Promoting Resilience in Children and Youth

Preventive Interventions and Their Interface with Neuroscience

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ABSTRACT: Preventive interventions focus on reducing risk and promoting protective factors in the child as well as their cultural ecologies (family, classroom, school, peer groups, neighborhood, etc). By improving competencies in both the child and their contexts many of these interventions promote resilience. Although there are now a substantial number of preventive interventions that reduce problem behaviors and build competencies across childhood and adolescence, there has been little integration with recent findings in neuropsychology and neuroscience. This article focuses on the integration of prevention research and neuroscience in the context of interventions that promote resilience by improving the executive functions (EF); inhibitory control, planning, and problem solving skills, emotional regulation, and attentional capacities of children and youth. Illustrations are drawn from recent randomized controlled trials of the Promoting Alternative Thinking Strategies (PATHS) curriculum. The discussion focuses on the next steps in transdisciplinary research in prevention and social neuroscience.

KEYWORDS: prevention; intervention; neuroscience; children; youth; frontal lobe

PROMOTING RESILIENCE IN CHILDREN AND YOUTH: PREVENTIVE INTERVENTIONS AND THEIR INTERFACE WITH NEUROSCIENCE

As a psychologist interested in creating change in communities and influencing public policy, I am often asked questions about developmental processes and trajectories in children. For example, "How can we help children resist

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negative influences when they live in high-risk neighborhoods?" "How can we improve children's academic outcomes when their families have experienced an intergenerational history of school failure?" "How can we help children control their emotions when their peers are bringing out the worst in them through teasing and taunting?" All of these questions imply the notion that many children are exposed to high-risk situations and the implication is that unless something is done, the probability of a poor outcome for some children is relatively high. Such situations are ripe for efforts to attempt to prevent difficulties that may spiral into longer-term poor outcomes across childhood, adolescence, and even adulthood. Beginning with the War on Poverty and the emergence of Head Start in the 1960s, preventive interventions have become central to our nation's public policy. As a result of the increased rate of both adolescent delinquency and drug use seen in the ensuing decades, the development of both preventive intervention programs and social/legislative policy initiatives has dramatically increased. The role of developmental science in public policy making has never been greater or more influential.

Improving the public's health, especially for those at greatest risk, is a complex problem that involves interventions at the level of economic and social policy as well as the ability to strengthen the skills of educators, parents, and youth themselves. Macrolevel interventions focused on changing community-level ecologies, attitudes, and behavior have ranged from large experiments in economic policy (e.g., earned income tax credits, TANF), changes in housing patterns,[1] social legislation ranging from raising the age at which youth can drive to building community partnerships to reduce youth problem behaviors and build positive youth development at the community level.[2] At a more microlevel, attempts to improve the culture, attitudes, and relations in families, peer groups, and schools have focused on building communication skills and values that promote positive developmental outcomes. Finally, there has been recognition that some attributes inside the individual, including skills, cognitions, and behaviors, may be malleable in response to preventive efforts. The enormous scope of activities undertaken is a testimony to our implicit understanding that child and youth outcomes are multidetermined and that various levels of influence impact developmental trajectories. Although at times these initiatives seem (or are) both random and chaotic, at another level they clearly reflect the combination of our growing basic knowledge of both the ecology of human development,[3] the advances made in developmental psychopathology,[4] and the emergent development of the field of prevention science.[5]

The study of resilience emerges out of the large research endeavor of public health epidemiology and the study of risk and protective factors and how they impact development. A number of guiding principles have emerged both from epidemiology and developmental psychopathology.[6,7] First, it is unlikely that there is a single "cause" of many of the preventable outcomes (e.g., mental disorders, substance abuse, school failure, delinquency); even in the case of disorders in which a biochemical or genetic mechanism has been discovered, the expression of the disorder is influenced by other biological or environmental events.[8,9] Second, there are multiple pathways both to and from risk and problem outcomes; for example, there are different combinations of risk factors that might lead to the same disorder. Third, no single cause may be either necessary or sufficient[10] and the effect of a risk factor will depend on its timing and relation to other risk factors. Fourth, many risk factors are not disorder-specific, but instead relate to a variety of outcomes. Finally, risk factors may vary in influence with host factors, such as gender, ethnicity, and culture.

Resiliency is commonly defined as positive or protective processes that reduce maladaptive outcomes under conditions of risk. That is, they are protective factors that may be especially important under conditions of risk. Although much less is known about protective factors and their operation,[7,11] at least three broad types of protective factors have been identified. These include characteristics of the individual (e.g., temperamental qualities and intelligence/cognitive ability), the quality of the child's relationships, and broader ecological factors, such as quality schools, safe neighborhoods, and regulatory activities.

An essential question related to adversity and resilience is the individual's development of an effective set of responses to stress. Central components of the stress response include the initial appraisal of the event and its emotional meaning, the ability to sufficiently regulate one's emotions and arousal to initiate problem solving and gather more information, the fuller cognitive-affective interpretation of the event, and one's behavioral response. Masten[12] has noted that among the most important resiliency factors are these very cognitive and emotion regulation skills.

Prospective longitudinal designs are critical to understanding the role of resiliency as they can identify (*a*) which risk factors are predictive of different developmental stages of a problem, (*b*) the dynamic relation between risk and protective factors in different developmental periods, and (*c*) what factors are most likely to "protect" or buffer persons under risk conditions from negative outcomes. In addition, randomized trials of preventive interventions can test these theories by examining how behavior changes are mediated.

THE INTERFACE OF PREVENTION, DEVELOPMENTAL PSYCHOPATHOLOGY, AND NEUROSCIENCE

Although developmental psychopathology, prevention, and neuroscience have developed in isolation, integrated research on protective factors and resilience has the potential to answer central questions regarding plasticity and the role of environmental and genetic process. While the primary goal of prevention science is to change behavior, behavior can be broadly defined as action, emotion, and cognition. Further, biological substrates underlie all of these processes and may serve as moderators, mediators, or outcomes of

TABLE 1. Levels and measures of the biological substrate

I. Neural processes	II. Autonomic nervous system
1. Structural aspects	1. Parasympathetic activity
A. Neuronal development and connections	A. Cardiac vagal tone
B. Localization of action	
2. Functional aspects	2. Sympathetic nervous system
A. Neurochemical systems (dopamine, noradrenaline, serotonin, brain-derived neurotrophic factor)	A. Resting heart rate
3. Neurocognitive function	3. Neuroendocrine function
A. Neuropsychological testing	A. HPA axis–Glucocorticoids
	4. Immunological function
	A. T cells/antibody titers to vaccines

preventive interventions.[13] A broad vision of the integration of prevention and neuroscience would examine how a variety of biological processes play a role in a deeper understanding of the processes and effects of preventive interventions. TABLE 1 provides a list of some of the biological substrates that would be of interest at the levels of both the brain and autonomic nervous system.

A central task for the next decade is to understand in much greater detail the relations between the multiple levels of the biological substrate and these resilience processes involved in cognitive processes and emotional regulation. With transdisciplinary collaboration involving neuroscientists and the use of multilevel models of measurement driven by the theory/logic model, prevention research has the potential to make a major contribution to understanding the developing interplay of biology and behavior.

Many preventive interventions focus on supporting improved emotion regulation and problem-solving skills in which executive functions (EF) and the actions of the prefrontal lobes play a central role. EF generally refers to the psychological processes that are involved in the conscious control of thought. Examples of processes include inhibition, future time orientation, consequential thinking, and the planning, initiation, and regulation of goal-directed behavior.[14] Substantial data indicate that EF skills as assessed by neuropsychological tasks are related to childhood maladaptation.[13,15] However, there has been little evidence in childhood between the performance of EF tasks (inhibitory control, working memory, planning) and neuroanatomical localization of activity in areas of the frontal lobe.[16,17] Due to the methodological requirements for valid Functional Magnetic Resonance Imaging (fMRI) assessments with young children, few data are available before the age of 10 years, although recent work using high-density Event Related Potential (ERP) assessments are particularly promising.[18] A series of methodological and conceptual challenges still have to be solved in order to fully assess the specific brain localization of neurocognitive and affective skills in children.[19] Further, there is a need to broaden methods to understand how childhood cognitive and affective processing (especially under conditions of stress) are related to other biological processes, including action in the autonomic nervous systems that include correlates of the hypo-pituitary-adrenal (HPA) axis,[20,21] immunological function, the parasympathetic system (vagal tone), as well as functional analysis of brain action (neurotransmitter release).

Pioneering work with children has already begun to show the potential yield of this vision in which interventions use measurement models and theories based on our rapidly developing knowledge of neuroscience. Research has indicated that there is correspondence between improved reading skills and changes in brain activity in reading-deficient children.[22] An intervention to improve the outcomes of children in the foster care system has indicated changes in both behavior and children's salivary cortisol.[23] Computer-based training for children with Attention-Deficit Hyperactivity Disorder (ADHD) has indicated changes in EF and behavior.[16] Meditation training in adults has been shown to alter both frontal brain activity (hemispheric laterality) and immunological response.[24] Further, a number of studies has shown the moderating role of biological variables, including how EF moderates the effect of a brief intervention on high-risk teens[25] and how the hypoactivity of anterior cingulate cortex predicts poor response to treatment for depression.[26]

Although neuroanatomical findings on cognitive and emotion regulation skills in childhood are sparse, there is a burgeoning literature on adults regarding brain localization of EF that can judiciously guide theory and action with children. The field of social–cognitive neuroscience (studies with lesion patients, patients with psychopathologies, and normally developing adults) has clearly implicated the orbital/dorsolateral/limbic circuit in the processing of emotional stimuli and the cognitive control and regulation of behavior.[27,28] Findings indicate a clear role for the anterior cingulate in the processing of emotions, executive attention processes, and working memory.[29–31] The role of the dorsolaternal prefrontal area has been shown in cognitive control and inhibition of emotional arousal.[32,33] Further, the orbital frontal area has been related to emotion processing and regulation.[34] Although research has attempted to completely localize processes in single neuroanatomical areas, it is clear that there is strong and rapid connectivity between these areas during decision making and there are sometimes contradictory findings between studies of specific loci.[35] As most of this work is less than a decade old, conclusions regarding specific loci may be premature. Further, noradrenaline, serotonin, and dopamine are projected to all these areas and thus energize action across systems. Double dissociation[36] and lesion studies as well as intervention trials[24] will play substantial roles in further differentiation.

THE DEVELOPMENT OF EF

Although infancy and toddlerhood provide a basis for critical aspects of later coping,[21,37] much of the child's more complex cognitive processes, coping, and regulation skills arise with neurocognitive maturation in the frontal lobes. This maturation proceeds from the preschool years through late adolescence. Although numerous linguistic and cognitive processes are developing, the development of EF appears crucial to healthy development and deficiencies in EF have been related to numerous poor outcomes. These outcomes involve cognitive processes related to effective emotional regulation and behavioral performance, including aggression, delinquency, depression, and disorders of attention.[13,38]

INTERVENTION AND EF: ILLUSTRATIONS FROM THE PROMOTING ALTERNATIVE THINKING STRATEGIES (PATHS) CURRICULUM

During the past few decades our research group has been involved in the development, implementation, evaluation, and refinement of a social and emotional learning curriculum based on neuroscientific principles that focus on promoting emotional awareness and effective cognitive control. The PATHS curriculum is a universal school-based prevention curriculum aimed at reducing aggression and behavior problems by promoting the development of social–emotional competence in children during the preschool and elementary school years.[39] PATHS is based on the affective-behavioral-cognitive-dynamic (ABCD) model of development.[40] The ABCD model focuses on how cognition, affect, language, and behavior become integrated in the developing child. A fundamental concept is that as youth mature, emotional development precedes most forms of cognitive development. That is, young children experience emotions and react to them long before they can verbalize their experiences. Early in life, emotional development is an important precursor to other ways of thinking and must be integrated with cognitive and linguistic abilities, which are much slower to develop. Then, during the elementary years, further developmental integration occurs among affect, behavior, and cognition/language through maturation of the prefrontal circuit. These processes of brain maturation are important in achieving socially competent action and healthy peer relations.

The PATHS curriculum places special attention on neurocognitive models of development.[41] Of significant importance are the concepts of *vertical control* and *verbal processing of action* (e.g., horizontal control). Vertical control refers to the process of higher-order cognitive processes exerting control over lower-level limbic impulses vìs-a-vìs the development of frontal cognitive control.[14] PATHS attempts to consciously teach children the processes of vertical control by providing opportunities to practice conscious strategies for self-control. This is achieved via instruction with curriculum lessons and a variety of cognitive/behavioral techniques that are developmentally appropriate from the ages of 4 to 11 years. One central example is the use of a control signals poster that teaches children the steps for problem solving in social contexts.

The curriculum also has an intentional and intensive focus on helping children to verbally identify and label feelings in order to manage them. This is achieved through curriculum lessons and the integration of "feeling faces" that children use throughout the day to identify their feelings and those of others.

A series of outcome trials have indicated that effective implementation of the PATHS curriculum leads to decreases in externalizing and internalizing problems by both teacher and self-report and to increases in social and emotional competence.[42–45] However, as with many preventive interventions, there has been little investigation of how such change is mediated. Although some aspect of this mediation may be due to changes external to the child (improved classroom environment, warmer teacher–student relations), we believe that the curriculum promotes more effective inhibitory control, emotion regulation, and planning skills. The curriculum logic model is based on the idea that the intervention will lead children (1) to become less impulsive and more planful in their social interactions, and (2) to recruit language to regulate behavior and communicate effectively with others.

We recently tested this mediation model in a randomized controlled study of 318 second-and third-grade children.[46] Schools were randomized to receive the PATHS intervention or to control status. Intervention teachers received both a 3-day initial training workshop as well as ongoing weekly coaching in curriculum implementation. The PATHS lessons were taught approximately three times per week, with each lesson lasting 20–30 min. In addition, teachers used techniques to generalize PATHS skills with the goal of supporting students to apply the PATHS skills in the "hot" naturally occurring contexts of their school day. These situations of high emotional arousal usually occurred during conflictual interactions with peers, with their teachers, or when feeling academic frustration. Students were assessed at pretest, posttest (7 months later), and follow-up (1 year after the curriculum ended).

Outcome findings examined teachers' ratings of both internalizing and externalizing behavioral problems using the Child Behavioral Checklist (CBCL[47]). EF were assessed by two well-known measures validated to activate anterior cingulate and dorsolateral prefrontal cortex.[48] Inhibitory control was assessed with the Stroop Test and verbal fluency was assessed using the Verbal Fluency Subtest of the McCarthy Scales of Children Abilities. To test a mediational model, it was first necessary to demonstrate that the intervention affected both behavior and EF. Results indicated that there were significant differences at posttest showing greater improvements in both inhibitory control and verbal fluency in the intervention children. At the 1-year follow-up, intervention children also were rated by teachers as lower in externalizing and internalizing problems. Further, posttest changes in both inhibitory control and verbal fluency were significantly related to teacher ratings of behavior problems at follow-up.

The specific mediational hypothesis we tested was that EF would mediate the relationship between prevention/control group assignment and teacher-reported externalizing and internalizing behavior problems. The findings indicated that improvements in inhibitory control at posttest significantly mediated the relation between experimental condition and both teacher-reported externalizing and internalizing behavior at 1-year follow-up. In addition, improvements in verbal fluency significantly mediated the relation between experimental condition and teacher-reported internalizing behavior. However, improvements in verbal fluency showed only a trend toward explaining change in teacher-reported externalizing behavior.

These findings provide empirical support for the conceptual theory of action that underlies the PATHS curriculum model. That is, child neurocognitive functioning plays a key role in children's social and emotional adaptation and changes in EF directly relate to reductions in behavioral problems. However, a broader view and greater incorporation of the biological substrate into our understanding of the processes would begin to assess less peripheral systems of mediation than only the use of neuropsychological tests.

Although our own work with the PATHS intervention is very preliminary, I use it as a case example of how we might develop transdisciplinary connections between prevention scientists and neuroscientists. A clear logic model of the intervention might hypothesize that such behavioral changes would lead to greater activation in the anterior cingulate and dosolateral prefrontal areas. Although such assessments could not be readily accomplished using fMRI at these younger ages, EEG–ERP assessments might be used. One might also hypothesize that such an intervention might impact the child's stress reactivity (HPA axis) or their parasympathetic activity under moderately stressful testing conditions. Finally, if such an intervention impacted both frontal activity and stress-reactivity, one might hypothesize that over time it might impact overall bodily health as assessed by immunological function.

The point here is that effective preventive models that have more fully articulated logic models of action should begin to ask "deeper" questions about the neuroscientific underpinnings of either change processes or obstacles to intervention impact. That is, how might measures of the biological substrate serve as mediators, moderators, and outcomes?

Of course, there are some important caveats at this stage in the scientific enterprise. First, children may recruit different brain regions than do adults to accomplish the same task and extrapolated theories from research on adults should be used with caution.[49] Further, even when fMRI can be used with older children, there are substantial conceptual and methodological challenges in interpreting such findings.[19] Finally, although some aspects of the effects of preventive interventions may be better understood by taking a neuroscientific perspective, much of the action of some prevention models occurs primarily through changes in the environment (quality of the classroom or community) or in the context of social interactions that may not be well-captured by current models of neuroscience.

These findings and others in neuroscience point to the importance of considering social–emotional development as best understood within broader theories that take into account how children's experiences and relationships affect their brain organization, structuralization, and development.[38] As such, there is a need for an extensive research agenda in which there is a transdisciplinary collaboration among prevention scientists, developmental psychopathologists, and neuroscientists. However, this will require not only clearer logic models of change and possibly more potent preventive interventions, but substantial advances in basic research in childhood neuroscience including improvements in both measurement and conceptualization. Through such work, carefully developed studies should take us past the "black box" outcome to more fully understand the cognitive and neural mediators and moderators of change.

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