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EMPIRICAL REPORT

Beyond the DSM: Development of a Transdiagnostic Psychiatric Neuroscience Course

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Abstract
Objective Clinical and neurobiological data suggest that psychiatric disorders, as traditionally defined in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM), are (1) more comorbid than expected by chance, (2) often share neurobiological signatures, and (3) reflect alterations across multiple brain systems that mediate particular mental processes. As such, emerging conceptualizations such at the National Institute of Mental Health's Research Domain Criteria Project (RDoC) have suggested that a different way to understand psychopathology may be with respect to the degree of dysfunction in each of these brain systems, seen dimensionally, which both cross traditional diagnostic boundaries and extend to a healthy range of functioning. At present, however, this scientific perspective has not been incorporated into neuroscience education in psychiatry, nor has its relationship to clinical care been made clear.
Methods We describe the rationale and implementation of a reformulated neuroscience course given to psychiatric residents at Stanford University centered on the conceptual framework of RDoC. Data are presented on resident feedback before and after revision of the course.
Results A clear motivation and rationale exists for teaching neuroscience in a transdiagnostic framework. This course was taken up well by the residents, with overall feedback significantly more positive than that prior to the course revision.
Conclusion This "proof of concept" neuroscience course illustrates a potential route for bridging between rapid advances in psychiatric neuroscience and the clinical education for trainees not otherwise versed in neuroscience but who are needed for scientific advances to translate to the clinic. The promise of this approach may be in part related to the similarity between this framework and problem-based approaches common in routine clinical care. In such approaches, clinicians focus on the expressed complaints of their individual patient and identify specific symptoms as the target of treatment—symptoms which are presumably the expression of dysfunction in specific brain systems.

Keywords Research domain criteria project (RDoC) · Neuroscience course · Psychiatry residents

Traditional formulations of mental illness, as codified since the third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) [1], have emphasized that psychiatric diagnoses represent entities definable by a set of symptom criteria. This view has dominated both psychiatric research and clinical practice, as well as insurance reimbursement and health policy decisions. As a consequence, neuroscience curricula in psychiatric training have generally followed this model as well. In a typical course, students and residents may be given a general and brief overview of brain systems and potentially an introduction to general neuroscience methods. The bulk of the course, however, may focus on describing neurobiological knowledge as it pertains to major psychiatric illnesses, with a primary focus on Axis I disorders. That is, a set of lectures may be presented on the "neurobiology of depression" or "neurobiology of schizophrenia." While this format presents an opportunity for integration of neurobiological knowledge across disorders, typically, the depth of neuroscience knowledge in psychiatric residents is insufficient to do so effectively.

Insights from the past two decades of cognitive neuroscience research on these illnesses, however, have challenged this view of psychiatric disorders as discrete entities. Indeed, evidence indicates that abnormalities in brain function are often similar across disorders, map onto specific symptoms or clinical impairments better than onto a specific disorder,

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and can be described in terms of dimensional differences in the functioning of brain systems. One form of this perspective has been more recently formalized through the National Institute of Mental Health's (NIMH's) Research Domain Criteria (RDoC) project [2]. With these evolving views of how best to conceptualize mental illness comes the challenge of educating students and residents in psychiatry, who will be increasingly expected to understand neurobiology, apply neuroscience-based insights to their clinical care, and adapt to a rapidly developing area.

Here, we present one approach to a neuroscience course for psychiatric residents implemented by one of us (AE) at Stanford University, which reformulates how to approach neuroscience education in light of advances in research. This course description is thus to be taken as a "proof of concept" which can yield hypotheses regarding neuroscience education that can be more directly tested in future work. Importantly, the aim of this course is not only to update neuroscience education to reflect our emerging understanding of mental illness but also in doing so to present it in a fashion that maximizes appeal to the general clinician. In a separate work involving a national survey of attitudes toward neuroscience and education, members of our research group have recently found that psychiatrists at all levels of training and experience (residents, practitioners, and psychiatry department chairs) enthusiastically endorse both the need to learn more neuroscience and the importance of transdiagnostic concepts [3]. As we argue below, in many ways a dimensional and transdiagnostic approach is a close match to the daily experience of routine clinical work, and in many ways it maximally honors the rich psychological and pharmacological traditions in the field. Moreover, many psychiatric residents enter with relatively little neuroscience education and may not readily seek out this knowledge, be it due to time constraints or inclination. Our ultimate aim was therefore to instill optimism for novel therapies and personalized medicine by application of insights from neuroscience now and into the future.

Conceptual Basis

There are two propositions on which the Stanford neuroscience course is based: (1) that a robust scientific literature exists pointing to the need and utility of reformulating mental illnesses in terms of dimensions of impairment in distinct neurobehavioral systems, and (2) that during routine clinical interactions, practitioners are comfortable thinking in transdiagnostic terms, even if they do not explicitly formulate their observations as such. Below, we elaborate on each of these core propositions and then present the structure of the course and an example lecture illustrating our approach.

The RDoC Formulation of Mental Illness

The clinical and neurobiological understanding of psychiatric disorders has been challenged for a long time by observations that the rate of comorbidity between disorders is much higher than expected by chance [4], that many patients fail to fit cleanly into an established diagnostic category, and that the neurobiological signatures of many disorders appear similar [5, 6]. Basic science in humans and animal experiments have delineated a number of core neurobiological functional units—neurobehavioral systems—that are composed of interconnected brain regions (themselves composed of microcircuits) that mediate specific mental, behavioral, or physiological capacities [6]. The functioning of any particular neurobehavioral system may be influenced by genetics and/or life events, occurring during development or adulthood. Moreover, any specific neurobehavioral system, such as those underlying responses to threat, modulation of attention, or establishment of patterns of attachment, can be described at a range of levels, from genes and proteins to circuits and ultimately behavior and self-report.

The understanding of psychopathology in terms of component abnormalities in discrete neurobehavioral systems is therefore at the heart of an RDoC-type approach [2, 7], which argues that mental illness is a set of these abnormalities that together present as a clinical syndrome in an individual patient. In other words, taking the basic premise that psychiatric disorders are fundamentally brain disorders, an understanding of a complex clinical presentation must ultimately relate back to abnormalities in core systems within the brain. Unlike traditional DSM-type diagnostic approaches to neuroscience, however, RDoC does not assume that a collection of symptoms reflects a single psychopathological process nor that symptoms alone can adequately describe the brain abnormalities at play. As such, the emphasis is on going beyond manifest clinical presentation and revealing relevant fundamental brain mechanisms. The high degree of comorbidity and shared neural substrates across DSM diagnostic categories, as well as clinical heterogeneity, no longer presents a challenge to diagnostic formulation. Rather, impairments are considered to exist dimensionally across the spectrum of normal functioning and different types of psychopathology. In other words, no assumptions of discrete disorders with clearly definable boundaries are made.

In some ways, DSM itself can be considered to have begun the transition to a dimensional RDoC approach. For example, disorders are grouped into "chapters" that denote a greater similarity between disorders within the chapter than those in separate chapters [1]. As such, the specific content and criteria for individual anxiety disorders may differ, but they are understood to fall within a more similar broader class of impairment [8]. One critical difference between a traditional DSM-type formulation and that offered by RDoC is that the latter

moves away from a purely symptom-driven classification and focuses on more proximal neurobiological mechanisms. Ultimately, it is hoped that the research generated by the RDoC approach will inform new versions of psychiatric classification systems that best capture neurobiological reality and do so in a clinically meaningful and practical manner.

Relationship to Typical Clinical Interactions

A critical proposition driving the Stanford neuroscience course is that clinically relevant neuroscience can itself be better taught by focusing on neurobehavioral systems. Put simply, we suggest that an RDoC-type approach more readily teaches to the level at which clinicians are accustomed to interacting with their patients.

During a clinical interview, information is typically solicited about presenting symptoms, history, disease or treatment course, salient events or stressors, and interim changes. Additional information or collateral history may be acquired from other sources as well. During this process, the clinician develops a working conceptual model of the patient and her/his specific complaints and difficulties. Whereas the ultimate coding of the diagnosis for billing purposes requires reference to a DSM diagnosis, the ability of the clinician to relate to and treat an individual patient is frequently driven by a specific understanding of that patient's clinical state. Many patients in clinical practice, in fact, may not clearly meet the criteria for any disorder, may be given multiple diagnoses, or may receive an NOS (not otherwise specified) diagnosis. As such, formulating neuroscience education around an RDoC-type structure may be a closer match to what the clinician does in practice. We also propose that an RDoC-type educational approach honors the rich tradition of psychiatry rooted in the importance of interpersonal interactions between the clinician and the patient, as well as an attentive approach to the specific patient's complaints. It is this humanistic element of clinical care in psychiatry that has ultimately drawn many clinicians to the field, such that its easy alignment with the RDoC heuristic could contribute to the success of this conceptualization. As such, the course was structured to minimize reductionism typical of neuroscience courses so that in every lecture, integration occurred across knowledge arising from animal and human work, pharmacological and psychosocial interventions, as well as intraindividual and social processes.

Two aspects, however, are important to note at this point. First, since the DSM-based structure and definition of mental illnesses are so heavily ingrained during psychiatric training, the alignment of an RDoC-type framework for neuroscience with the clinical practice of psychiatry may not be immediately apparent to many clinicians. Experience with this course has demonstrated that this shift is embraced, but only after multiple illustrations of the utility of this conceptual restructuring. Second, RDoC as a formalized system of nosology is only in its infancy and was created to guide research, not as yet to direct clinical care [6]. As such, it is presented in the course as an organizing principle that promotes patient-centered neuroscience, rather than offering a specific and codified diagnostic system. Although future work will be needed to more directly test these hypotheses, the course described in this article can be regarded as an initial proof of concept of the feasibility of a transdiagnostic approach to neuroscience education.

Course Organization

Table 1 shows the lecture titles from the 2012–2013 course, which was given weekly to third year psychiatry residents at Stanford over a period of 6 months, before the course moved into the second year curriculum during the 2013 calendar year. This move was motivated by the desire to provide this neuroscience exposure earlier in training and thereby maximize its impact on learning in subsequent years. Prior to this course, the primary diagnostic conceptualization that residents received was entirely based on the DSM. As such, all efforts are made to integrate the transdiagnostic neuroscience material with DSM diagnoses residents are already familiar with.

Several organizing features are important to note. First, the topics of lectures generally reference a neurobehavioral system (e.g., fear and extinction, attention/executive function, salience and perception, and reward). These topics are closely aligned with the current formulation of RDoC [2, 7] but differ in certain respects to reflect the judgment of the course director (AE). For example, greater emphasis has been placed on emotion regulation, which is described across two lectures. Pain perception, which is not explicitly included in RDoC, is presented in a separate lecture. Finally, certain methodological topics relevant to emerging interventional approaches (e.g., brain stimulation, optogenetics, and resting-state networks) are discussed. Although lectures in the course have been presented by many of the experts in their fields, this is certainly not a critical component of the course and was possible at Stanford simply by virtue of the available faculty.

Another important organizational feature to note is that most lecture topics also reference a range of traditionally defined disorders relevant to that neurobehavioral system. This was done to frame for the students the alignment between a transdiagnostic approach such as RDoC and the one based on DSM with which they are more familiar. It also makes clear from the first day that an understanding of dimensions of dysfunction within discrete neurobehavioral systems will necessarily relate to a spectrum of clinical states, which may otherwise not be presented together within a DSM-type framework. One example of this, explored in more depth below, is the lecture on attention and executive function and its

Table 1 Lecture titles for the 2012–2013 neuroscience course

Introductory lectures
Why should psychiatrists care about neuroscience?
Introduction to neuroimaging
Introduction to human genetics
RDoC topic lectures
Salience and perceptual systems and psychotic disorders
Fear and extinction and anxiety disorders
Attention/executive function systems and schizophrenia, depression, and ADHD
Reward system, addiction, and depression
Social neuroscience and pair bonding
Attachment systems and personality disorders
Theory of mind, empathy, and autism spectrum disorders
Memory systems, aging, and cognitive decline
Habit system, OCD, and Tourette syndrome
Explicit emotion regulation
Implicit emotion regulation
Pain perception and chronic pain disorders
Eating-related behaviors and eating disorders
Resting-state networks in psychopathology
Neural circuit intervention lectures
Brain stimulation therapies
Optogenetics and future circuit-based therapies
Integration lectures
Promise and reality of psychiatric genetics
The history and future of psychiatric classification
Challenges in translating neuroscience to clinical care
Integrative neuroscience and discussing your patient's brain with them

relationship to schizophrenia, depression, and attention-deficit/hyperactivity disorder (ADHD).

In addition to this series of lectures, we have experimented with journal clubs related to themes raised in the lectures and more patient case-oriented discussions. In general, however, the residents preferred the lecture format.

Example Lecture: Attention/Executive Function Systems and Schizophrenia, Depression, and ADHD

The goal of this lecture is to describe frontoparietal attentional systems and their role in executive functioning (considered to be a component of the RDoC Cognitive Control construct) and to illustrate how they are perturbed not only in several seemingly disparate disorders but also in individuals at risk for those disorders and how an understanding of this neurobehavioral system can inform emerging neuroscience-based treatments [6]. The lecture begins by soliciting opinions from the residents about how they would define executive function in order to begin operationalizing the topic. The residents then experience first-hand engagement of executive function by performing the Stroop and anti-saccade tests in the classroom, hence also gaining exposure to neuropsychological methods for measuring the construct in clinical and research contexts. A circuit heuristic is then presented that introduces the key neuroanatomical substrates for this well-defined neurobehavioral system, including neuromodulators (i.e., dopamine, norepinephrine, and acetylcholine). The first traditionally defined disorder reviewed is schizophrenia, including discussion of neuroimaging studies, the now-resolved controversy regarding whether patients are "hypo-" or "hyperfrontal" [9], neuropathological work on the prefrontal cortex [10], a demonstration of the relationship between executive functioning and patients' real-world functional capacities (whereby cognitive impairments are the earliest and best predictors of long-term course, distinct from the positive symptoms classically associated with the disorder) [11], and genetic and familial neuroimaging data demonstrating that similar impairments in executive function circuitry are evident even in unaffected individuals at risk for schizophrenia [12–14]. Drawing on these data, the residents are then presented with results from several proof-of-concept treatment studies that use an understanding of the neurochemistry of this neurobehavioral system (using nicotinic acetylcholine agonists) [15], or an understanding of its cognitive neuroscience (using a "brain training" approach) [16], to treat cognitive dysfunction in schizophrenia in novel ways not addressed by current medication treatments.

Following this framework, similar results are presented for major depression and ADHD, including neuroimaging, genetic, and novel treatment data. As such, the residents see the same neural systems implicated in slide after slide, illustrating very explicitly the overlap between these three otherwise disparate disorders within the domain of executive functioning. On the basis of these data, the residents are encouraged to be more curious about the cognitive status of their patients (whether they have been diagnosed with schizophrenia or

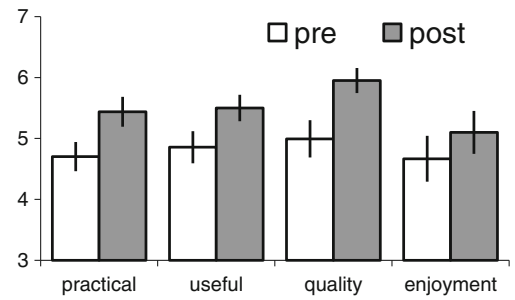

Fig. 1 Resident feedback ratings (1=low, 7=high) on how practical, useful, of high quality, and enjoyable the course was before (*pre*) and after (*post*) revision from a DSM-oriented to an RDoC-oriented course. Plotted are means and their standard errors

depression), including the application of the easily administered neuropsychological tools that they experienced firsthand in the lecture. As such, the point is made that this domain of dysfunction is often not directly explored in clinical care, in part because current therapeutics do not improve cognition. Nonetheless, the residents are encouraged to draw the conclusion that not only is assessing cognition of critical importance to understanding these patients and feasible to do in routine clinical care, but it is also important for being able to properly apply novel therapeutic approaches that may not be far from practical clinical implementation.

Course Feedback

Residents provide feedback at the conclusion of every course using a 1–7 scale rating how practical, useful, enjoyable, and high quality the course was. We used these data from the year before and after the RDoC-oriented revision (Fig. 1). Of note, these ratings are given after every course at Stanford and were not geared for the specific assessment of the changes made in the neuroscience course and hence can be considered useful measures of convenience in the present context. Nonetheless, we found that the revised course was rated as significantly more practical and of higher quality ($p<0.05$, unpaired t test), a trend toward greater utility ($p=0.09$), but similarly enjoyable ($p=0.61$). Thus, though the instructors changed with the course revision, these data suggest that the material and their presentation held greater appeal to the residents than a more traditionally designed course organized around DSM diagnoses.

Conclusions and Future Directions

We present here the rationale and implementation of a neuroscience course for psychiatric trainees that is based on a conceptual reformulation of mental illness away from the diagnostic categories present in DSM and toward a dimensional and transdiagnostic perspective as represented in the NIMH's RDoC initiative. At the core of the RDoC approach to neuroscience education is the concept that causative brain-level abnormalities are best understood at the unit of the neurobehavioral system, wherein perturbations may be seen across a range of traditionally defined disorders. We suggest that a dimensional and transdiagnostic neurobiology of mental illness is well aligned with both extensive clinical neuroscience data and the problem-focused nature of routine clinical interactions with individual patients. The challenge in future curriculum development is thus not in establishing a proof-of-concept course, but rather in finding ways to help this approach take root through continuing educational experiences. Likewise, direct evaluation of resident attitudes and use of the ideas from this course in clinical practice would be important in assessing the utility of our proposed approach for teaching neuroscience. Finally, although Stanford has many experts in clinical neuroscience who can teach lectures in this course, such expertise is unlikely to be the case universally. Through rapidly evolving Internet-based educational tools, however, successful implementation of this course at other programs may be facilitated through the use of online lecture dissemination tools (e.g., Coursera), multi-site video-teleconference, or pre-recording of lectures for later viewing.

Implications for Educators

- Advances in neuroscience are of increasing relevance for training of psychiatrists.
- Traditional concepts of psychiatric illness and its neurobiology may not fully capture the state of the science or the experience of clinicians with their patients.
- We have outlined a new approach at teaching neuroscience that emphasizes the centrality of abnormalities in dissociable neural systems and mental capacities, which thus crosses traditional diagnostic boundaries and aligns with problem-focused clinical care.

Implications for Academic Leaders

- Rapid advances in neuroscience knowledge, and increasing relevance of neurobiology to clinical care in psychiatry, emphasize the need for a reconsideration of how neuroscience is taught in psychiatry.
- There is a lot of enthusiasm among trainees for learning neuroscience, in particular if it aligns well with their clinical experience and style.
- National trends toward dimensional and transdiagnostic neurobiological models of mental illness offer a cutting-edge way to merge scientific advances with innovative teaching approaches.

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