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Translating Neuroscience into Counselling Practice
Transposition la neuroscience dans la pratique du counseling

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ABSTRACT

Recent advances in the field of cognitive neuroscience have led to a call for counsellors to translate new knowledge about brain-mind relationships into counselling practice. In this article, we address how counsellors can bring neuroscience into their practice with clients across developmental life stages, by utilizing interventions that promote positive brain plasticity (i.e., increased efficiency in brain structure, function, and connectivity) and reverse the effects of negative plasticity (i.e., decreased neural efficiency such as maladaptive necrosis or synaptic loss).

RÉSUMÉ

Le progrès récent dans le domaine de la neuroscience cognitive a incité les conseillers et conseillères à incorporer les nouvelles connaissances sur les relations entre le cerveau et l'esprit dans la pratique du counseling. Dans cet article, nous abordons des moyens d'intégrer la neuroscience dans la pratique des conseillers et conseillères auprès de clients aux différents stades de développement, en utilisant des interventions qui favorisent la plasticité positive du cerveau (i.e., l'efficacité accrue de la structure, de la fonction, et de la connectivité du cerveau) et qui inversent les effets de la plasticité négative (i.e., l'efficacité neurale réduite, comme dans le cas de la nécrose liée à l'inadaptation ou de la perte synaptique).

During the last two decades we have witnessed an impressive evolution of our understanding of the neurobiological basis of psychological processes. Methodological developments in neuroscience have brought the possibility of directly examining important neurobiological correlates of the human mind. Research programs using techniques such as neuroimaging (Gonçalves et al., 2015), event-related potentials (Pinheiro et al., 2014), psychophysiology (Oliveira-Silva & Gonçalves, 2011), neuromodulation (Carvalho et al., 2015), and neurobiochemistry (Mesquita et al., 2013) have substantially contributed to the understanding of the relationship between brain, mind, and health. Such research has helped to elucidate (a) alterations in brain processes associated with different clinical conditions, (b) how alterations can be traced from the genetic and molecular to the brain systems levels, and (c) how the brain processes are influenced by effective psychosocial interventions.

The National Institute of Mental Health (NIMH) recently acknowledged the importance of neuroscience research to mental health by endorsing the Research Domain Criteria Project (RDoC; Insel & Lieberman, n.d.). This project invites mental health experts to characterize psychological domains (e.g., negative and positive valence systems, cognitive systems, systems for social processes, arousal, and regulatory systems) in different levels of analysis (e.g., genes, molecules, cells, circuits, physiology, behaviour, self-reports, and paradigms). The objective of the RDoC project is to move the field toward a transdiagnostic approach in which mental health issues are seen as alterations of biological and mind processes. Not clear from the RDoC matrix is how different units and domains interact to guide clinical practice. As pointed out by Cuthbert (2014), the model fails to address the environmental, sociocultural, and developmental aspects associated with each component of the RDoC matrix.

For counsellors, the ultimate objective of the RDoC matrix is the translation of neuroscience findings into more effective prevention and psychosocial interventions. In order to accomplish this, we not only need to understand the neural correlates of psychological dysfunction, but we must also identify the psychosocial mechanisms (i.e., environmental aspects) that positively or negatively influence neuroplasticity across various stages of development (see Figure 1 for an illustration).

In this article, we address how counsellors can bring neuroscience into their practice with clients across developmental life stages by utilizing interventions that promote positive brain plasticity and reverse the effects of negative plasticity. In the present context, *positive plasticity* refers to increased efficiency in brain structure, function, and connectivity as a product of internal/external stimulation and is associated with adaptive neurogenesis (i.e., development of new neurons) or synaptogenesis (i.e., developing or strengthening synaptic connections). On the contrary, the concept of *negative plasticity* refers to decreased efficiency in brain structure, function, and connectivity as a consequence of internal/external stimulation and is associated with maladaptive necrosis (i.e., neuronal death) or synaptic loss (i.e., loss or weakening of synaptic connections). It is important to note that there are situations, particularly during neurodevelopment, in which programmed cell death (i.e., apoptosis) or synaptic loss (i.e., pruning) are adaptive. Therefore, in the present context, the concepts of positive and negative plasticity encompass only situations of increasing or decreasing the brain's efficiency induced by internal/external stimulation.

NEUROPLASTICITY AND DEVELOPMENT

Recently, we have witnessed a growing interest in the contributions of neuroscience to counselling psychology practice and research (Gonçalves & Perrone-McGovern, 2014). Some of the most popular counselling textbooks are progressively including neuroscience research (e.g., Ivey, Ivey, & Zalaquett, 2014). Counselling psychology journals are also beginning to address the contributions of neurosciences. For example, the October 2014 issue of the *Journal of Counseling*

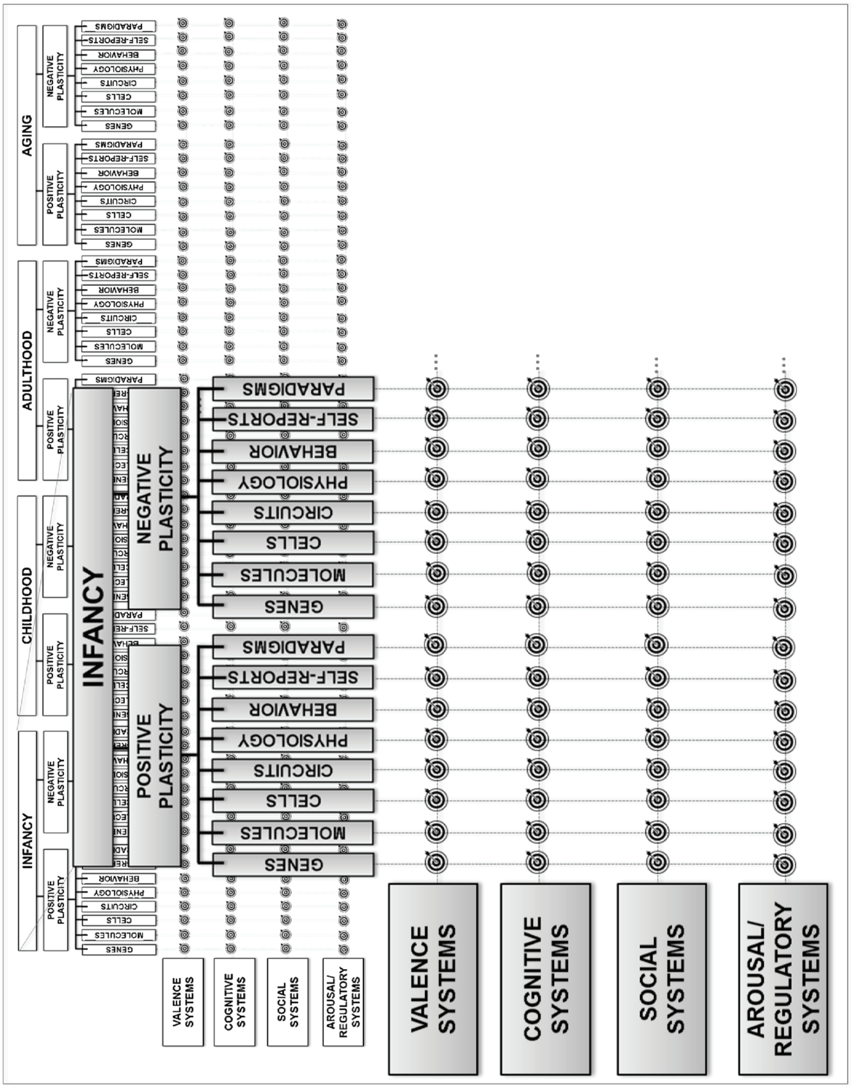

Figure 1. A developmental approach to Research Domain Criteria (RDoc).

Psychology featured a special section on the interface of neuroscience and counselling psychology. Additionally, the section is organized in a lifespan perspective, drawing on the contributions of neuroscience research with infants (Sampaio & Lifter, 2014), children and adolescents (Fine & Sung, 2014), adults (Simon-Dack & Marmarosh, 2014), older adults (Wright & Díaz, 2014), and healthy interpersonal relationships (Coutinho, Silva, & Decety, 2014).

A few decades ago, researchers believed that the only changes one could expect after childhood development of the brain were those associated most typically with the aging process (e.g., declines in information processing speed and the ability to learn and recall new information; see Verhaeghen & Cerella, 2008, for a review). However, the pioneering work of Nobel laureate Eric Kandel (2005) revealed that brain cells were able to compensate for degeneration and form new neural connections in response to novel learning experiences or exposure to new environmental stimuli. This phenomenon is referred to as *neuroplasticity*. Kandel's research demonstrated how neurons change, both at the functional and structural levels, in response to learning. For example, research shows that habituation causes negative plasticity by interfering with the efficacy of synaptic neurotransmission. In contrast, sensitization enhances synaptic transmission and is responsible for positive plasticity processes such as synaptogenesis and neurogenesis (Kandel, Dudai, & Mayford, 2014).

Perhaps one of the most interesting illustrations of the effect of learning on brain plasticity was of London taxi drivers (Maguire et al., 2000). It is widely acknowledged that a high level of spatial navigation proficiency is required for licensed taxi drivers in London. Maguire et al. (2000) studied this population and found that the London taxi drivers had a significant volumetric increase in the posterior part of the hippocampus (a region that has been associated with spatial memory). Additionally, driver experience was linked to positive plasticity in these regions of the brain. However, the finding that these same taxi drivers had a significant volumetric decrease in the anterior part of the hippocampus (a region associated predominantly with verbal learning) illustrates negative plasticity. In other words, by over-exercising spatial memory processes, taxi drivers seemed to be underusing verbal memory and thus introducing negative plasticity (i.e., atrophy) for the corresponding brain region. Another study by Woollett and Maguire (2009) confirmed that navigational expertise was associated with decreased associative verbal memory in taxi drivers.

While the study with London taxi drivers illustrates negative plasticity in terms of structural brain atrophy, numerous clinical studies show evidence of negative plasticity at the functional level (e.g., decreased hemodynamic response) without morphological alterations (e.g., atrophy). For example, Pizzagalli et al. (2004) found that melancholia was associated with functional but not structural alterations in the subgenual prefrontal cortex (a region known to play an important role in mood disorders). This illustrates that, at the macro level, functional brain alterations may not be correlative of alterations in brain morphology (i.e., volume and/or shape).

Neuroscience research has identified several psychosocial factors that contribute to negative neuroplasticity. Psychosocial factors of emotional neglect, addiction, stress, and environmental impoverishment introduce processes of negative plasticity (Duman, Aghajanian, Sanacora, & Krystal, 2016). These are pathophysiological factors at molecular and cellular levels associated with psychological distress, and responsible for brain changes at structural, functional, and connectivity levels. Neuroscience research has also revealed psychosocial processes that promote positive neuroplasticity through synaptogenesis (i.e., new synapsis) and, to a lesser extent, neurogenesis (i.e., new neurons) (Clemenson, Deng, & Gage, 2015). As illustrated below, four processes that have profound implications for counselling and are essential to promoting healthy development and counteracting the effects of negative neuroplasticity are nurturing and caring, healthy behaviour, emotional regulation, and environmental enrichment (Opendak & Gould, 2015).

In what follows, we will illustrate how counsellors can bring neuroscience into their practice by designing interventions to promote positive brain plasticity (nurturing and caring, healthy behaviour, emotional regulation, and environmental enrichment) and reversing the effects of negative plasticity (emotional neglect, addiction, stress, and environmental impoverishment) across developmental life stages (infancy, childhood/adolescence, adulthood, and aging adults; see Figure 2). More specifically, examples of core health development tasks will be presented for each developmental period (infancy, childhood, adulthood, and aging), along with the neurobiological correlates underlying these tasks, and evidence-based strategies to facilitate each task and promote positive neuroplasticity.

INFANCY HEALTH DEVELOPMENTAL TASKS

Secure Environment

One of the major health development tasks in infant development is the construction of a secure environment (i.e., the caregiver provides a safe, caring, and predictable environment in which the infant's needs are consistently met). Emotional neglect or the lack of secure attachments can have devastating effects on brain development. Similarly, the epigenetic effects (i.e., alterations in gene expression) of nutritional stress (i.e., the toxic impact of certain types of nutrition exposure on enzymatic activity regulating patterns of gene expression), psychosocial stress, and environmental stress, can negatively influence infant health and development (Thayer & Kuzawa, 2011). The establishment of secure environments and the use of nurturing and caring strategies are instrumental in promoting infants' mental and physical health and building a strong foundation for later development.

Negative Plasticity and Emotional Neglect

The neurobiological consequences of emotional neglect constitute a core topic for current developmental neuroscience research (Schechter, 2012). For example, a study by Tottenham et al. (2010) found that children residing in an orphanage

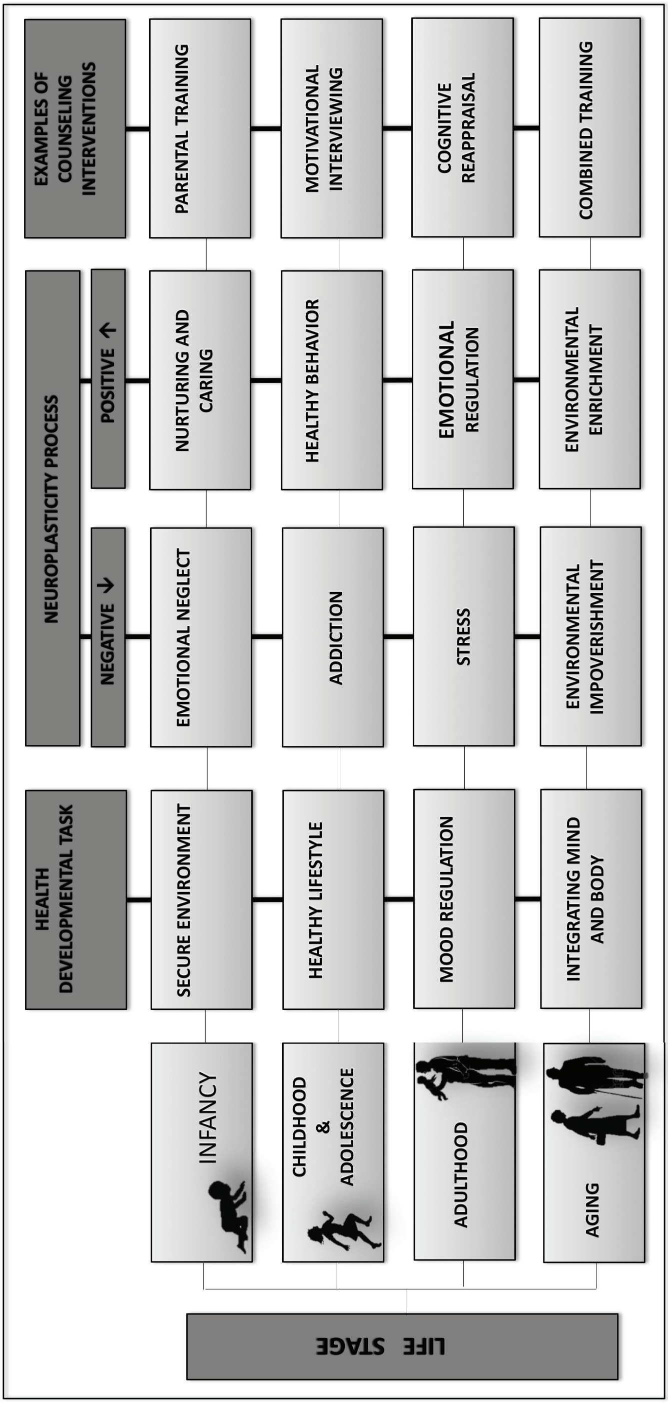

Figure 2. Neuroplasticity and development (downward arrows - decrease negative plasticity; upward arrows - increase positive plasticity).

for long time periods showed evidence of an increased amygdala volume associated with difficulties in emotional regulation. Consistent with this finding, Govindan, Behen, Helder, Makki, and Chugani (2010) reported that changes to the integrity of white matter tracts (i.e., levels of fractional anisotropy and diffusivity in bundles of myelinated axons) connecting frontal, parietal, and temporal brain regions became more evident as the length of time children spent at an orphanage increased. These alterations were found to be associated with patterns of inattention and hyperactivity. Finally, Hanson et al. (2013) found evidence for white matter alterations in the prefrontal cortex that were associated with the presence of neurocognitive deficits. In sum, early emotional neglect seems to be one of the mechanisms responsible for negative plasticity influencing early brain development, with the potential for devastating consequences on social, emotional, and cognitive development.

Positive Plasticity and Nurturing/Caring

There is consistent evidence from animal studies that early experiences of nurturing and caring (e.g., licking and grooming behaviours of mother rats toward their pups) regulate emotional and cognitive response to stress. High levels of licking and grooming were found to act as a stress buffer by attenuating hypothalamic–pituitary–adrenal (HPA) axis activity (i.e., the feedback response system between the hypothalamus, the pituitary, and the adrenal glands in the face of emotional stress) by increasing glucocorticoid receptor expression in the hippocampus (Liu et al., 1997). Most interestingly, however, is the fact that when high licking and grooming mothers fostered offspring from low licking and grooming mothers, the stress phenotype was reversed (Meaney & Szyf, 2005). In other words, the nurturing behaviours of foster mothers acted like a therapeutic environment. This research also demonstrated that the licking and grooming induced the activation of a serotoninergic pathway affecting an increased expression of the glucocorticoid receptor gene in the hippocampus and prefrontal cortex (Meaney & Szyf, 2005). Glucocorticoid overexpression was shown to be responsible for increased resistance to stress by the downregulation of HPA activity (Zhang et al., 2013). Milgrom et al. (2010) extended this research with humans, showing that training pregnant women in nurturing (e.g., facial expressions, movement and massage, skin contact, and multisensory stimulation) helped to reduce stress and facilitated white matter connectivity in infants.

Example of Counselling Intervention – Parental Training

Osofsky and Lieberman (2011) have suggested a theoretical framework for the implementation of infant health services that may be important in promoting positive brain plasticity. The authors call for parent-oriented interventions aimed at creating nurturing and secure environments to counteract the effects of low socioeconomic status and environmental impoverishment (i.e., negative plasticity). A meta-analysis by Barlow, Parsons, and Stewart-Brown (2005) identified several evidence-based caring and nurturing interventions aimed at promoting effective attachment and socioperceptual sensitivity (e.g., skin-to-skin care, infant massage, and infant carriers). Research has also shown the effects of parent sensitivity training on infant brain development. For example, Milgrom et al. (2010) found that 10 sessions of parent sensitivity training (e.g., helping mothers of preterm children to recognize and cope with signs of infant stress, strategies of stimulation and optimizing interactions, use of touch, movement and massage, and nesting) increased the maturity of white matter connectivity in infants as measured by several diffusivity white matter indexes: apparent diffusion coefficient (ADC), fractional anisotropy (FA), radial diffusivity (RD), and axial diffusivity (AD). Low ADC is associated with an increase of white matter integrity. High FA values indicate white matter integrity. High AD is a marker of axonal damage. High RD is a marker of altered myelination processes. The authors found that parent sensitivity training was associated with increased connectivity (e.g., higher FA, decreased RD, decreased AD) in several brain regions. It is important to note that maturity in white matter connectivity is a reliable predictor of overall cognitive development (Fischi-Gómez et al., 2015). This research shows that programs providing a nurturing and secure environment have an important positive influence on brain plasticity and help ameliorate the effects of early stress of preterm children. This, in turn has an impact on later cognitive development.

More longitudinal research is needed to understand the long-term neural impact of early parenting interventions. However, evidence from naturalistic studies show that early maternal support (as measured by an experimental waiting task) is a good predictor of hippocampal volume at later age (Luby et al., 2012). Counsellors could provide similar programs for caregivers of infants who have been neglected, abandoned, mistreated, or abused in order to attenuate the negative outcomes on the infants' psychological and brain development (Bernard et al., 2012).

CHILDHOOD AND ADOLESCENCE HEALTH DEVELOPMENT TASK

Healthy Lifestyle

During childhood and adolescence, an example core health development task is the formation of healthy habits and behaviours. The American Psychological Association (2013) resolution on the "Promotion of Healthy Active Lifestyles and Prevention of Obesity and Unhealthy Weight Control Behaviours in Children and Youth" encourages psychologists to utilize evidence-based interventions to promote healthy, active lifestyles. Several school- or family-based programs have now been found to promote healthy lifestyles in children and adolescents (Brown et al., 2016; Lloyd & Wyatt, 2015). These programs most often target the promotion of a balanced diet and increased physical activity.

Negative Plasticity and Addiction

Addiction has been widely demonstrated to have negative neuroplasticity effects across development. However, this may be particularly true during adolescence, as this is a crucial stage for prefrontal cortex maturation. Research has shown that several brain regions and pathways are affected by addiction (Volkow, Wang, Tomasi, & Baler, 2013). For example, a study by Cousijn et al. (2012) found that the heavy use of cannabis was negatively correlated with amygdala and hippocampus gray matter volumes, which are associated with both emotional (e.g., stress regulation) and cognitive symptoms (e.g., memory impairments). Similar data were reported by Ashtari et al. (2011) in adolescents with a history of heavy cannabis use, showing morphological alterations in the hippocampus that were still present after 6 to 7 months of abstinence. In addition to substance-related addictions, other addictions (e.g., Internet, sexual, gambling) have been found to significantly alter cortical-subcortical connectivity (e.g., Hong et al., 2013; Sescousse & den Ouden, 2013). For example, Hong et al. (2013) found that Internet addiction was associated with a decreased connectivity in frontal subcortical and parietal subcortical networks with significant involvement of the putamen (a region shown to play an important role in inhibitory control). This shows that, along with other addictive behaviours, Internet addiction may impair circuits regulating inhibitory processes.

Positive Plasticity and Healthy Behaviour

Recent research has provided compelling evidence that nutrition and exercise promote positive brain plasticity through the mechanisms of neurogenesis, synaptogenesis, or angiogenesis (Gomez-Pinilla, 2011). In a recent review, Hötting and Röder (2013) provided evidence that physical exercise can facilitate neuroplasticity across developmental stages, and can have mutual enhancement benefits when associated with cognitive training. For example, a study by Holzschneider, Wolbers, Röder, and Hötting (2012) showed that spatial memory training potentiates the effects of aerobic training in hippocampus functioning. The impact has been demonstrated mostly for aerobic but also for resistance and coordination exercise (Hötting & Röder, 2013).

Along with exercise, a well-balanced, calorie-restricted diet was found to improve cognitive functioning, possibly mediated by promoting synaptic plasticity mechanisms (Witte, Fobker, Gellner, Knecht, & Flöel, 2009). There is abundant research showing that healthy lifestyles (e.g., exercise and nutrition) may influence brain plasticity in a positive way and may counteract the effects of negative factors such as stress and addiction.

Example of Counselling Intervention: Motivational Interviewing

Researchers have demonstrated the benefits of psychosocial interventions that promote healthy lifestyles. For example, Martins and McNeil (2009) suggested the use of motivational interviewing (MI) in primary care settings to promote healthy diet and exercise. This intervention strategy was initially designed for adults with substance abuse problems.

Interestingly, a recent study by Feldstein Ewing, Filbey, Hendershot, McEachern, and Hutchison (2011) demonstrated that instances of alcohol-dependent patients' change talk during motivational interviewing inhibited brain regions associated with reward (e.g., nucleus accumbens, orbitofrontal cortex) in response to alcohol cues. Based on these data, the authors proposed a translational model to explain how the neural effects of MI within the session can be generalized to change outside the session (Feldstein Ewing et al., 2011). This translational model implies that clients' change talk can mediate behavioural change by impacting plasticity of several neurocognitive pathways such as those involved in emotional learning (e.g., parahippocampal gyrus, posterior cingulate cortex, precuneus), motivation and reward/incentive (e.g., anterior cingulate, insula, basal ganglia), and executive functioning (e.g., orbitofrontal cortex, inferior frontal cortex). Effective connectivity within and between these pathways may be instrumental in self-regulating patterns of healthy behaviour during childhood and adolescence.

Adulthood Health Development Tasks

Mood Regulation

Many adults experience daily stressors from managing demands of multiple roles including work, family, community, and social roles. Not surprisingly, stress is one of the most important factors associated with emotional and physical ailments in adulthood. Acute stress has been associated with a number of ailments, including asthma, eczema, migraines, gastrointestinal symptoms, and panic attacks. There is also evidence for the role of chronic stress in, for example, hypertension, type 2 diabetes mellitus, atherosclerotic cardiovascular, anxiety, depression, and sleep disorders (Chrousos, 2009).

While homeostatic models emphasized the role of automatic negative feedback in the peripheral regulation of the stress response, more contemporary allosteric models make claims for the role of the central nervous system in the anticipatory positive regulation of the stress response (Ramsay & Woods, 2014). As remarked by Sapolsky (2007), decades of research show that we can attenuate the activity of the HPA axis and prevent the pathogenic effects of stress response by regulating thoughts and emotions. Therefore, a central health developmental task for adults is to learn how to downregulate the HPA by using a flexible repertoire of emotional regulation strategies.

Negative Plasticity and Stress

Research has demonstrated the neurotoxic effect of stress, which is likely due to the neuronal overexposure to glucocorticoids. Lupien, McEwen, Gunnar, and Heim (2009) reviewed human and animal research on the neurocognitive effects of stress, and noted that the regions more prone to declining in adulthood (e.g., amygdala, hippocampus, prefrontal cortex) are also the most vulnerable to stress. A longitudinal study by Papagni et al. (2011) showed that in healthy adults, the number of life-threatening stressful events experienced was associated with decreased gray matter volume in hippocampal and parahippocampal regions as well as the anterior cingulate cortex. These brain regions are fundamental for integrating cognitive, affective, and autonomic responses.

Positive Plasticity and Emotional Regulation

A third mechanism shown to be important to brain functioning is emotional regulation. Emotional regulation refers to a group of strategies to potentiate pleasure and avoid pain. According to Tamir (2015), two classes of motives may be responsible for emotional regulation: hedonic (maximize pleasure and minimize pain in terms of immediate phenomenology) and instrumental (regulating emotions to increase the probability of obtaining future benefits such as facilitating performance, knowledge, or relationships).

Individuals use emotional regulation strategies on an ongoing daily basis. In contrast, for stress regulation, individuals are required to regulate both external (i.e., environmental stressors) and internal (i.e., physiological and emotional reactions) demands exceeding current personal resources (Wang & Saudino, 2011). Emotional regulation strategies such as emotional suppression, cognitive reappraisal, and mindfulness, were shown to positively impact brain functioning in several cortical and subcortical regions (e.g., hippocampus, amygdala, and prefrontal cortex; Lucassen et al., 2014) by counteracting the negative effects of stress at the cellular and molecular level (e.g., dendritic retraction, neuronal losses, or glial alterations; McEwen et al., 2015).

In expressive suppression, the outward expression of emotion is inhibited immediately after an emotional response is generated. In a typical counselling situation, the patient identifies emotional triggers along with the most common body and behavioural reactions to those triggers. Then the patient is trained in suppressing the expressive component of the emotional reaction to those triggers (e.g., facial expression, body posture, eye blinking). Giuliani, Drabant, Bhatnagar, and Gross (2011) found that the practice of emotional suppression was correlated with a significant volumetric increase in the anterior insula, a region associated with processes of emotional awareness. Cognitive reappraisal, an important component of cognitive behavioural therapy (Yoshimura et al., 2014), consists of a process by which the individual generates alternative interpretations of an emotional trigger to produce an affective change (e.g., positive reframing).

Vrtička, Sander, and Vuilleumier (2011) found that while some brain networks are shared with emotional suppression (e.g., prefrontal regions), there was a significant lateralization effect of the amygdala in emotional suppression versus cognitive reappraisal. Specifically, the right amygdala was affected in emotional suppression (probably associated with the autonomic nonverbal aspects of emotional regulation) and the left amygdala was modulated in the cognitive reappraisal condition (possibly reflecting the use of predominantly verbal and cognitive strategies).

A recent meta-analysis revealed that the left amygdala seems to be predominantly involved in higher-level verbal and cognitive processing, in contrast to the role of the right amygdala in fast and automatic detection of emotional stimuli. These data show that specific emotional regulation strategies can influence distinct brain regions associated with multiple components of emotional processing. In fact, several studies have provided evidence that the right amygdala is preferentially involved in automatic emotional processing, whereas the left amygdala seems to play a role predominantly in cognitive emotional processing (Dyck et al., 2011).

Contrary to reappraisal, in mindfulness individuals redirect their attention to the here and now sensory experience, reducing the activation of cognitive control brain structures (prefrontal midline regions) in favour of structures associated with sensorial emotional processing (e.g., sensory cortex, insula, thalamus; Farb, Anderson, & Segal, 2012). A study by Allen et al. (2012) confirmed that mindfulness practice impacted emotional regulation as illustrated by improved response inhibition in an emotional Stroop task. In this task, a number-counting Stroop task (including congruent trials in which Arabic-numeral distractor information was consistent with the number of digits and incongruent trials in which Arabic-numeral distractor information was inconsistent with the number of digits) with interleaved emotional images of different valence was presented. Improved response inhibition was associated with increased activation of the anterior cingulate cortex, medial prefrontal cortex, and right anterior insula. In summary, different strategies of emotional regulation (i.e., emotional suppression, emotional reappraisal, and mindfulness) seem to have significant effects in different brain regions associated with multiple components of emotional processing.

Example of Counselling Intervention: Emotional Regulation

A study by Kanske, Heissler, Schönfelder, Bongers, and Wessa (2011) showed that distraction and cognitive reappraisal were effective in regulating emotions at both the subjective and physiological levels, although they operated through different neural pathways. Kanske et al. (2010) found that both coping strategies activated typical control brain regions (i.e., medial and dorsolateral prefrontal, and inferior parietal cortex) while decreasing amygdala activity. However, cognitive reappraisal seems to activate the orbitofrontal cortex (a region associated with affective reversal tasks), whereas distraction tends to activate the dorsal anterior cingulate and the parietal regions (part of the attentional control network).

Counsellors can help patients develop appropriate coping strategies to choose between either disengagement (i.e., distraction) or engagement (i.e., cognitive reappraisal) as emotional regulation strategies (Sheppes & Levin, 2013). The use of flexible emotional self-regulation strategies may be instrumental in helping clients adapt to the multiple situational demands of adult life. For example, in high-intensity emotional situations, individuals may be instructed to use disengagement strategies associated with the dorsal attention network or, conversely, instructed to use engagement strategies associated with the orbitofrontal cortex when facing low-intensity emotional situations. When confronted with repetitive emotional stimuli, an individual may employ engagement self-regulation strategies as well. Other strategies such as mindfulness can be used to potentiate general well-being (Sauer, Walach, & Kohls, 2011), whereas emotional suppression may help regulate the negative impact of emotion in certain cultural contexts (Soto, Perez, Kim, Lee, & Minnick, 2011).

AGING HEALTH DEVELOPMENT TASK

Integrating Mind and Body

Older adulthood can be seen as a stage with the task of integrating our life narrative. Integrating mind and body may be seen as an important developmental task at this stage. Vallet (2015) suggested recently that aging populations are an ideal target for a holistic approach to cognition in which mental and body functions are addressed as a whole.

Negative Plasticity and Environmental Impoverishment

The neural impact of impoverished environments was examined in the seminal study by Krech, Rosenzweig, and Bennett (1966), demonstrating that animals housed in impoverished environments showed evidence of significant changes in both brain chemistry and anatomy. Whereas most animal studies involve the manipulation of housing conditions, this same type of manipulation cannot be ethically implemented with humans. Thus, research on humans in impoverished environments has many potential confounding variables and threats to validity that are inherent in their naturalistic (vs. laboratory-based) design. With humans, the lack of essential environmental resources, often associated with socioeconomic status, has been shown to influence brain functioning (Hackman, Farah, & Meaney, 2010). For example, Johnson, Kim, and Gold (2013) demonstrated that higher socioeconomic status (as measured by the Hollingshead two-factor index of social position, which weights both highest occupation and education) was associated with improved white-matter integrity and better working memory in aging populations. Consistent with this finding, Brayne et al. (2010) analyzed data from large population-based cohort studies and found that even though education did not reduce the risk of neurodegenerative and vascular diseases, it was an important moderator on the clinical effects of pathology.

Positive Plasticity and Environmental Enrichment

Environmental enrichment was one of the first mechanisms identified as influencing brain plasticity. The classic study of Bennett, Diamond, Krech, and Rosenzweig (1996) showed that increasing the environmental stimulation in rats' cages (e.g. toys, activities) contributed to a significant increase in terms of weight, thickness, and acetyl-cholinesterase activity of the cortex. These effects have been extensively replicated, showing their influence in neurotrophin expression and epigenetic changes (Baroncelli et al., 2009).

Given methodological constraints, fewer controlled studies are available with human participants. However, an interesting study by Miller, Colella, Mikulis, Maller, and Green (2013) demonstrated post-morbidly that environmental enrichment limited hippocampal atrophy following a traumatic brain injury. While these findings require replication in healthy aging populations, several researchers have noted that lifestyle variables associated with environmental enrichment (e.g., cognitive stimulation, social support, nutritional balance, exercise) improve brain functioning (Mora, 2013).

Example of Counselling Intervention: Combined Treatment

Research has shown that brain plasticity can be maintained in the aging brain by integrating mind and body through a combination of cognitive enrichment and physical exercises. Pieramico et al. (2012) tested the effects of a combined training program that lasted 6 months and included cognitive, aerobic, and sensorial stimulation on brain structure (i.e., connectivity and cortical thickness) and cognition (as measured by clock drawing, letter verbal fluency, Trail Making Test, Frontal Assessment Battery, and Babcock story tests) on the brain's resting state activity, functional connectivity, and cortical thickness. The training program consisted of a 6-month intervention in three sections carried out daily (cognitive training, aerobic training, and music stimulation) with increasing task complexity in the second trimester. Cognitive training included activities such as crossword puzzles, book reading, Sudoku, logical puzzles, group discussion, and fun-recreation. Aerobic training included walking, dancing, and daily living choice activities. Finally, environmental enrichment was complemented with music listening three times per week.

The results showed the beneficial effects of the combined treatment in improving brain resting functional connectivity as well as positively impacting cognitive performance, particularly short-term and long-term memory. Additionally, increases in cortical thickness in the orbitofrontal cortex, precuneus, and hippocampus (areas associated with default mode and dorsal attention networks) were associated with the effects of the combined training. In other words, the combined treatment improved cognitive functioning by strengthening the connectivity among brain regions involved in reflective and self-referential processes (i.e., default mode network) as well as the individual's attention to external stimuli (i.e., dorsal attention network).

Recent research has shown that effortful learning is instrumental in assuring the survival of neurons that are continuously produced throughout life (Shors, 2014). Therefore, the use of challenging cognitive tasks may be an important strategy to prevent cognitive decline in the older population. However, as recently defended in *A Consensus on the Brain Training Industry from the Scientific Community* (Stanford Center on Longevity, 2014), it is important that practitioners employ challenging cognitive activities in the context of interpersonal and ecological adaptive environments rather then through the use of sophisticated computer games. This would allow room for a more adequate balance of body and mind strategies in delivering preventive and rehabilitation counselling to older adults.

CONCLUDING REMARKS

In this article we presented a neurodevelopmental approach to translate neuroscience research into counselling practice. We illustrated four psychosocial factors that have been found to have a deleterious effect on brain structure and functioning, and that are associated with poor mental and physical health: emotional neglect, addiction, stress, and environmental impoverishment. We presented evidence and delineated methods for enhancing mental and physical health through psychosocial processes that promote positive neuroplasticity: nurturing and caring, healthy behaviour, emotional regulation, and environmental enrichment. Finally, we presented examples of evidence-based counselling strategies for the promotion of positive neuroplasticity associated with core health development tasks across life stages (infancy, childhood, adulthood, and aging).

Despite the promising paths available for integration of neuroscience and counselling, one needs to approach the translation of basic science knowledge into clinical practice with caution. Human change is a complex process, and we need to avoid the temptation of biological reductionism and oversimplification. Additionally, some of the methodological developments derived from neuroscience research still need to pass evaluative criteria such as those suggested by White et al. (2015): (a) verifiability, (b) usefulness, (c), consistency, (d) reproducibility, (e) mechanism driven, (f) completeness, and (g) deployability. With these limitations in mind, we believe that, given our emphasis on health, prevention, and development, counsellors are in a unique position to assume the role of neurodevelopment health providers to promote positive brain plasticity across the lifespan.

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