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Opinion paper

On the viability of neurotechnology and mind–body methods in pediatric mental health: Perspectives on integrating new tools to complement old techniques☆

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ABSTRACT

The techniques and tools of neurosciences have developed with ever increasing pace and sophistication. Calls for increased clinical translation of the European Union's Human Brain Project, ongoing activities of the United States' Brain Research through Advancing Innovative Neurotechnologies' (BRAIN) initiative, and a number of other international efforts in brain science orient the use of neurotechnology toward assessing and treating neuro-psychiatric conditions. This reflects, and may be important to support recent World Health Organization and UNESCO directives to improve mental health, particularly in children and adolescents. In light of this, we argue that it will be vital to encompass a broader scope of research, so as to examine both "high tech" and "low tech" approaches to mind–body therapeutics for neuropsychiatric disorders that may be of particular benefit in pediatric and adolescent patients. In this essay, we propose a four-fold paradigm that (1) engages use of new neurotechnologies (e.g.—functional neuroimaging; neurogenomics; neurofeedback; transcranial magnetic and/or electrical stimulation) to assess and affect neuropsychiatric state(s); (2) develops a more mechanistically-based integrative approach to treatment of neuropsychiatric disorders in pediatric and adolescent patients using both new, "high tech" (i.e.—neurotechnology) and older "low tech" mindbody methods (e.g.—meditation/mindfulness); (3) employs these methods in a bio-psychosocial framework; and (4) acknowledges and addresses technical and neuroethical problems arising in and from this approach.

1. Introduction

The techniques and tools of neurosciences have developed at ever increasing pace and sophistication. Recent progress reflects concentrated urgings and efforts to revise the scope and aims of the European Union's *Human Brain Project* (HBP) toward a more translational focus [1,2]. This would be more in line with and complementary to both the United States' *Brain Research through Advancing Innovative Neurotechnologies*' (*BRAIN*) initiative, and other large-scale brain research enterprises world-wide [3]. A significant portion of these projects' work is directed toward developing novel technologies and approaches to assessing and modulating neural substrates and mechanisms affected by a number of neurological and psychiatric disorders. Such efforts are well-aligned with – and could fortify – recent international calls for, and World Health Organization and UNESCO dictates to revise mental health care [4,5]. An important focus is the early identification and treatment of mental disorders. In this light, there is renewed interest in and emphasis on the assessment and care of neuropsychiatric conditions in children and adolescents.

In the United States, much of this work will be engaged by intra- and extramural programs of the National Institutes of Health (NIH). Within the NIH, these studies will be primarily undertaken by the National Institute of Mental Health (NIMH) and National Institute of Neurological Disorders and Stroke (NINDS). However, of greater interest are those ways that the (newly re-titled) National Center for Complementary and Integrative Health (NCCIH; formerly the National Center for Complementary and Alternative Medicine) might be positioned and employed to take full advantage of such funding initiatives, and advance integrative mental health both in the United States, and on the global stage.

In accordance with its mission, one of the aims of the NCCIH is to work in concert with both other institutes of the NIH, and

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international research programs. A defined goal of the NCCIH is to advance research and translation of mind and body interventions, practices, and disciplines, by developing " . . . effective, practical, personalized strategies for promoting health and well-being . . . evidence-based decision making regarding use of complementary and integrative therapies and their inclusion in health care and health promotion" [6]. By its charter, the NCCIH is committed to studying those "promising health approaches already in use" in international contexts, through the use of rigorous scientific methods and advanced technologies [6].

2. Toward an integrative, complementary paradigm

To do so, we believe that it will be important, if not essential, to encompass a broader scope of research, so as to examine both "high tech" and "low tech" approaches to mind-body therapeutics for neuropsychiatric disorders and conditions. This is certainly valuable to mental health and health promotions' concerns relevant to the general population. Moreover, we maintain that this is particularly important for the mental health care of children and adolescents, given: (1) the epidemiology of childhood and adolescent neuropsychiatric disorders; (2) constraints, issues and/or problems arising in and from use of neuropsychopharmacologic agents during development; and (3) growing public and ethical concerns about the excessive and/or inappropriate employment – and long-term effects – of psychotropic drugs in pediatric and adolescent treatment settings [7,8,9]. We do not advocate abandoning neuropsychopharmacology. To the contrary; there is evidence to support ample clinical benefits to be gained if and when such agents are prudently utilized [see Ref. [10], for review]. But we argue that other methods may be equally, if not more effective, and can and should be used both to optimize the benefit (and reduce the burdens and risks) of pharmacologic interventions, and to provide alternative modes and trajectories of care.

Therefore, we call for a more encompassing perspective (and paradigm) that entails and seeks to obtain four principal goals: First, is the need to capitalize upon the use of new neurotechnologies (e.g.- functional neuroimaging; neurogenomics) to foster an improved understanding of (a) brain development, substrates and mechanisms of cognition, emotion and behavior in both health and pathology, and (b) various treatments that show promise in affecting these brain structures and functions.

Second, is to use this information to develop a more mechanistically-based, integrative approach to assessment, diagnoses, therapeutics, and prevention. Herein we call for the complementary, and synergistic use of both newer "high tech" (e.g. —neurofeedback, transcranial electrical (tES) and/or magnetic stimulation (TMS)) and older "low tech" (e.g.—meditative and mindfulness practices, emotive focus techniques, music, etc.) treatment(s).

Third, is to employ such assessments and interventions within a bio-psychosocial framework, to insure evaluation and therapeutic targeting of the multiple factors that may be contributory – and correlated to – both psychiatric pathology and health.

Of course, we acknowledge that such an approach is not without potential technical and (neuro) ethico-legal problems. These include the relative novelty of neurotechnological approaches and their potential to elicit as yet unknown (and/or unanticipated) effects, concerns regarding informed consent, and the ways that such approaches might be misused; these issues are further addressed in a subsequent section of this manuscript. Thus, a fourth goal is to address these issues so as to reduce if not resolve those questions and challenges that arise in and from the articulation of such an integrative, complementary approach.

Such a convergent, complementary approach requires broad scale coordination, and necessitates directed financial and policy support by those organizations sponsoring and instrumental to current (and future) initiatives in translational brain research [11]. A comprehensive discussion of this coordinative effort, how such a paradigm might be articulated in practice, and factors affecting its utility and implementation is beyond the scope of the present essay; for a more detailed view, see Giordano [12,13]; Giordano et al. [14], and Shaneyfelt and Peercy [15].

3. The importance of evidence and ongoing research

At the fore is the requirement to base any and all translational applications and therapeutic directions upon evidence obtained from rigorous studies and outcomes' assessment. There is considerable literature addressing the putative mechanisms and demonstrated effects of various forms of mind-body methods (see, for example—Refs. [16,17]). Our specific interest is in the use of meditative and mindfulness practices in the treatment of a host of psychiatric disorders. However, evidence regarding the effectiveness of these techniques in pediatric patients is somewhat equivocal. On one hand, there are abundant historical reports illustrating the effectiveness and safety of a variety of meditative practices in children. Such folk empiricism should not be disregarded. On the other hand, recent studies that have suggested that certain meditative practices may elicit undesirable effects on children's learning and memory abilities [18].

Similarly, while studies support the safety and effectiveness of certain types and techniques of neurofeedback, and TMS in pediatric and adolescent settings [19,20], there is some ambiguity in the reported outcomes of tES [21]. It is becoming apparent that contextual factors (e.g. - brain state, cognitive and emotional focus and "load", environmental conditions) may all influence the viability and effect(s) of these approaches [21–23]. This suggests the need for additional research to more thoroughly investigate and elucidate the interactive effects of psychological condition, meditative practices and state(s), and neurofeedback, tES and/or TMS in pediatric and adolescent individuals in distinct environmental circumstances. It will be important to employ both neurotechnologic (e.g.—neuroimaging-based) and objective sign/subjective symptomatic outcomes' metrics to determine whether and what biological (e.g.—genotypic, phenotypic, physiologic), psychological, and social variables play a role in both response, and contributing to effects of these methods, so as to ascertain what works (and what doesn't), in whom, how and why, and under what conditions. Recent work by Strawn and colleagues provides evidence for this approach in practice [24].

4. Neuroethical concerns and address

To be sure, the overarching goals are to maximize benefit and minimize burdens, risks and harms to the pediatric and adolescent patient (if not to prevent the onset of psychiatric pathology altogether, thereby diverting the individual from the burdens and harms of becoming/being a "patient" in the first place). Fundamental to upholding these aims of beneficence and non-maleficence is the need to insure that any and all techniques are appropriately rendered, and that safety is paramount. This is essential to the probity of informing patients – and/or their surrogates (i.e.—for under-aged pediatric and adolescent patients) – of the methods, anticipated effects, and desired outcomes, which are required for consent (and assent in those individuals who are less than consenting age).

Certainly, international guidelines provide protocols and the "mechanics" for obtaining and assuring informed consent (and/or assent) of children in biotechnology research [25,26]. Yet, given the