

Linking Early Brain and Biological Development to Psychiatry: Introduction and Symposia Review

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Abstract

Objective: This paper introduces the special issue of the *Journal of the Canadian Academy of Child and Adolescent Psychiatry* on the theme of how multiple factors in early brain and biological development can influence a variety of outcomes in mental health and addictions in childhood, adolescence and adulthood. **Method:** In Part 1, we preview three papers in this issue. In Part 2, we highlight two recent innovative knowledge-transfer symposia featuring the application of the science in early development and addictions. **Results:** The papers focus on the subtopics of brain plasticity, mood disorders, and comparative research with monkeys on gene-environment interactions and parent-child attachment. In addition, the research presented at the Early Brain and Biological Development Symposium and the Recovery from Addiction Symposium is also reviewed. Held in 2010 in Banff, Alberta, each five-day program was intended to bridge the gap between scientific and clinical experts and those in the province responsible for policy, programs, and services. **Conclusions:** The science now links common neurobiological maturation processes, adverse early childhood experiences, and key aspects of the social environment with risks for mental health disorders and addictions later in life. The final paper in this issue examines the clinical and policy implications of this research knowledge.

Key words: addiction, brain, development, knowledge-transfer, symposium

Résumé

Objectifs: Présenter le numéro spécial du *Journal de l'Académie canadienne de psychiatrie de l'enfant et de l'adolescent* qui explique qu'au moment du développement cérébral et biologique certains facteurs peuvent avoir une incidence sur la santé mentale et les addictions pendant l'enfance, l'adolescence et à l'âge adulte. **Méthodologie:** Dans la première partie nous présentons trois articles tirés de ce numéro; dans la deuxième, nous nous concentrons sur deux symposiums récents et novateurs qui ont pour thème le transfert des connaissances et qui traitent de l'application des méthodes scientifiques à l'étude du développement du cerveau et des addictions. **Résultats:** Ces articles se concentrent sur la plasticité du cerveau et les troubles de l'humeur; ils analysent les interactions gène-environnement et l'attachement parent-enfant à partir d'une étude comparative menée sur des singes. En outre, ces articles portent sur les travaux de recherche présentés lors de deux symposiums, le Early Brain and Biological Development Symposium et le Recovery from Addiction Symposium. Ces symposiums de cinq jours chacun, qui se sont tenus en 2010 à Banff (Alberta), visaient à créer un lien entre scientifiques et cliniciens, et entre les responsables, au niveau provincial, des politiques, programmes et services. **Conclusion:** Les scientifiques reconnaissent maintenant le lien entre la maturation neurobiologique courante, les expériences négatives vécues dans la petite enfance, les principaux aspects de l'environnement social et les risques de maladie mentale ou d'addiction. L'article final de ce numéro du *Journal de l'Académie canadienne de psychiatrie de l'enfant et de l'adolescent* analyse les implications cliniques et politiques découlant des résultats de ces études.

Mots clés: addiction, cerveau, développement, transfert de connaissances, symposium

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Submitted: May 16, 2011; Accepted: July 29, 2011

This paper serves as an introduction to this special issue of the *Journal of the Canadian Academy of Child and Adolescent Psychiatry* on the theme of how multiple factors in early brain and biological development can influence a variety of outcomes in mental health and addictions in childhood, adolescence and adulthood. Early childhood is a time of great opportunity for positive growth and a period of considerable risk as well. What is done – or not done – during this early part of life can have profound implications for the individual and also for society. As a demonstration of practical value of this research, we also highlight two recent innovative symposia featuring the application of science in this area to research, training, and clinical services in the province of Alberta.

Early brain and biological development is influenced by the effects of the interplay of experiences occurring before and after birth on a child's genetic code. Emerging research across a wide range of disciplines provides compelling evidence that what happens during the first few years of life influences health outcomes, behaviour, social adjustment, and learning over the long term. Early development thus sets the course for health and well-being over the lifespan. A research-based understanding of epigenetics, developmental neuroscience, and behavioural neuroscience is shifting the way we approach support for development in childhood and adolescence and the way we must begin to redirect clinical treatment and prevention activities for many diseases including mental health and addictions. Full appreciation of these scientific facts is leading to important opportunities for clinical and policy innovations for child and adolescent mental health in Canada (Kutcher, Hampton, & Wilson, 2010).

PART 1: Introduction to the Special Issue

The theme of the special issue concerns how multiple factors in early brain and biological development can influence a variety of outcomes in mental health and addictions in youth and adulthood. This article provides a brief overview of each paper in the issue and notes why this information is relevant to research and clinical services for child and adolescent psychiatry.

Preview of the Papers in this Issue

Paper 1. The first paper: "Brain Plasticity and Behaviour in the Developing Brain" was prepared by Bryan Kolb and Robbin Gibb. It reviews ways the developing brain is sculpted by a wide range of pre- and postnatal factors. The paper begins with an overview of brain development, is followed by a brief review of the principles of brain plasticity

and concludes by considering how certain factors influence brain development and adult behaviour. Brain structure and function are altered by the experience of a wide range of factors during pregnancy and after birth (Kolb & Wishaw, 2011). Brain development starts before birth and continues into early adulthood. The development of the brain reflects more than the simple unfolding of a genetic blueprint; rather it reflects a complex dance of genetic and experiential factors that shape the emerging brain. Brains develop in ways that reflect the influence of exposure to environmental events such as sensory stimuli, drugs, diet, hormones, and stress. Plasticity refers to the brain's capacity to change in response to external influences and experiences, particularly during the first few years of life. Research in epigenetics suggests that early interpersonal experiences (e.g., caregiver-child relationships) influence both gene expression and brain architecture, which then influence a wide range of behaviour in adulthood.

Paper 2. The second paper is called "Psychological and Neurobiological Mechanisms by Which Early Negative Experiences Increase Risk of Mood Disorders" by Stefanie Hassel, Margaret McKinnon, Andrée Cusi, and Glenda MacQueen. This paper examines how early life experiences can have severe and long-lasting effects on behavioural and emotional functioning, which, in turn, appear to increase the risk for unipolar depression and other disorders of affect regulation. Depression is a chronic and serious mental illness that appears to change brain architecture and function (McKinnon, Yucel, Nazarov, & MacQueen, 2009). It is linked to an increased risk of other mental and physical health problems. In addition, the whole family of an individual who experiences depression may experience depression, as well, as it is a chronic and cyclical disease. The specific neurobiological and psychological mechanisms, however, through which adverse early life experiences confer risk for mental health and addiction disorders are just beginning to be understood. Several areas of research offer promising potential for greater understanding of such mechanisms. For example, alterations in brain structure and function in the limbic and prefrontal cortical regions of the brain, certain changes in cognitive function which co-occur with or pre-date the onset of mood disorders, basic social cognition processes, and emotional temperament and personality factors may all affect vulnerability to mood disorders.

Paper 3. The third paper is called "Risk, Resilience and Gene-Environment Interplay in Primates" by Stephen Suomi. It reviews research investigating how genetic and environmental factors act – and indeed actually interact – to shape the behavioral and biological developmental trajectory

ries of individuals. The paper is organized into three areas: description of the normal patterns of social organization and development in rhesus monkeys; behavioural and biological consequences of different early attachment relationships; and, gene by environment interplay. Rhesus monkeys share many of the same genetic factors and social characteristics with humans and thus offer a useful comparative perspective for understanding primary developmental issues. Genetic factors are not the only source of inter-individual variability in the behavioral and biological characteristics of monkeys, as social experiences also matter, especially early attachment experiences with the infant monkeys' biological mothers (or in some cases, alternative caregivers or peers) during their initial months of life. These early attachment-related experiences become manifest not only in terms of observable behaviors and expressions of emotions but also in terms of neuro-endocrine output, neurotransmitter metabolism, brain structure and function, and even gene expression. Secure attachment relationships somehow confer resiliency to individuals who have certain genetic factors (particularly the 5-HTT and MAO-A genes) that may otherwise increase their risk for adverse developmental outcomes. Much of this "maternal buffering" appears to take place in the context of early face-to-face interactions between rhesus monkey infants and their mothers. The study of rhesus monkeys provides compelling evidence of how gene-environment interactions can yield a wide range of positive and negative outcomes later in life (Suomi, 2006).

Implications of the Research

These three review papers each highlight research that underscores a central theme of the importance of early experiences in contributing either to lifelong health and resiliency or to illness and psychiatric problems. The exciting collaboration of research scientists from psychiatry and neurobiology has yielded some interesting and important insights into how the brain develops over time and how it is affected both by genetic and biological factors as well as social factors.

For scholars and practitioners in the field of child and adolescent psychiatry who work with very young parents, there are several important implications. The first is the need for a strong emphasis on a context of positive social relationships for pregnant mothers and during early parenting years. This period is one of high-risk for maternal depression and stress for all other family members who must adjust to a new child. Providing supports, skills training, therapeutic interventions and mental health treatments for young parents is one area where child psychiatry can make a difference.

A second implication is that the period of adolescence is a fertile time when many mental health illnesses and addictions may first emerge and for family stress to peak as well. As the brain of the adolescent continues to mature until the age of the early- to mid-20's, targeted psychiatric interventions for teens and young adults can effectively identify and address risks and early warning signs much sooner than is typical of first treatment interventions during the years of the late 20's or early 30's. Such early interventions are shown to decrease both the severity and treatment-resistance of future mental illnesses.

A third theme from the neuroscience research on early development relevant to the readers of this Journal is the recognition of the social context in general. The interplay of the child and care-giver and of the child in other relationships interacts with the neurobiological maturation processes and is a major component of how genes are expressed and thus of healthy neurocognitive development. And this is precisely the area where child and adolescent psychiatry has a lot to offer in terms of theory, research and clinical applications that address how to have positive social relationships, both within the family and with the larger social milieu that affects every one of us.

The application of these insights for clinical practice, intervention programs, and social policy is an important next step. Please note that the final paper in this special issue addresses this issue in depth. However, in the next part of the present paper, we present an example of an innovative approach to knowledge translation in the area of early brain and biological development that began last year through two recent applied action symposia. Part of this work identifies new knowledge translation tactics for how to communicate the "core stories" from the research to the public and to policy makers. It also examines how this area of neuroscience and child development can shape the development of best practices in addiction treatment and recovery.

PART 2: Review of Science in Action Symposia

In 2010, the Alberta Family Wellness Initiative partnered with Alberta Health Services and Alberta's Safe Communities Secretariat to develop two inter-related and interdisciplinary knowledge-mobilization strategies to bring scientific findings and knowledge to issues of early childhood and addiction.¹ As part of a three-year plan for Alberta, these strategies aim to create a platform to provide knowledge competencies and encourage engagement and integration among and between researchers, policy makers, and clinical practitioners in a variety of fields. The strategies

Table 1. Symposia Summary Reports and Related Knowledge-Transfer Papers

Volume 1. Early Brain & Biological Development: A Science in Society Symposium. Summary Report. Norlien Foundation. (2010). Calgary, AB, Canada: Author.

Volume 2. Recovery from Addiction: A Science in Action Symposium. Summary Report. Norlien Foundation. (2011). Calgary, AB, Canada: Author.

Both summary reports available from: <http://www.albertafamilywellness.org/resources>

The "Working Papers" series of brief reports by the National Scientific Council on the Developing Child and the Harvard University Center on the Developing Child. Available from: http://developingchild.harvard.edu/library/reports_and_working_papers/working_papers/

- Paper 1 (2004) - *Young Children Develop in an Environment of Relationships*
- Paper 2 (2004) - *Children's Emotional Development is Built into the Architecture of their Brains*
- Paper 3 (2005) - *Excessive Stress Disrupts the Architecture of the Developing Brain*
- Paper 4 (2006) - *Early Exposure to Toxic Substances Damages Brain Architecture*
- Paper 5 (2007) - *The Timing and Quality of Early Experiences Combine to Shape Brain Architecture*
- Paper 6 (2008) - *Mental Health Problems in Early Childhood can Impair Learning and Behavior for Life*
- Paper 7 (2008) - *Workforce Development, Welfare Reform, and Child Well-Being*
- Paper 8 (2009) - *Maternal Depression can Undermine the Development of Young Children*
- Paper 9 (2010) - *Persistent Fear and Anxiety can Affect Young Children's Learning and Development*
- Paper 10 (2010) - *Early Experiences can Alter Gene Expression and Affect Long-Term Development*
- Paper 11 (2011) - *Building the Brain's "Air Traffic Control" System: How Early Experiences Shape the Development of Executive Function*

were launched with two major five-day symposia held in Banff, Alberta, Canada. The first symposium was held in the spring of 2010 and focused on the topic of early brain and biological development. The second symposium was held in the fall of 2010 and addressed the neuroscience and developmental foundations of addiction and related best practices in treatment and recovery from addiction.

Over 100 participants from various organizations in the Province attended each symposium. The participants were different for each symposium and were carefully selected through a competitive application process. Furthermore, each participant was asked to continue his or her involvement over a three-year period. These people represented a diverse range of backgrounds, perspectives, and professions including: policy makers, program developers, health practitioners, clinicians, researchers, physician residents in training, students, members of the judiciary, advocates, and funders, in addition to numerous professional bodies and organizations. The learning environment for both symposia featured plenary presentations in the mornings by the expert faculty, followed by afternoon sessions with large cohort groups that focused on understanding and learning to communicate the science. Various applied learning tasks, including considerations in communicating the symposium content to colleagues, were accomplished in small groups and as individuals. On the last day of each symposium, the learning team small groups made presentations to senior level guests from academic, health care, and policy areas in Alberta on their plans to carry the work forward in the year ahead following the symposium.

The faculty presenters at the Early Brain and Biological Development (EBBD) Symposium included 11 professors from major university research programs in Canada and the United States. The Recovery from Addiction (RFA) Symposium featured a faculty of 17 professors and senior clinicians from research universities and treatment programs in Canada and the United States. The RFA Symposium also had four experienced clinicians who led large-group interactive workshops and discussions each afternoon. Three of the faculty members (Bryan Kolb, Glenda MacQueen and Stephen Suomi) are also co-authors of papers in this issue. Due to the overlap in content between their symposium presentations and their papers in this issue, the material from their talks in Banff is not included in the symposium summaries presented below.

Each symposium has a detailed summary report that is available at no cost (see Table 1). The first author of the present paper was the rapporteur for both of these reports. Much of the material presented in the following sections is adapted from these more detailed reports.

Symposium 1: Early Brain and Biological Development

This Symposium addressed major themes in the scientific study of early brain and biological development and included the basics of brain development and child development, the social and biological environment, child and adolescent mental health, and the later life implications of all these factors, including the intergenerational transmission of the ef-

fects of toxic stress on brain architecture. The set of “Working Papers” developed by the National Scientific Council on the Developing Child and the Harvard Center on the Developing Child were provided to all of the participants as core knowledge resource materials (see Table 1).

Expert Knowledge from the Development Symposium Presentations

The central ideas from each of the presentations are presented below as the foundational knowledge derived from the research work in the area.

Scientific Evidence Replacing Myths (by Thomas Boyce). Much of what was thought to be “known” about early childhood development has changed or been significantly revised as new knowledge has emerged from the more recent neuroscience research (Champagne, 2010). This presentation examined eight such myths. For example, the concept that destiny is in our genes (i.e., genetic determinism) is now beginning to be undermined by a series of elegant and exciting new studies. This research reveals that most human traits and most diseases come not just from genetics or, alternatively, from environmental experience, but rather from a convergence of the two into what are called gene-environment interactions (Nelson, de Haan, & Thomas, 2006).

Embryonic and Neural Development (by Charles Nelson). Human development consists of the complex series of events that turns a single cell into a moving, sentient, thinking and feeling individual. Prenatal experiences and early brain development are two critical aspects in the healthy development of every child. The stages of brain development from the time of conception to the period just after birth include neurulation, neural tube formation, cell proliferation, cell differentiation and synaptogenesis, myelination, and pruning (Nelson & Lucina, 2008). Multiple factors, such as prenatal exposure to alcohol and drugs and maternal depression and stress, have deleterious effects on brain and biological development during this time (Thompson, Levitt, & Stanwood, 2009). Exposure to cumulative adversity during these periods may cause enduring neurobiological changes responsible for a range of deficits in different domains. Thus, a healthy early environment is very important for development to proceed in a positive manner.

Stress and Development (by Matthew Hill). Stress adaptation processes play a major role in early brain and biological development (McEwen, 2008). There is more than one kind of stress and they each have different outcomes. Research has identified three different grades of stress: positive stress, tolerable stress, and toxic stress. Positive stress is an appropriate response to a challenging situation, but is entirely manageable. Positive stress has brief increases

in heart rate and mild elevations in stress hormone levels. Tolerable stress is more serious and occurs when events seriously challenge our biological response, but its effects can be diminished through supportive social relationships. Exposure to positive and tolerable stressors is believed to produce a long-term inoculating effect such that individuals may become more resilient to stress later in life through the development of active coping skills. Toxic stress results from experiences that are severe, uncontrollable, unpredictable, and produce an intense physiological response in the brain and body. Severe and prolonged toxic stress in early childhood is associated with persistent negative effects on the nervous and stress hormone systems, leading to lifelong problems in learning, behaviour, and health.

Reward and Motivation Systems (by Pat Levitt). The cognitive, social-emotional, and reward systems of the brain are interconnected. Genetic and environmental factors combine to influence the formation and function of these systems in early childhood (Hammock & Levitt, 2006). There are sensitive periods during early development and maturation when the architecture and chemistry of the reward systems in the brain can be changed and damaged (Thompson & Levitt, 2010). A key period for building the motivation and reward system is the first three years of life when the neurological cell development for the higher cognitive function system peaks at about age two and gradually declines in activity but continues through adolescence.

Individual and Contextual Influences on Development (by Jacob Burack). Children constantly influence - and are influenced throughout the course of their development - by many aspects of the social environments in which they live. Other people thus play a vital role in creating a positive context for child development and can serve as protective factors against stressors (Burack, Blidner, Flores, & Fitch, 2007). There are also biological differences in how children respond to stress and take advantage of social supports, with some children being more context sensitive than others (Ellis & Boyce, 2008).

Child Maltreatment (by Harriett MacMillan). There are five types of child maltreatment: physical abuse; sexual abuse; emotional/psychological abuse; neglect; and, exposure to intimate partner violence (domestic violence by adults that is witnessed by children). Child abuse and neglect can cause death, serious injury, and long-term emotional and physical health consequences for children (MacMillan, 2010). Its effects can extend across the lifespan. Abuse can be prevented and both victims and perpetrators may benefit from appropriate clinical treatment.

Trauma in Childhood (by Ruth Lanius). Adverse childhood experiences (such as maltreatment, home instability, or

family problems) can lead to complex psychological and physical adaptations. Post-traumatic stress disorder (PTSD) related to childhood trauma is associated with significant deficits in emotion regulation, interpersonal functioning, and an impaired sense of self (Lanius, Kermetten, & Pain, 2010). Certain regions of the brain important for regulating emotions and social interactions also appear to be altered due to early maltreatment.

Intergenerational Stress and Parenting (by Linda Mayes). Being a parent is more difficult for those who have, themselves, suffered early adversity or chronic stress. Such historical experiences can reduce the capacity of some parents to care for others, by reducing their distress tolerance, increasing their reactivity to stress, and impairing both decision-making skills and emotional attentiveness. These effects of parenting are related to the ways early stress affects the basic stress-reward systems and brain functioning of offspring later when they become adults and (for many) also become parents themselves (Chaplin, Fahy, Sinha, & Mayes, 2009).

Early Development and Health Later in Adulthood (by Pat Levitt). Early stressors in childhood, even before birth, can influence the physical and mental outcomes of adults. Studies on the developmental biology of stress and allostasis help to explain some of the underlying reasons risks of physical and mental health disorders are found among those with troubled childhoods (Center on the Developing Child at Harvard University, 2010).

In summary, a unifying principle from the faculty presentations at the EBBB Symposium was that early experiences establish the foundation for all the development, learning, and health across the lifespan of a child. The necessity to buffer children's exposures to toxic stressors – in the form of disruptive, long-term, unprotected, and overwhelming experiences – is viewed as a critical implication of the science for program and policy development.

The next part of this paper presents new research – also presented at the EBBB Symposium (by Susan Nall-Bales and Nathaniel Kendall-Taylor) – that focuses on using cognitive science tools and quantitative and qualitative research methods to create more effective messaging of scientific findings so that it can be shared with others.

Knowledge Translation: Scientific Concepts as Core Stories

Cognitive science research has shown that people tend to use interpretive frameworks and mental models that are culturally constructed when taking in new information. Accuracy in communicating scientific information can be im-

proved by using research that explores how the public conceptualizes and organizes information. The FrameWorks Institute (Bales & Gilliam, 2009) has found success using a simplifying model – called a “core story” – that features use of metaphors to bridge the gap between expert and public thinking. The Institute has also collaborated with the National Scientific Council on the Developing Child and the Harvard Center on the Developing Child to implement some of these framing recommendations into their “Working Papers” series of knowledge transfer reports. Thus, these reports offer a model of effective framing communication principles.

The following core stories have all been developed, tested, and found effective in research studies conducted by the FrameWorks Institute as simplifying models to use in improving public understanding of early child development and children's mental health.

Core Story #1 – Brain Architecture. The basic architecture of the brain is constructed through an ongoing process that begins before birth, peaks in childhood and adolescence, and continues into all phases of adulthood. The metaphor here is building a house and needing a strong foundation to have a well-functioning structure.

Core Story #2 – Skills Beget Skills. Brain architecture and developing abilities are “built from the bottom up” such that simple brain circuits must be successfully created in order for more advanced circuitry and skills to develop later on. The visual metaphor that matches this concept is that of a set of scaffolding, with the simple lower levels needed before more complex higher levels can be added.

Core Story #3 – Serve and Return. The interactive influences of genes and experience shape the architecture of the developing brain with particular importance to the nature of children's engagement in relationships with parents and others. It is like a game of tennis or volleyball, where the active ingredient is the “serve and return” or the back and forth repeated interactive nature of how children relate to caregivers and other people.

Core Story #4 – Can't Do One Without the Other. The cognitive, emotional, and social capacities of a developing child are inextricably intertwined. Brain development, basic learning, behaviour, and physical and mental health are inter-related in childhood and over the life course. Like a fabric that has many interconnected woven fibres, these different experiential domains of child development influence and are influenced by one another.

Core Story #5 – Toxic Stress. Toxic stress in the early years of life damages the developing brain and leads to problems

in learning, behaviour, and increased risk for physical and mental illness.

Core Story #6 - Pay Now or Pay Later. Both brain plasticity and the ability to change behaviour decrease over time as a child ages. Creating the right conditions in the early years for childhood development is more effective and far less costly than addressing problems later in life. Thus, funding programs and services that offer a healthy environment and positive experiences in infancy and early childhood must be a priority both developmentally and fiscally.

The goal of preparing these core stories is for scientists and others to be able to use a common language to convey scientific information effectively and understandably to the public and non-scientists. Adoption of a common terminology and conceptual analysis for the core ideas developed by the experts in the field will ensure this knowledge can be used and acted upon by those in a multitude of applied and practical contexts.

Symposium 2: Connecting Early Development and Addictions

The Recovery from Addiction (RFA) Symposium was a companion event to the EBBB Symposium. It focused on sharing research and clinical best practices to improve the understanding of why the link between early brain and biological development and addiction is critical to properly addressing addiction and other related mental health disorders.

Becoming addicted is a gradual process and involves many different and interdependent causal factors. Research clearly demonstrates that most addicted adults first developed these problems during adolescence or young adulthood. This finding makes sense from a developmental perspective, since teenagers have greater access to and may seek out opportunities to experiment with alcohol, drugs, and other potentially addictive experiences as they gain more independence from their parents. From a biological perspective, adolescence is also a time in which the part of the brain responsible for decision-making and executive control is undergoing considerable change and is not yet fully mature (Nelson & Lucina, 2008).

However, the roots of addiction go back much further as research has identified many aspects of early development as risk factors for addiction later in life. Exposure to a host of negative experiences prenatally and the first few years of life can alter brain architecture and may increase the likelihood of developing addictions and mental health disorders. For example, prolonged exposure to toxic stressors in the home and local communities due to maltreatment (Mac-

Millan, 2010), parental, marital and residential instability (Felitti & Anda, 2010), parental mental health (McLaughlin et al., 2009), and parental addiction problems (Chassin & Handley, 2006) are all factors that have been consistently associated with higher risk for addiction in youth and adulthood.

Expert Knowledge from the Addiction Symposium Presentations

The central ideas from the presentations at the RFA Symposium are presented below as the foundational knowledge of the research in the area. The major themes include the neuroscience and development basis of addiction, implications for clinical best practices for addiction treatment and recovery, and adopting policy-related innovations for improving the quality of addiction and related health services.

Process and Multiple Addictions (by James Montgomery). Addiction can manifest in many ways, but it has historically been categorized into substance- or chemical-related addictions (i.e., tobacco, alcohol, and street or prescription drugs) and behavioural or process-oriented addictions (i.e., pathological gambling, sex addiction, eating disorders, compulsive shopping, and compulsive working, among others). These two types can occur within the same individual and there can be multiple variants of substance or process addiction co-existing in an individual at the same time (Carnes, Murray, & Charpentier, 2004). Furthermore, each addiction may be active to differing degrees of severity at different points in time across the course of the disorder. Process addictions often exist in combination with each other and with chemical addictions (Schneider, Sealy, Montgomery, & Irons, 2005). The co-existence and interaction of these conditions is known as addiction interaction disorder. Multiple addictions make treatment more complicated and can promote relapse. Despite their high prevalence, process and multiple addictions are under-recognized and under-treated.

Common Neurobiology of Reward and Addictions (by Mark Gold). Addiction is a process based in altered functioning of the reward and motivation systems of the brain. Neuroimaging studies show that habitual drug use alters the reward system in the brain and is associated with high levels of the neurotransmitter dopamine (Blum, Liu, Shiner, & Gold, 2011). A key finding is that substance-based and process kinds of addictions both reinforce their own use and compete for the same neurobiological dopamine reward pathways in the brain (Gearhardt et al., 2011). Evidence now indicates that process addictions – such as gambling, compulsive sex, and eating fatty or sugary foods – have many similarities with how the brain reacts to drugs of abuse (i.e.,

alcohol, cocaine, heroin). For example, sugar accesses the same core neuroanatomy of the brain and produces smaller but similar elevations in dopamine levels as drugs of abuse, indicating it has addictive potential. It is therefore important to ensure that the implications of exposure to, and frequent use of, sugary, salty, fatty, and energy dense foods are understood within the context of addiction (Avena, 2010).

Shame in Addiction Treatment and Recovery (by Garrett O'Connor). Shame is at the core of understanding addictions. In the human psyche, the purpose of shame is to keep one within the bounds of normalcy by regulating one's feelings and behaviour concerning the methods used to satisfy basic instincts and desires that are inherently rewarding or punishing. But shame actually is more complex and has two faces: malignant (negative) shame can lead one deeper into addiction whereas healthy (positive) shame can spur recovery. The familial context of shame and addiction are closely intertwined, as addicts are ashamed of themselves and their families are ashamed of them. Without proper treatment, the family cycle of abuse, addiction, and shame can be passed on from one generation to the next. Because of its central role in the psychology of addiction processes, the issue of shame and how it influences self-identity must be addressed in order for addiction treatment and recovery to be successful. Twelve-step and other psychosocial support therapies can be effective for using positive shame dynamics to heal addiction and encourage recovery (Betty Ford Institute Consensus Panel, 2007).

Trauma-Informed and Gender-Sensitive Treatment (by Stephanie Covington). Gender influences how and why individuals develop and recover from addictions. Theory, research, and clinical experience all converge to recognize the central role of trauma in the lives of women with addictions (Covington, 2008). As addictions often first take hold in youth, it makes sense to consider ways of increasing the awareness of potentially addictive behaviours within the context of family dynamics and the risk factors in the other physical and social environments where children reside. This approach emphasizes addiction as a family disease, and thus it is important to create new ways of including family members of the addicted person – especially for teens and young adults – in the therapy process. Traumatic experiences disconnect the child from his or her emotions and render the adolescent or adult version of the child more likely to become addicted or to form attachments with others who are addicted. This therapeutic model also takes trauma into account and avoids triggering trauma reactions and/or re-traumatizing the individual. Women's treatment facilities for addiction should be designed to feel like sanctuaries – sacred places that offer safety, refuge, and protec-

tion for women. Principles of women-centered treatment can be applied in various settings and research on substance abuse treatment with women in prison and drug-court settings documents the success of this approach.

Parenting-Skills Education and Addiction (by Amelia Arria). Addiction is a multi-generational disorder that can be passed from parent to child (Johnson & Leff, 1999). Research shows that certain kinds of parenting practices can either increase or reduce the risk for adolescent substance use and addiction (Chassin & Handley, 2006). Parents who themselves have substance use disorders might face unique parenting challenges when raising their children and should receive special training and support while in treatment. Seven key parenting practices are effective in reducing the risk of adolescent substance use and other addictions. Addiction treatment programs thus should offer specialized educational and parenting skills programs for mothers and fathers who are already participating in addictions treatment. Providing more supports for parents and families of addicted individuals is also important for preventing addiction and fostering recovery (Arria, Moe, & Winters, 2010).

Lessons from Chronic Disease Management (by Richard Lewanczuk). Despite the magnitude of the problem, addiction remains profoundly under-diagnosed and under-treated. Recognizing addiction as a chronic condition having a basis in brain development and early experiences may help to lessen its stigma (as has happened for cancer) and to encourage the development of more prevention and treatment programs that focus on the earlier stages in the development of addiction. Recent advances in the management of chronic diseases have been used to help reduce wait times for services, reduce health care resource utilization, and improve overall patient health. Principles from the management of chronic diseases are being used successfully in some contexts to improve the prevention, treatment, and support of individuals with addictions (Saitz, Larson, Labelle, Richardson, & Samet, 2008). Key tactics of such an approach include screening and early detection, multi-disciplinary and holistic care teams, patient education and self-care, and case management over many years.

Physician Health Programs (by Michael Kaufmann & Dianne Maier). Physician Health Programs (PHPs) that address substance abuse and other addiction and health problems with impaired physicians in Canada and the United States represent model programs that are based on the use of chronic disease management concepts. These occupationally-based and member-sponsored programs include routine addiction screening, case identification, intervention, multidisciplinary treatment, long-term follow-up, regular biochemical monitoring, workplace return-to-work

strategies and ongoing peer support from others who have been in the program. PHPs also have recognized the benefit of family-based care for addiction and therefore also offer services for physicians' family members. Research studies of PHPs in Canada (Brewster, Kaufmann, Hutchison, & MacWilliam, 2008) and the United States (McLellan, Skipper, Campbell, & DuPont, 2008) show excellent outcomes that include maintenance of remission of addiction over a five-year period for over 70% of cases, enhanced personal and professional functioning, improved overall life satisfaction, and very few patient care adverse incidents once the physicians have returned to work.

Improving Treatment through Business Process Improvement (by David Gustafson). Given the high personal and societal costs involved, new and more effective approaches to supporting recovery from addiction are vital. Business process improvement is a systematic approach to help optimize an organization's underlying operational processes in order to achieve greater efficiency and improve results. Some of the key practices that are supported by hundreds of studies include: aligning the area of change with the agenda of senior leadership; enlisting an executive level champion to be the change leader; borrowing proven effective ideas from external sources; understanding the area of change by personally going through the same experiences as do the patients/staffs; and, making changes in very small steps and doing it quickly to assess results (i.e., rapid cycle testing method uses a progressive series of improvements with each change implemented over a three week period). This approach has been used successfully in many industries and is now being applied to health care (Gustafson & Hundt, 1995). Research projects in the United States illustrate the power of these principles to transform processes and improve outcomes in the field of addiction treatment (Hoffman, Ford, Choi, Gustafson, & McCarty, 2008).

A Better Measurement Model for Addiction Treatment Outcomes (by Thomas McLellan). There is increasing demand from patients and purchasers of addiction treatment services for effectiveness, performance, and quality (McLellan, Chalk, & Bartlett, 2007). Effectiveness indicates good patient function following treatment. Performance is measured in part by changes in patient symptoms and function during outpatient treatment. Quality is when both effectiveness and performance measures are in line. All three of these measures are needed to improve addiction treatment. But more important may be revising the conceptual model used to evaluate addiction treatment in general. A change in definition from "addiction as curable" to "addiction as chronic disease" would benefit the field as a whole. Currently, most addiction treatment providers offer patients

with mild or moderate severity symptoms brief and episodic care with little or no long-term follow-up. Clients with more severe conditions are admitted to acute care or residential services, clinically stabilized, and released after a short period of treatment. But most of these same patients are later re-admitted to the same programs or similar services when their conditions predictably have worsened and they have relapsed again. This patient experience profile shows why treating addiction as an acute condition is an ineffective and outdated approach (McLellan & Meyers, 2004). Alternatively, the field could achieve realistic improvements by moving toward a different system of practice that follows, monitors, and evaluates patients regularly during outpatient treatment in a chronic care management approach, as is already being done in the Physician Health Programs to great success. This conceptual shift also brings important and beneficial changes in how effectiveness, performance, and quality of addiction treatment are defined and measured.

Improving Addiction Treatment through Financial Incentives (by Thomas McLellan). In health care management in the United States, there is a growing movement to develop new payment methodologies that connect reimbursement for health services with the results they are intended to produce. As addiction treatment services becomes more integrated with health care services, it becomes important to be aware of the trends in delivery and funding strategies that are being piloted to improve the quality, efficiency, effectiveness, and cost of care. The addiction field can benefit from adopting relevant aspects of these financial contracting initiatives. Pilot programs in the United States with publicly funded inpatient and outpatient addiction service providers offer lessons on how these kinds of strategies can be implemented (McLellan, Kemp, Carise, & Brooks, 2008).

The Core Story of Addiction and Gaps between Experts and the Public (by Susan Nall-Bales and Nathaniel Kendall-Taylor). The current research literature and the knowledge featured at the RFA Symposium was analyzed to identify major themes. From a communication framing perspective, the following components comprise the "core story" of addiction:

- Addiction is a brain-based neurobiological phenomenon that can be defined functionally as a neurological impairment of rational decision-making;
- Addiction develops as a result of a complex interaction between genetic and environmental factors (i.e., epigenetic processes);

- In order for interventions to produce maximal benefits, they need to be evidence-based, should occur early in the course of the disease and be sustained over time, and incorporate multiple modalities of treatment; and,
- The chances of maintaining long-term recovery are significantly greater when using chronic care treatment models that have been shown to yield better outcomes.

Research on public perceptions of addiction conducted by the FrameWorks Institute has identified large gaps between what is supported by the science – the core story of addiction noted above – and what is believed about addiction by the general public (Kendall-Taylor, 2010). The first finding concerns definitional models of addiction. Addiction was defined by the public as a dependence on a foreign chemical, most often limited narrowly to illicit drugs or alcohol. Addiction was also thought of as a process driven by an irrational need that takes place within the individual. This definition largely ignores the role of other social and interpersonal factors in the development of addiction (such as early toxic stress experiences or maltreatment by parents/others) and instead blames the individual for his or her problem. Another key issue is the misperception by the public that addiction is untreatable – that it never really gets any better – which is clearly at odds with the real potential for recovery and the high level of success of programs using a chronic disease approach to treatment. The extent of these gaps is troubling as these pessimistic and incorrect views can limit the support for addiction policies and services.

Research in Alberta on Addiction Prevalence and Treatment Services (by Cam Wild). The RFA Symposium also revealed the results of new epidemiologic and applied research being conducted within the province of Alberta. One research project estimated the prevalence of addictions among the general population of adult Albertans (Wild et al., 2010a) and another project surveyed mental health and addiction providers in the Province about several aspects of addiction treatment services (Wild et al., 2010b).

The first study examined the prevalence of ten addictions, including substance-related problems with alcohol, tobacco, marijuana, cocaine and process-related addictions of gambling, eating, sex, work, shopping and video gaming. It used an online sample of 4,000 adults and a telephone sample of 2,000 adults. Results revealed that four out of every five people (80%) in the Province were personally impacted by at least one of these ten addictive behaviors at some point in their lifetimes. In addition, about half of the respondents reported that they experienced problems with two or more addictions. The number of respondents who experienced a problem in the past year with a specific addiction ranged from 20% for eating to less than 1% for

cocaine. Note that these data represent self-perceived problems rather than clinical assessments made by treatment professionals. Other results reflect significant gaps in the availability of treatment services from the perspective of prospective clients. Other than tobacco addiction, all of the other nine kinds of addictions had 50% or more of the sample who said that the available treatment was inadequate. Perhaps related to the perceived lack of access to treatment and to stigma issues, among those who reported having a problem with an addiction, the overwhelming majority said that they chose to deal with it on their own via some form of self-care and had not sought professional treatment.

The second research project collected survey data from different types of addiction treatment providers in Alberta to profile the nature of existing programs and services and their capacities and to identify gaps in services and areas of unmet need. In total, 53 program directors, 517 practitioners and 55 solo practitioners returned surveys. Respondents perceived that the number of clients using mental health and addiction service providers is increasing in Alberta. The majority of all provider types (85%) offered services for alcohol and illicit drug addictions but services for process addictions were less common, ranging from 25% to 66% of providers offering service depending on the type of addiction and the kind of provider. About two-thirds of all providers offered services for concurrent disorders (i.e., clients presenting for treatment with both an addiction and a mental illness). However, addiction treatment is mostly done in a short-term model, as the majority of providers in Alberta do not conduct any follow-up on cases after they have completed addiction treatment.

Clinical Implications for Addiction Treatment. The experts at this Symposium all consider addiction to be a chronic, relapsing brain disease with a complex etiology and clinical course. This view of addiction then demands a more sophisticated approach to treatment than is currently provided. For example, the Physician Health Plan addiction care programs that use a chronic disease management approach have more than doubled the success rates of the best episodic services, and report success rates as high as 85% over five years. These programs use a holistic model that includes qualified service providers, a progression from more intensive to less intensive care settings, case management, family-centered care, and long-term monitoring to manage relapse. The success of the PHP model indicates that it is possible to improve outcomes in addiction treatment by adopting elements of the chronic care approach and strengthening linkages across the continuum of care. This model can be used as a gold standard that clinical programs in other contexts can emulate.

Furthermore, with the acknowledgement that the seeds of addiction can be sown early in development, while the brain is developing and long before the disease manifests, experts now agree that addiction can occur in many forms, including behaviours. With this in mind, standards for clinical care should include the ability to assess and treat both substance and process addictions and their simultaneous occurrence and interaction within a single patient. The frequent overlap of mental health disorders (particularly depression and anxiety) and medical conditions with addiction also indicates the need to more functionally integrate addiction treatment services with the provision of mental and other health services.

Summary of Part 2. Taken together, the information provided at and generated during these two applied symposia provide a broad-based platform that scientifically justifies more attention being paid and resources allocated to prevention of addictions in the early years of life. Two anchoring principles from the symposia were that:

1. Early experiences lay the foundation for healthy brain development and all aspects of human development across the lifespan; and,
2. Addiction is a chronic disease of brain reward and motivational systems, with its roots in toxic stressful experiences characterized by chronic, long-lasting stressors that occur and persist without consistent and supportive relationships.

Both of these points are of interest to child and adolescent psychiatry, as they underscore the need to promote healthy early life experiences for children and the need to intervene in the lives of children in order to provide appropriate clinical services and treatment, where necessary, as early in the life of a child as possible while that child's brain is still under construction.

Conclusion

This paper provided an introduction to this special issue on early brain and biological development and its influence on mental health and addictions in childhood, adolescence and adulthood. Research on brain plasticity, mood disorders, and gene-environment interactions and attachment processes all reveal a common thread that recognizes how adverse early childhood experiences, the actions of parents and others in the social environment, and basic neurobiological maturation processes interact to create risks for the development of mental health disorders and addictions later in life. The two symposia offer a demonstration of practical value of this research on ways that science is being used

and communicated to drive a three-year multi-disciplinary strategy for improving the research, training, and clinical services in Alberta. The primary message from this research and the knowledge translation symposia is that early development is a period of great significance for promoting positive mental health and preventing the development of psychiatric disorders.

End Notes

- 1 Created in 1997, the Norlien Foundation is a proactive private foundation with offices in Calgary and Edmonton, Alberta. The Foundation is active in knowledge translation and transfer, applied research, evaluation, and networking. It has established partnerships with numerous national and international organizations working in the areas of childhood development, addiction, and mental health. In 2007, the Norlien Foundation created the Alberta Family Wellness Initiative. Based on a framework of epigenetics and developmental and behavioural neurosciences, this initiative creates opportunities to better understand and apply scientific knowledge to factors influencing child development and its relationship to addiction and other mental health outcomes. For further information see <http://www.norlien.org>

Acknowledgements / Conflicts of Interest

Both authors are consultants for the Norlien Foundation.

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