain Processing describes the state at which the brain is operating prior to engaging the NBRH process and then how the brain changes its processing during the healing sessions (more about this during the "nexus" portion of this article). The phase of Reciprocal Whole Healing describes the resulting state of healing as well as the feedback looping back into the initial phases.

Regenerative Interpretation

In this phase, participants are constantly re-examining and reinterpreting their reality, attempting to communicate with the regenerative capacity of the human psyche during the healing process. The primary concept applied during this phase is that of Courageous Gradualism. Each day the participant steps into a "now bubble" (focusing only on the moment) and walks in natural surroundings. The nature of these surroundings varies from participant to participant e.g. wooded area, park, body of water, rural road, depending upon where they live. The one commonality is trying to walk in an area that provides the least amount of human stimuli such as sights and sounds. The participant starts walking for a length of time that does not make their symptoms worse. Typically a participant might begin at ten minutes per day and then start adding on one minute each subsequent day. The goal is to 'sneak up on' the brain so that it does not notice the gradual change. Participants begin memorizing nature-based poetry during these daily walks in natural settings. For example Robert Frost's poem, The Road Not Taken acts as an embodied metaphor (Corazon, et al., 2011), providing a mental image of the new paths the participants have chosen, further strengthening and embodying ("defined as a person's physical engagement with the environment

through the sensory motor systems" Corazon, et al., 2011, p.162) their relationship with natural processes. Participants are encouraged to begin the memorization process by learning one to two lines of poetry in the first week depending upon their capability. However, it is important to note that hard targets are never set. Because each human is unique and has different levels of awareness and perception as to their attitudinal relationship with natural processes, "dose response" is variable (Bratman, et al., 2019).

Consequently, increasing the number of lines to be learned and the length of the walks is entirely dependent on individual progress- there is no fixed schedule. Participants say these lines of poetry out loud in order to anchor the memory more easily and firmly in the brain. Affirmations are also repeated during the walks. These are individually tailored to the specific status of the participant. Although it may seem to the reader that the memorization and affirmations limit the amount of time and quality of awareness of the participants' natural surroundings, the concept of "gradualism" is key in understanding the true nature of the process. During weekly meetings with the guide, participants are encouraged to choose a process pace that allows for reflection and enjoyment of their surroundings. Once they have established a walking duration of 40-60 minutes, there is ample time to work on memorization, affirmations and appreciation of their surroundings. It is intended that moving through these different foci is gentle and fluid (more on this in the case study sections for the participants). The goal of "gradualism" is to begin with the smallest of improvements in order to break inertia and create healing momentum. Often courage is required to break out of negative habits and leave the safety of the known. Momentum begets momentum as the dopamine reward of expectation and reward produces self-motivated participants as they start to link achievement with improved health and lessened symptoms (Dispenza, 2008).

Barometric Adaptation

During the healing phase of Barometric Adaptation, the participant's brain must adapt to the ever-changing conditions provided by the natural world each day e.g. temperature, precipitation and topography, and the changing influences of the body/mind e.g. pain, fatigue/strength, motivation and mood. These constantly changing influences must be factored into the walking, memorization and affirmations. Because the participants are inside a metaphorical 'now bubble', the normal distracting influences of daily human life are temporarily marginalized in order that the brain can take a break from the usual stressors and only focus on the natural surroundings and tasks inside the bubble. All of this assists in moving towards "cognitive restoration". The results of these behaviours are intended to create altered states of mind which then feed back into the model, changing the

physical wiring of the brain with new neurons, new synaptic connections, and strengthened myelin sheath (Coyle, 2009).

Debriefing sessions and the role of the 'guide'

The third intervention in the NBRH model , that of weekly debriefing sessions, plays a supportive role to the other two more influential interventions (walking in nature and memorization). I use the term 'guide' to signify the manner in which these weekly discussions occur (the concept of guide was actually a term that one of my participants used to describe my role from their perspective). These meetings were in the form of discussions and partnerships rather than that of an 'analyst' or a 'therapist' during for example interventions such as cognitive behavioural therapy (CBT). I don't characterize the role of the guide to be that of a therapist, at least not in the conventional use of that term. It does not involve psychotherapy, trying to uncover the root cause of the problem in the subject's past history. The root problems of the participants in this study were well known ie illness and injury.

As a guide during the debriefing sessions my role was to a. review the progress made by participants during the previous week; b. discuss new objectives for the next week, e.g. how many days a week they would go on their walks and how much time they felt they could handle during each walk; c. discuss with them their thoughts and feelings about their progress in regard to memorizing the poetry and affirmations; and d. discuss what they noticed about their natural surroundings. My intent is always to create an atmosphere of being supportive, compassionate and empathic. The participants don't pay anything for these sessions as I see my contribution as a form of service.

I met with each participant, separately, once a week for approximately 30-45 minutes. My goal during these debriefing sessions was primarily to listen to the stories that each participant shared, listening particularly to the emotions expressed by the participants. Because I had faced similar challenges from a long-term, undiagnosed illness, particularly as it related to brain fog and lack of energy, I was able to share some of my own similar, authentic experiences, emotions and suggestions about the nature-based healing process. I tried to do this in an open, honest and sincere manner rather than through a top-down, lecturing atmosphere. I believe that there are advantages for anyone involved in healthcare when they have experienced similar symptoms to those of the participants and have experienced the same process as the participants- in this case the NBRH model. During the weekly sessions, as we talked about their progress, I always reinforced that they choose their own process pace and that the smallest gain was success. I believe this latter principle of the NBRH model is integral to promoting healing, particularly in complex, chronic illnesses.

We would also discuss their meaning-making process in regard to the nature-based poetry they were memorizing, both in terms of the words and their own memorization process. We shared the interpretations we each made, trying to anchor the metaphorical words with the actual natural surroundings they experienced during each walk.

Post-concussive syndrome

"Although there is little agreement among medical professionals on how to define or diagnose a concussion" (Blennow, et al., 2012, p. 886), minor head trauma is usually referred to as post-concussive syndrome (PCS) (World Health Organization, 2016). This kind of trauma can cause soft-tissue damage to the brain resulting in symptoms such as headaches, dizziness, nausea, sensitivity to light and sound, and short-term memory problems. Of particular interest in the current study is that concussion can cause mental fatigue due to imbalances in neurotransmitters (Corazon, et al., 2019), a topic which will be addressed later in the paper.

Nature-based healing and post-concussive syndrome in the literature

In a 2019 study of using nature-based healing (NBT) to assist individuals with PCS during their healing process, Corazon et. al stated that after an extensive literature review, they found no other studies (other than their own) that involved the use of nature in treating post-concussive syndrome (PCS). In a 2020 literature review, Vibholm et. al found only five studies that involved nature-based rehabilitation for a broader category of "acquired brain injury". The nature-based model used in the current study is significantly different from that of the 2019 study and the 2020 review. What makes this model different is that: a. it involved a guide having debriefing sessions with individuals rather than group therapy ; b. it involves embodied experience (Puk, 2021a; Stephen, et.al, 2009); c. it involves immersion walking in natural surroundings and/or "urban nearby nature" surroundings (Doherty, 2016). Aerobic walking has been linked to retaining plasticity in white matter (axons and myelination) resulting in improved episodic memory performance (Colmenares, et. al, 2021); d. during their daily walks the participants were conducting their own healing process in a self-directed manner, meeting with the guide once a week to discuss their progress in utilizing the nature-based healing model that they experienced during their previous daily sessions; and e. memorizing poetry involving nature-based words and images. Self-directedness is critical in the development of a sense of agency during the healing process . This "feeling of control over actions and their consequences" (Moore, 2016) provides the participant with a degree of confidence that 'I can do this' and the motivation to push for more and more control over their own healing. In the NBRH model, natural surroundings facilitate this sense of agency.

New Case Study: Michael

Michael was a male in his early fifties who had fallen from a ladder onto the pavement, causing a concussion (as evidenced in an MRI) and neck injury. He had been off work most of a year when he began this current healing process . He had been repeatedly examined and tested by specialists and diagnosed with PCS. Unfortunately no treatment had ever been forthcoming. As a result he was quite resentful towards doctors. He tried physiotherapy sessions over several months but his symptoms did not improve. He also went into the physiotherapy gym to exercise but he found the TV screen and background radio music being played, to be too loud . This caused further aggravation. The major symptoms when he began the NBRH process were mostly due to multiple stimuli e.g. sound, light, and conversation. Typical of people with PCS, Micheal was constantly battling to reduce sensory input in his daily experiences (Corazon, et al., 2019). During each day, once a tipping point was reached, he would start to grimace as pain built up in his neck area and his shoulders would start to tighten up. The only way he could alleviate these symptoms was to walk away from the situation. In his initial assessment, on a scale of 1-10 (1 meaning the symptoms or behaviors were absent and 10 meaning they interfered totally), Michael scored 8 on memory, 8 on attention/focus in conversation, 8 on relationships with others, and 8 on concentration, 9 on worry and anxiety, 9 on enjoyment of life, 10 on pain, 10 on balance, 10 on the effect of multiple stimuli, 10 on conversation, and 10 on ability to do his job.

Michael did not have a problem with energy levels so he began his healing process by walking three times per week, forty-five minutes per day, eventually getting up to six times per week, sixty minutes a day, after two months. He did some of this in an urban park area nearby where he lived and some he did in a rural, isolated, forested area with minimal human influence. He liked the latter best as he felt he could make much more progress with less cognitive distraction from multiple human stimuli of moving objects and noises. Kaplan (1995) would explain this “cognitive restoration” as not just a minimization of external stimuli, but more importantly a reduction of the required energy spent trying to control interfering thoughts and emotions- more on this in the discussion section below. Michael was assigned the first verse of the “Road Not Taken” and by the end of the first two weeks he had memorized this verse.

“Two roads diverged in a yellow wood,

Sorry I could not travel one and be one traveler

Long I stood and looked down one as far as I could

To where it bent in the undergrowth…”

During these initial debriefing sessions, he was also given two affirmations- “I am staying in the moment” and “Is this (negative thoughts or behaviours or observations by others) helping me to heal? If no let it go”. He repeated these affirmations continuously during his walks. Once Michael observed that he was making progress in terms of the memory work, he began to be self-motivated. He was encouraged that he could help himself in the healing process. The more diligently and consistently he conducted his daily walks, the more he progressed. He eventually memorized the whole poem and began learning a portion of a more complex poem by Wordsworth called Lines Written Above Tintern Abbey. The language, syntax and flow of this 1799 poem is quite different than what we would intuitively expect. This requires a lot of repeated focus and attention on detail, correcting mistakes over and over. This is hopefully what assists the brain in the healing process. Repetition increases the thickness of the myelin sheath that insulates each neuron. The thicker the myelin sheath the more effectively an electrical current can travel, resulting in improved memory retention (Coyle, 2009; Hasan, et al., 2019; Bonetto, Belin and Karadottir, 2021; Xin and Chan, 2020).

“…And I have felt a presence

that disturbs me with a joy of elevated thoughts...”

These poems are chosen because of their strong themes of the interrelated relationship between natural processes and human systems. This means that the participants are not only embodied in nature but are also repeating the embodied metaphorical words and sentences about nature during these walks in order to amplify and solidify the results (Corazon, et al., 2011). Participants walk in and through the theatre of nature.

Three months later he repeated the assessment and made significant gains, lowering his overall scores on all items by forty points! Significant improvement was demonstrated in particular in memory, attention/focus and anxiety/worry, in which he scored in the range of 1-3. On relationships with others he went from 8 to 5 and enjoyment in life from 9 to 5. However the most impressive change was in his attitude. During the debriefing sessions, he would often remark, “I get it now” in terms of the point of the NBRH process that when you think differently you often act differently. By the end of the fifth month, he stated that “I’ve changed since I’ve started this”. By the end of the sixth month he stated during a debriefing session, that “I’ve totally changed mentally since I started this. I am a different person”. He observed that he was "starting to concentrate more on my relationship with the natural world" and that he now "enjoyed walking in the rain", which he did not do at the beginning of the healing process. In particular, when he temporarily moved into a trailer in a rural, forested area to conduct his daily healing process, he would go on bike rides on quiet, dirt roads. He

expressed joy in being surrounded by trees, blue sky and quietness. That same statement "I am a different person" was also made by Jesse after her first three months.

New Case Study: Maia

Maia was in early twenties when she was in a car accident four months prior to beginning the NBRH model. Although no testing was done in the hospital emergency department and subsequently, her symptoms were affecting her job and her daily routines. During an initial debriefing session, she described a terrifying experience when she had got lost after her accident first occurred. She stated that she could not remember where she was while driving in a part of the city she previously knew well and had to phone for someone to come and get her. Like Michael, Maia also started physiotherapy treatment but her symptoms did not improve. When she went into the physiotherapy gym to practice various balance exercises, she found it quite upsetting in that she could not keep track of her repetitions and couldn't remember the routines. Maia's main symptoms prior to starting the NBRH process, were that of poor balance scoring 8 of 10, short-term memory 9 out of 10, ability to multitask 8 out of 10, ability to do complex tasks 9 out of 10, how it affected her job 8 out of 10, sleep 9 out of 10 and her confidence level 9 out of 10. She regularly had headaches, particularly after reading and talking on the phone. When asked how often she normally (pre concussion) went outdoors for a walk or to recreate on a daily basis (other than to or from work or visiting friends) she scored "never". She stated that she never found any point or enjoyment in experiencing nature. In terms of short-term memory she couldn't remember much of what happened beyond the current day. She also described herself as having low energy levels as she got tired very quickly, causing more head pain.

At the beginning of the NBRH process, she started walking from her apartment two to three times for the first week and ten minutes each day increasing one minute per day. She was assigned to learn the first line of the "Road Not Taken". During an initial debriefing session, I drew a line representing the path in the poem and her current path on chart paper. A line representing her new healing path branching off her old path, just as it did in the poem, was then drawn on the chart paper. She was able to visualize the new direction she was taking as she walked. She was also given two affirmations to repeat to herself during the walking: "I am a healing person" (as opposed to thinking of herself as ill) and " is this (thinking/behavior) helping me to heal? If no let it go".

As with both Jesse and Michael, the first few weeks were challenging for Maia as she was forcing her brain to operate in a different manner than it had become accustomed to during convalescence. She stated her skepticism about the process

and in particular about going outside for her daily walks. She had stopped trying to do any complex thinking tasks, believing that she was too “ill” to do otherwise. Her perception of her incapacity was relayed to her brain repeatedly until this neuropathway had become well worn. It took her most of the first week to memorize the first line. During the second week, she began walking four times per week and started adding one minute per day to her walks. She found an area close to her home where she could walk around a human-made lake and eventually a quiet pathway through an urban forested area. Kardan et al. (2015) found that city streets with a high density of trees, correlated with "significant higher health perceptions" (p. 1).

By the beginning of the third week she started walking five times per week, twenty minutes per walk. She eventually was walking forty minutes per walk. At six weeks, she stated that she could now remember things that happened during the week, when prior to the healing process, she couldn't remember things from the previous day. After two months Maia completed the assessment again lowering her overall scores on all items by twenty-nine points. In particular, she went from 8 to 5 on balance, 9 to 6 on short-term memory, 7 to 3 on the effect of symptoms on conversation, 9 to 5 on completing complex tasks, 8 to 4 on multitasking, 8 to 5 on being able to do her job, and 9 to 1 on sleep- the latter improvement according to Maia, influenced by experiencing nature on a regular basis (going from 0 times per day before the healing process to 5 days per week), thus benefiting from the stimulation triggered by the sun to produce serotonin and melatonin. The initial skepticism was now replaced by a feeling of the comfortableness and “joy” she felt while walking in natural surroundings. She also expressed surprise that the forested path that she had no previous experience with, could invoke such feelings. She became aware of individual trees and the “peaceful” feelings they created in her mind.

After five months, she returned to full-time work. In terms of her relationship with nature, similarly as with Michael, she stated she now enjoyed walking in the rain… and she said this with a degree of amazement, surprising even herself. This is quite noteworthy considering her previous attitude towards the outdoors. She also said that she liked to walk mid-afternoon when the sun was highest. What is significant about these observations is that Maia was noticing the natural world for the first time e.g. rain and sun, and starting to develop a new, emotional and embodied relationship with nature. During her walks, not only was she moving through natural surroundings, she was also carrying the embodied metaphors of the nature-based poetry that she was immersed in each day. She also stated that in hindsight she felt she had been "in a shell at home" prior to beginning the healing process.

Summary

1. All three participants were referred to the guide as a last resort when nothing else worked.

2. All three suffered from significant brain impairment, although Jesse suffered from a disease and the other two from concussion.

3. All three progressed in a similar manner following the Nature-based Regenerative Healing model.

4. All three stated that they felt they were "different people" by the end of the third month, sixth month and second month respectively.

5. All three used the same nature-based poems, albeit in different order.

6. All three developed a more meaningful, embodied relationship with natural processes than they previously had.

Defining characteristics of the NBRH nature-based healing model

There are many variations of nature-based healing described in the literature (Jordan, 2015; Jordan & Hinds, eds., 2016; van den Bosch & Bird, 2018;). However the one defining characteristic that is central to this approach is an emphasis on developing a close relationship with nature and the subsequent effect on mental health (Jordan, 2015).

The essence of the NBRH model that Jessica, Michael and Maia utilized includes the following characteristics:

1. NBRH sessions are always conducted in natural surroundings, ideally minimizing the influence of the human-constructed world.

2. participants conduct self-directed daily NBRH sessions i.e. they walk on their own.

3. every session includes a/movement (usually walking); b/memorization; c/ poetry that emphasizes ecophily i.e. developing a valued connection with the natural world (Puk, 2021a); d/targeted affirmations appropriate to each participant that focus on creating a positive emotional mindset and overcoming the negativity bias of the amygdala (Hanson, 2013).

4. weekly debriefing sessions with the guide to review progress and to set new goals. During these meetings, the participant and the guide discuss the meaning that the participant develops about the nature-based poetry that they have been memorizing. By constantly repeating the same words and phrases and doing so in the relaxing and focussed atmosphere of natural surroundings, the participants are drawn into trying to make sense of these passages. The intention is that this

analysis and meaning-making of nature-based imagery will further connect each participant more broadly to the authentic natural world in which they are immersed. The sessions also include reviewing any progress made in the week before and suggesting new affirmations based on the participant's feedback. As mentioned previously, I view my role as a guide rather than a conventional therapist. Most of the 'work' in the healing process is done by the participant during their daily communications with natural processes. I view nature as the third 'member' of the NBRH process. The emphasis is on situating this new relationship with natural habitats within the daily life of the participant rather than a return to a normative lifestyle.

Discussion

Reflexive influences in the research process

Reflectivity in qualitative research involves self-examination and self-knowledge and attempts to describe how the characteristics and experiences of the researcher impact their research (Berger, 2015). It attempts to describe the "contextual intersecting relationships … between the participants and themselves" (Dodgson, 2019), thus allowing for transparent understanding by the reader. The following reflexive description begins to explain the complexity of being a guide and researcher, with the intent of providing the reader with insight into the discussion section to follow. In particular, as a researcher, why did I choose the various themes in the development of the working theory, found in the discussion section? What are the influences that are brought to bear in presenting the 'angle'/perspective silently exhibited in these themes?

Every individual has lived experiences unique to themselves. The following are a few influences that I either consciously or unconsciously utilized in identifying the working theory themes, keeping in mind the three characteristics of grounded theory outlined above.

1. neural damage as a lived experience of serious illness or injury.

The primary and overwhelming symptom that the three participants in these studies have in common is that of pervasive brain fog. When you suffer either from disease or injury damage to your neurons, your one and only goal, moment to moment, is to heal and return to some degree of normality. There is nothing else! It is a very singular, isolating reality. Cognition is our primary means of participating in our surroundings, to hold down a job, parenting, and social communications. One's cognitive ability in turn influences our emotional and perhaps spiritual ability to interact with everything else. Constant brain fog commits you to a different 'universe', affecting your ability to think effectively, your short-term memory and your ability to communicate with others. Your very

identity shrinks to a small space. Fear can be pervasive. I lived through my own nature-based healing experience with brain fog and neural damage. Thus I understood firsthand what these three participants endured. This has influenced my interest in neuroscience literature, particularly as it relates to natural processes and my emphasis on identifying the meta-themes of emotion, cognition restoration and memory.

2. Ancestral lived experiences

My ancestors on my father's side were born into Ukraine, known as the 'breadbasket of Europe'. For centuries, Ukrainians have been deeply connected to the soil, to plants, to growth and to their natural surroundings. And yet interrupting this abiding connectedness to the natural world, Ukraine has also for centuries, suffered from and repelled invaders, building an historical resilience and undergoing constant cultural and personal regenerative healing. I believe that the memory of these evolutionary, ancestral influences have been passed on to my cells through DNA. Thus I recognize that natural processes played a key role in developing resilience and regenerative energy in the participants of this study.

3. Academic instructor and researcher

As an instructor and researcher in ecological consciousness, nature-based well-being, cognitive science and complexity theory, I am quite familiar with the literature in these areas. As a result, I am able to connect what I observe as an instructor and know as a researcher, with the experiences of the participants in these two studies. Making those connections involves the criteria of professional experiences as described in constructivist grounded theory. Other researchers may have a different perspective in regard to the intersection between human healing and natural processes, based on their own professional experiences.

4. Personal philosophy and lifestyle

I live in the boreal forest of Northern Ontario, sitting on the Canadian Shield. This is a rugged landscape of ancient rock, forest and lakes. I move through the beauty of this natural milieu of sun and air, soil and water, with close encounters with black bear, wolves, lynx, lichen, growth and decomposition, rain and snow, on a daily basis via hiking or xcountry-skiing. I attempt to live the themes addressed in the working theory below and incorporate these themes into my research through a nexus of personal and professional observation, affect and analysis. I also benefit from the shared partnership with the participants as I humbly observe the courage and perseverance they demonstrate while wrestling with their challenges. I enjoy hearing about the new insights they often acquire about the natural surroundings in which they are immersed.

A working model of nature-based healing

In the following discussion I describe my working theory as to why the model appeared to be effective, with special attention given to the nexus of the various influences. Each of the influences and their effect on healing that I will review have been described in the literature. However, how they work together is an example of complexity. I cannot say with certainty which of these influences resulted in the healing process for the participants. Rather, it is my hypothesis that the model creates an amplifying effect as the various meta-influences (emotion, cognitive restoration and memory) create a kind of synchrony within the embrace of natural processes in which no one component can be pulled apart without affecting the whole (Figure 1). In keeping with the tenets of grounded theory (see my earlier references) my description of these influences and how they may have affected the participants are "suggestive". Because of the nature of complexity, there is overlap in some of the sections, as each takes a slightly different slant when attempting to describe synchrony. The overarching question that I address is, what might the results of these case studies tell us about the human-nature relationship and health, particularly when it involves neural disruption?

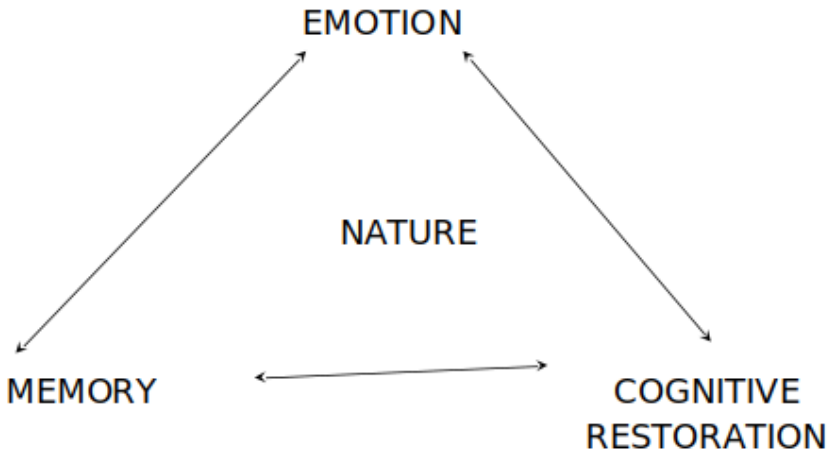

Figure 1: Nature-based healing: A working model

Emotion

Perhaps an undervalued aspect of healing involves that of one's emotional state of mind. In allopathic medicine for example, prescription drugs are often administered regardless of one's state of mind. That is, their efficacy is considered to be independent of emotion. However many studies have found that natural surroundings have the capacity to invoke positive emotions and are thought to play a key role in nature-based healing (Corazon, et al., 2011; Vujcic, et al., 2017). In the case of Jesse, Michael and Maia, developing a hopeful, optimistic outlook was a critical factor. Natural processes can play a strong role in developing such an outlook through the stimulation of neurotransmitters in the brain. One example is the photonic energy from the sun that is converted into electro-chemical energy as it is received by the retina and directed towards the pineal gland. Here serotonin, often referred to as the 'happiness' neurotransmitter is manufactured, creating an overall sense of well-being. At night serotonin is converted into melatonin which influences our circadian rhythms (Mead, 2008; Williams, 2018). Getting proper sleep and feeling good with oneself can provide a major influence in healing. Creating a positive state of mind is critical in the healing process, particularly when the majority of the healing process is conducted in a self-directed manner. When all the benefits of the sun's energy was explained to Michael, he in particular developed a rich brown tan over most of his body as he tried to present as much body surface as possible during his walks.

We also know that movement/exercise contributes to the development of a positive mood in the production of four key neurotransmitters: serotonin (keeping aggression and anger in check and resisting the development of depression), dopamine (creating a calming effect as a reward for learning), norepinephrine (influencing attention and perception), and endorphins (sense of euphoria) (Ratey, 2012; Selhub and Logan, 2012; Bruening, 2017). Each day that the three participants were walking in natural settings they were potentially benefiting from the amplifying relationship from the 'happiness' effect of serotonin, the 'calming' effect of dopamine, the 'alertness' of norepinephrine and the 'satisfying' effect of endorphins. As they increased their daily walking, these benefits may have gradually improved their mood. Each had started the nature-based process in a rather gloomy mood (in particular Jesse and Maia in tears) about the uncertainty of their futures. For all three, there was a strong correlation between increased time spent walking in natural settings and an increasingly positive mood. White, et al. (2019) found that spending 120 minutes per week in nature is optimal for good health and well-being. In the current study however, daily walking in natural surroundings was just as or more important as overall weekly totals, with the goal of developing consistency and creating habit of mind i.e. developing a daily routine like brushing teeth and going to work.

The fifth neurotransmitter that may have been at play is that of oxytocin. Oxytocin often known as the "hugging" neurotransmitter is produced when one feels loved or cared for or well-thought of (Bruening, 2017). This is all about perception. Similarly if one feels a strong connection with nature (other living organisms such as trees and flowers) or with natural processes such as a warm wind on the face or the smell of various plant fragrances, this might also trigger the production of oxytocin. In this sense, nature is seen as an "active partner" in the healing process (Berger and McLeod, 2006, p. 87). "Ecophily" has been described as a feeling of kinship with or loving kindness towards the natural world (Puk, 2021a). In order to develop an ecological consciousness, one first needs to develop an ecophilic, sustaining, embodied relationship with natural processes. If hugging a human can stimulate oxytocin, then feeling embraced by nature may do the same as this is also a matter of perception. If you believe it, it may come to be (Lipton, 2011; Dispenza, 2008).

My theory is that all of these neurotransmitters work in an amplifying manner, each reinforcing the other, creating a powerful synchronizing effect. During the NBRH process, walking in natural settings on a regular basis may create an outcome greater than the effect of any one influence. This may account for the rather rapid progress that all three experienced. It is my belief that as each participant observed that they were improving their memory abilities, this had a reciprocal effect on their mood. They felt better about themselves, in some cases amazed and gratified, and this in turn may have stimulated the production of serotonin and dopamine which then acted to stimulate more positive emotion. As the daily routine becomes habitual, the intent is that so too does the stimulation of healing neurochemicals. The affirmations are also intended to stimulate the production of serotonin, oxytocin and dopamine, providing a happier and calming atmosphere in the mind. This more contented atmosphere appeared to eventually seep into the daily lives of the participants beyond their daily walks. The participants are then motivated to become more and more diligent in following the protocol.

Cognitive restoration

Modern urban life is jammed full of constant stimulations of the brain, constantly taxing the body's resources to deal with all these distractors. The stimuli of experiences in nature however are emotionally distinct (Madan, et al., 2019). Kaplan (1995) proposed that it was the attempt by the unconscious brain to continuously control ("inhibit") all these distractions that cause unrecognized stress. He suggested that one of the key benefits of being in contact with nature is that those constant distractors of modern urban life are absent. The brain did not have to deal with this stress and could relax as nature provided the medium to reduce this "inhibitory load". According to the scope of meaning theory,

"communication with the environment takes place at an emotional, nonverbal and cognitive level (Visholm, et al., p. 663). Thus this connection with nature provides a climate of “cognitive restoration”. This appeared to be a key component in the healing process of all three participants in the current study. Multiple stimuli such as traffic lights, artificial indoor lighting, back-ground radio music, conversation, moving objects (e.g. vehicles, pedestrians, computer images) provided a constant requirement of all three participants to try to ignore these interferences in their daily lives, limiting the space required to heal. According to Ulrich and his Aesthetic-Affective theory (Ulrich, 1993) nature automatically has a positive influence on stress relief and general human health. These outcomes are 'automatic' because the brains of early humans developed a "predisposition" from within nature. The quietness and peacefulness of more natural surroundings provided the brains of the three participants a healing environment, much less taxing and energy draining than modern, industrial influences (Williams, 2018) and provided the opportunity for their neuropathways to start to regenerate. We can not overstate that the human brain evolved fully immersed in nature on a daily basis (Ulrich, 1993). I believe this influence is the seat of human-nature.

On the other side of the ledger, we know that cortisol when produced on a chronic basis due to fear, anxiety, worry, uncertainty or depression has a negative effect on the brain (Bruening, 2017). It can not only damage neurons but also over-tax the immune system. The memorization, the affirmations and the stimulation from the natural world is intended to accomplish a number of things. First this dynamic distracts from thinking about negative issues. The protocol only has time for focusing on accomplishing the daily tasks i.e. memorizing new lines, reinforcing the lines and verses already committed to memory, focusing on affirmations and observing nature. There is little time left to worry about the uncertain future or to constantly review a painful past, which I believe is critical in repairing the emotional core of the participant. Thus the NBRH process attempts to limit the production of cortisol. As this decrease in cortisol becomes habitual, it hopefully spills over into daily life and becomes an integrated behavior, sewn into the fabric of emotion and thought. This is what occurred with all three participants who were dispirited prior to beginning the NBRH model, worried that they might never return to normal health.

Memory

Memorization while walking in natural settings is at the heart of the nature-based regenerative healing model. While they are walking, the participants are repeating out loud lines of nature-based poetry. Corazon et al. (2011) describe how “using metaphors together with bodily-involving activities can strengthen the consolidation and richness of the explicitly learning related to the metaphor”p.166. As the participants walk in and reflect on their natural

surroundings, the simultaneous bodily involvement along with the combination of the nature-based poetic metaphors will theoretically endorse the healing effect by "semantically relating cognition and bodily involvement" (Corazon, et al., 2011, p.161).

In the NBRH model, this process begins with simpler poems and eventually moving to poems in which the syntax and language (e.g. Wordsworth) is quite different from 21st century language. By repeating the natured-based poetry lines utilized in this study, a number of processes are thought to be stimulated in the brain: neurogenesis (birth of new neurons), new synapses are being created and perhaps most importantly myelination may be occurring (Coyle, 2009; Hasan, et al., 2019; Bonetto, Belin and Karadottir, 2021; Xin and Chan, 2020). This resulting development of long term memory also has the potential to change gene expression (Kandel, 1998; Kandel and Squire, 2000). All of this is to say that it is possible to rewire the brain through deliberate thought and action (Lipton, 2011; Dispenza, 2008). New neurons and new synapses mean new neuropathways i.e. collections of interconnected neurons that contain representations of the external world. The more the words then lines then verses are repeated the stronger these neuropathways may become. The standard slogan for neuroplasticity is that "neurons that fire together wire together" (Doidge, 2008; Doidge, 2016; Wexler, 2008). New neuropathways mean alternate routes that information might utilize in place of damaged neurons, for example, to overcome brain fog and memory lapses that all three participants experienced in these two studies. As well, the electrical current that provides the energy for information to be relayed from one neuron to another is carried by the myelin sheath that surrounds each neuron. Various studies have indicated that the thicker this sheath, the faster, more accurate and stronger the signal may be (Coyle, 2009; Hasan, et al., 2019; Bonetto, Belin and Karadottir, 2021; Xin and Chan, 2020). Constant focus on repetition and correcting mistakes in the development of any skill has the potential to create thicker myelin around a neuron. The thicker the myelin, the more effective the passage of information.

I cannot of course know with certainty that this occurred in the participants. What I can say is that learning poetry when one has brain fog initially causes the individual to struggle, repeat, correct and focus on detail. As the participants proceeded through their healing experiences, the syntax of the poems became more difficult to first make sense of and the more it directed the participants to focus on detail. Having the supportive surroundings of nature provides the stress-free, "cognitive restorative" environment conducive to this healing process.

That "physical activity in nature" (i.e. more generally movement) benefits health and well-being has been extensively documented (Lawton, et al., 2017). Bratman et al. (2015) found that walking in nature provided the conducive environment to

decrease "rumination and neural activity" in the prefrontal cortex, i.e. to decrease the constant and repetitive negative thoughts swirling in the brain due to the constant stimuli of modern living. In the current study the focus has been primarily on the interaction between neurons and nature. Movement not only stimulates the production of mood- influencing neurotransmitters but also stimulates the birth of new neurons and new synapses (Ratey, 2012). Stress resulting in chronic rumination, caused by uncertainty, fear and anxiety about one's health can erode the synaptic connections. Thus while mood producing neurotransmitters may have been boosting the inner strength of Jesse, Michael and Maia, the daily walking may have also been directly helping to rewire the brain, creating new neuropathways.

The nexus of nature and neurons

There are four main components to the current nature-based healing model: 1.nature providing a supportive milieu, 2. the nutrients that nature provides, 3. the evolutionary influence that nature provides in human development and 4. repetitive self-talk during the healing process.

Let us start with the evolutionary influence that nature has utilized to shape the functioning of the human brain i.e. the functioning of neural networks. Evolutionary psychology involves the "study of the human mind as a product of evolution through natural selection", examining many branches of psychology including environmental psychology (Roberts, van Vugt & Dunbar, 2012). The modern human brain contains a negativity bias particularly emanating from the amygdala, that we have inherited from our earliest ancestors (Hanson, 2013). It is believed that these ancestors developed this neurological bias because they were predominantly influenced by the constant reality of life-threatening conditions. Negativity involves stress and the production of chronic cortisol which impedes the healing process. Healing however requires a supportive, affirming influence. In the nature-based regenerative healing model, the participants were continuously talking to themselves by repeating lines of poetry and affirmations that were intended to have a positive healing influence in developing new neuropathways, particularly in the limbic system, that may eventually override this negativity bias (Hanson, 2013).

That's not to say that this bias disappears, rather that we can learn to control and minimize the influence of this negativity bias. But to accomplish this requires repetition and is another reason why daily sessions in natural surroundings may be critical in creating new neuropathways to overcome the evolutionary hill that we have to overcome, in reshaping how our limbic system operates. And then, in order to be able to focus on the repetitive self-talk that healing requires, we need a supportive milieu, a soft fascination with peaceful, quiet and calm surroundings that natural locations provide. At the same time, the nutrients that natural

processes provide, as well as the benefit of moving through nature, can all contribute to this enriched nexus.

Potential Follow-up Research

What questions might researchers attempt to answer in order to strengthen the efficacy of the NBRH model and thus strengthen the confidence potential users might develop towards it?

Would participants with neural damage using the NBRH model heal as efficiently if:

1. no memory work was involved?

2. poetry that didn't have nature-based images or themes was used?

3. memory work was involved but no movement was involved (i.e.participants might simply sit in natural surroundings)?

4. no affirmations were involved?

5. other locations were involved e.g. urban parks, coastal regions, arid regions or locations with minimal natural surroundings such as city sidewalks?

6. does believing that the participant has an emotional connection with natural processes e.g. hugging a tree, actually stimulate the production of oxytocin as it does when people embrace people (see also Rice, 2012)?

Answers to these questions might further strengthen the NBRH model. A working model and the resulting working theory are by definition always in flux.

Demand characteristics

In any qualitative study demand characteristics i.e. clues that may influence the responses of the participants , need to be accounted for, particularly when self-reporting responses are utilized. For example, how do we know whether the participants are trying to please the researcher by giving responses they feel the researcher is looking for?

In this study, demand characteristics are addressed in several ways:

1. None of the three participants knew of each other's existence, yet the healing progress they each made, utilizing essentially the same NBRH model, was quite similar (as noted in the scores described previously).

2. Their quantitative scores were compared with the researcher's observational notes made during all sessions over a period of many months. The scores and the observations were congruent.

3. In Jesse's case study (Puk, 2021b), the interviews were conducted and reported on by a research assistant, who did not know the participant; and yet similar responses were reported in all three case studies.

Recommendations

1. One potentially interesting adaptation that might be made involves the interaction between the guide and the participant. This would involve having both guide and participant, walking together on occasion so that the guide can see and hear first-hand how the participant is conducting themselves during their independent sessions. The guide could then provide in-field suggestions based on what the participant experienced rather than interpreting what the participant tries to remember and describe during the once a week debriefing sessions.

2. It would be interesting to use the same NBRH model for 'healthy' individuals to determine what benefits might be derived e.g. how the process might enrich the emotional/mental/physical aspects of their lives; and how it might improve memory throughout adulthood. The author is currently conducting several studies exploring this focus.

3. The assessment scales might be broadened to provide more insight into the changing relationship between the participants and nature.

4. Nature-based healing approaches such as the NBRH model should be considered as a treatment for post-concussive syndrome within allopathic medicine (Buckley & Brough, 2017).

Limitations

1. As with all qualitative studies, much of the data is dependent upon the accuracy provided by the participants.

2. The debriefing guide was also the researcher.

3. This study involved case studies of two participants with post-concussive syndrome. An additional participant, with brain impairment, from a previous study was provided for comparative purposes.

4. The role of a placebo effect might also be considered as a potential influence in the participants' healing process i.e. might they have progressed in their healing because of this effect. As described previously, at the outset, all three participants expressed doubt and skepticism in regard to the NBRH model and all three felt they were never going to enjoy a "normal" life again. I believe that what is really involved in a placebo effect is self-belief, either consciously or unconsciously. It was only after a period of time of progressing through the daily influences of the NBRH model that when they experienced and observed for themselves their own

healing progress i.e. a lessening of their symptoms, that self-belief appears to have played a role along with all the other influences involved in the NBRH model. I believe this is a factor in most healing experiences including when taking medications.

Conclusions

Jesse, Michael and Maia all progressed through their brain healing journey in a similar manner. They all utilized the same Nature-based Regenerative Healing Model. It is postulated that achieving a degree of emotional stability, that is, an enduring and affirming mood, played a significant role in their recovery. Although we cannot say which influences played a role, how, and to what degree, for these specific participants, my belief is that this strengthened emotional core was created through the amplifying and reciprocal effects of a synchrony of emotion, memorization and cognitive restoration conducted in the milieu of daily interaction with natural processes. No one experience, no one element, no one behavior can be said to be the one and only critical key in this process but rather that each of these entities amplify each other, simultaneously, repeatedly, creating a "different" person. "… For I have learned to look on nature…"! Nature, although composed of infinite parts, presents as a whole, acts as a whole, and is experienced as a whole, divisible only through our own misunderstandings.

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Consent

Written informed consent was obtained from the participants for the publication of this study. This consent included using data collected during the study in resulting publications, except in the use of participant names. Participants agreed that pseudonyms would be used instead, in any publications. Participant names used in this article are pseudonyms. The study was approved by the Lakehead University Research Ethic Board.

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