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Integrating Development into the RDoC Framework: Introduction to the Special Section

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Abstract

The goal of this Special Section was to highlight the generativity of taking a developmental perspective toward the RDoC framework that considers developmental processes and principles and the environmental and contextual processes relevant at different ages and developmental stages. The nine papers in this Special Section and two invited commentaries exemplify and highlight sophisticated efforts to integrate development and principles of developmental psychopathology into the RDoC framework. In so doing, the papers both demonstrate how a developmental perspective can bolster strengths of the RDoC approach and identify notable gaps and shortcomings in how the RDoC framework, assumptions, and constructs are currently conceptualized. There are critical tensions between conducting developmentally-informed and informative RDoC research. Our measures and research designs are often outstripped by the challenge of testing our ambitious ideas. Examining the causal transactions between individual differences in RDoC dimensions and normative maturational tasks, supportive and hindering contexts, and the potential moderation of associations by developmental history will produce important information about the development, manifestation, and course of psychopathology. Addressing these gaps holds great potential for identifying preventive-intervention targets, impactful intervention settings, and environmental and contextual supports.

General Scientific Summary

Taking a developmental perspective toward the RDoC framework that considers developmental processes and principles will further our efforts to understand the development, manifestation, and course of psychopathology. This hold great potential for identifying preventive-intervention targets, impactful intervention settings, and environmental and contextual supports.

Keywords

Development; Research Domain Criteria; RDoC; psychopathology

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The Research Domain Criteria (RDoC) framework is intended to spur research investigating psychopathology and takes as its starting point neurobiologically informed dimensions of functioning (Insel et al., 2010). This framework is delineated in a matrix specifying six domains (negative valence, positive valence, cognitive, social processes, arousal/regulatory, sensorimotor) composed of constructs comprising behavioral elements, processes, mechanisms, and responses that span from normal to abnormal functioning. Investigators are explicitly encouraged to measure these constructs across multiple units of analysis (genes, molecules, cells, circuits, physiology, behavior, self-report, laboratory paradigms) to harness knowledge across animal and human, behavioral and neuroscientific, research. The RDoC framework explicitly emphasizes the importance of understanding developmental trajectories across various phases of the lifespan—a “third dimension” in the matrix. However, the instantiation of the RDoC philosophy is rarely informed by developmental theory nor developmental science, and neither was deeply considered during the creation of the RDoC matrix and its domains, consideration of its units of analysis, or even in its framing or conceptualization of psychopathological processes. As such, developmental, as well as environmental, elements of the RDoC framework, both of which we consider to be fundamental to all psychopathology research, may come across as something of an afterthought. There has been little guidance for researchers seeking to incorporate development into RDoC-informed research, despite calls for just this kind of guidance (see Beauchaine & Hinshaw, 2020; Casey, Oliveri, & Insel, 2014; Franklin, Jamieson, Glenn, & Nock, 2015; Garvey, Avenevoli, & Anderson, 2016; Mittal & Wakschlag, 2017; Pacheco et al., 2022).

In this Special Section of the *Journal of Abnormal Psychology*, we have gathered nine papers that exemplify sophisticated efforts to integrate development into the RDoC framework. These papers demonstrate how strengths of the RDoC framework come to the fore when a developmental approach is used, but also how some RDoC constructs and assumptions fall short when applying even basic developmental principles within the framework. In this introduction, we describe how we understand the synergy between the RDoC philosophy and a developmental perspective on psychopathology, further informed by two invited commentaries by experts in the National Institute of Mental Health (NIMH; Sanislow et al., this issue) and the Hierarchical Taxonomy of Psychopathology (HiTOP) consortium (Tackett & Hallquist, this issue). We highlight the critical tensions between conducting developmentally-informed and informative RDoC research and the realities of our current knowledge base. This tension illustrates the advantages and disadvantages of different research designs, and the challenges inherent to matching the complexity and ambition of our ideas and hypotheses to the level of confidence we can place in our ability to test them. We consider carefully what the papers in this Special Section can tell us about the future of RDoC research, as well as the limits to the current body of evidence. Finally, we propose several changes to ground RDoC research on the foundation provided by developmental theory and research.

Why Does RDoC Need a Developmental Perspective on Psychopathology?

The RDoC agenda stands to benefit in several ways from incorporating a more developmental perspective, guided by both classic and contemporary models of

developmental psychopathology (Beauchaine & McNulty, 2013; Cicchetti, 1993; Hyde, 2015; Rutter, 1997; Sameroff, 1995; Sroufe & Rutter, 1984). In terms of basic science research, a developmental perspective is informed by an understanding of both typical and atypical developmental processes and provides leverage for testing questions about causality. In terms of application, it is impossible to separate people and their functioning from the environments and contexts in which they are developing. While research need not be explicitly or even nominally “developmental” to advance the RDoC agenda, developmental science provides traction for understanding psychopathology. In the following, we provide context for reading the papers in this Special Section, including psychopathological process, the conceptualization of environments and contexts, measurement and units of analysis, and the implications for application.

Psychopathological processes as dynamic, rather than static.

The RDoC framework encourages exploration of how the biological systems underlying aspects of neurobehavioral functioning develop over time by reorienting the focus of psychopathology research to neurobehavioral systems (and away from socially derived categories of dysfunction). These systems begin to be constructed in the first moments of life and are modified throughout the lifespan via developmental and contextual pressures, affordances, tasks, and constraints that shape and co-evolve with these neurobehavioral systems. By considering both development and context, the neurobiologically-informed RDoC dimensions of functioning are placed within a conceptual model that acknowledges “problem behaviors” themselves can serve a functional purpose (Fonagy & Luten, 2018). By better understanding the typical and atypical development of these neurobehavioral systems—over time and in concert with environmental and contextual conditions—we better understand the role of individual differences in functioning in these neurobehavioral systems for varied forms of psychopathology across the lifespan. Moreover, this allows us to test more mechanistic hypotheses about psychopathology outcomes of theoretical and practical interest in a way that avoids the circularity of defining all etiological processes as necessarily “pathological” in nature.

Tye, Bussu et al. (this issue) use a measure of individual differences in neural responses, indexed using event related potentials (ERPs), to varying face stimuli in children at low and high risk for autism spectrum disorders (ASD) to identify pathways to social functioning difficulties via differences in engagement or processing of face stimuli. Their data suggest that individual differences in toddlers’ face processing (an index of social communication, a social processing domain construct), measured using electrophysiology in a face processing task, is predicted by diffuse *underreactivity* to faces (versus noise stimuli) in infancy, but a different pattern of *amplification* of sensory input among high-risk children later in development. This suggests both that distinct ERP metrics emerge as risk markers at different developmental stages—an example of heterotypic continuity—and that different developmental stages present unique opportunities for intervention.

Damme et al. (this issue) consider differential specificity of individual differences in irritability as a function of age within the context of normative social changes in expectations for and supports regarding child negative emotionality. As preschoolers move

into early childhood, parents and caregivers increase their expectations that children can manage negative emotions, such that elevated irritability relative to one's same-age peers during early childhood may reflect different mechanisms compared to earlier developmental periods. Consistent with this, they show that, although higher levels of irritability in preschool (an index of frustrative nonreward, a negative valence domain construct), measured using a parent-report questionnaire, are a diffuse predictor of varied behavior problems in preadolescence—an example of multifinality—higher levels of irritability in early childhood are specific to preadolescent externalizing problems, as well as reduced volume in some brain regions, as measured by MRI.

Li et al. (this issue) embrace the emphasis of the RDoC framework on transdiagnostic processes in their examination of associations between a polygenic score (PGS) for general psychopathology (the p factor) and multiple RDoC dimensions, including negative emotionality (an index that spans acute threat, potential threat, sustained threat, loss, and frustrative nonreward, the negative valence domain constructs), novelty seeking (an index of reward responsiveness, a positive valence domain construct), and picture vocabulary (an index of language, a cognitive domain construct), measured using self-report questionnaires and performance on a neurocognitive test. They find that the transdiagnostic PGS predicted depression trajectories during the transition from adolescence into early adulthood, as well as suggestive evidence of a specific indirect association for negative emotionality (but not novelty seeking or picture vocabulary). Studies like this show how one can leverage longitudinal data to home in on potentially explanatory mechanisms linking neurobehavioral systems and psychopathology processes.

McLaughlin and Gabard-Durnam (this issue) give an example of experience-dependent and dynamic development of reward responsiveness (a positive valence domain construct), whereby lower levels of reward responsiveness result in less pursuit of positive experiences, thereby changing the learning history of youth low in reward responsiveness, thus producing further impairments in reward processing. These dynamic models are an important way for developmentally-informed research to guide our understanding of RDoC because they take into account how development shapes subsequent interactions with the environment.

Environmental embeddedness.

The first wave of RDoC research rarely considered the role of environments in the development or manifestation of the RDoC dimensions explicitly. Evaluating how or under what circumstances environmental contexts influenced outcomes was also not a priority. This oversight can be addressed by situating the RDoC framework within developmental science. We agree with Beauchaine and Hinshaw (2020) that specific aspects of the environment that should be considered in developmentally-informed RDoC research, and their hypothesized relationship to psychopathology, should not be prescribed by the framework. Instead, just as RDoC recast a focus on diagnostic classifications to make better use of the extensive body of evidence on basic psychological processes, it will be essential that RDoC research explore the role of a broad array of environmental influences on the development and manifestation of neurobehavioral systems. It is undeniable that adverse environments can and often do play an important role in the development of varied forms of

psychopathology. This work must include both normative, as well as more extreme, adverse environmental conditions. Specifically, we must understand the normative developmental tasks the RDoC dimensions are serving and responding to, and how environmental contexts moderate the experience of developmental pressures and individual differences in the capacity to adapt to them. Environmental changes may have differential predictive validity over time partly as a function of normative development in the relevant RDoC dimensions. Moreover, RDoC research on how individual differences in these systems may be differently respond to environmental supports and challenges will inform our understanding of how the environmental context provides conditions under which disorders associated with these dimensions can be alleviated.

Liu et al. (this issue) consider frustrative nonreward in a key normative context, parent-child interactions. In a sample of adopted infants, anger (an index of frustrative nonreward, a negative valence domain construct) was measured during an arm-restraint-by-parent task. The child's response was associated with biological parents' externalizing problems, but not adoptive parents' overreactive parenting. This highlights the importance not just of levels or units of analysis, but precision of measurement for assessing different stages of neurobehavioral processes with different risks for psychopathology.

Ethridge et al. (this issue) also consider a broader context spurred by pubertal maturation, part of a normative developmental transition in adolescence that is marked by the tasks of developing independence from family, forging more complex peer relationships, and adaptive risk-tasking for exploration and skill development. During this developmental transition, reduced reward responsiveness (a positive valence domain construct) may be particularly problematic if it interferes with these major developmental tasks, which set the stage for the subsequent normative transition into early adulthood. They show that pubertal status is associated with reward responsiveness, measured using electrophysiology during a reward processing task, but that the direction of this association differs as a function of maternal history of depression. This reflects the principle that individual differences in neurobehavioral systems may be adaptive or maladaptive, depending on the contexts in which they are expressed. Understanding the function and context of RDoC dimensions is a critical contribution of developmentally-informed studies.

Measurement and units of analysis.

Issues of measurement have been largely overlooked in RDoC research. Reliable and valid measurement is indispensable for testing our hypotheses, and the fidelity of our measures to the constructs sets the ceiling on our inferences. Measurement development for the RDoC dimensions (including at the construct and domain levels) and evaluation of the psychometric properties of both established and newer measures used in RDoC research has lagged behind other aspects of RDoC research. The RDoC requirement of measurement across multiple units of analysis echoes strengths long evident in developmental science by contextualizing measurement and evaluating the incremental validity of different measurement approaches. Developmental data will help to benchmark the anticipated magnitude of convergence effects and mean level differences across informants/methods/levels. For example, under conditions that might maximize agreement across methods for

quantifying individual differences in children, convergence is typically modest to moderate in magnitude. Meta-analyses of assessments of youth externalizing problems (a salient, relatively observable and objective set of behaviors) finds a mean correlation of .30 across informants (De Los Reyes et al., 2015), with somewhat higher convergence for informants in the same context/similar roles with respect to the child (e.g., mother-father versus child-teacher). With this benchmark in mind, it seems quite unrealistic to expect more than moderate convergence of individual differences in neurobehavioral traits when assessed using very different methods. It is more likely that one could construct a map of a gradient of anticipated convergence wherein similarity in assessment context—when (over both short- and long-term time windows), how (broad and narrow features of the methods and paradigms used), and what (similarity of content, stimuli, or conceptual definition the construct)—set the boundaries for the maximum level of agreement. It is likely more useful to use the most informative methods for the particular question than it is to reflexively use multiple methods without appreciating their incremental validity, convergence, and what exactly they are measuring.

Peterson and LeBeau (this issue) present a sophisticated technique—vertical scaling—for addressing one of the major hurdles to making appropriate inferences from longitudinal data, that of designing a measurement strategy that balances developmental sensitivity with the ability to distinguish change in a measure over time that is driven by change in the underlying latent construct versus change in measurement properties across age (see Mittal & Wakschlag, 2018 for another example of this issue in neurodevelopmental disorders). This is a persistent methodological challenge in longitudinal developmental research and this paper offers an exciting step forward. The authors demonstrate that eliminating items that vary in sensitivity across age (i.e., limiting measurement only to items that are common across all ages) reduced the validity of their scale. In contrast, *modeling* changes over time in individual difference measures while estimating changes in the underlying latent construct yields measured with greater construct validity, thus allowed more psychometrically robust tests of how RDoC dimensions may change over time. Critically, in order to make use of this sophisticated technique, RDoC research needs a body of normative data, including neuroimaging, psychophysiology, behavioral, self-report, and laboratory methods, developmentally sensitive modifications of those measures at different ages, and a battery of core measures (again including multiple methods) that span and provide continuity and across developmental stages. Especially powerful is vertical scaling applied across different methods or tasks (not just across questionnaires or informants), which makes possible the combination across both cross-sectional and longitudinal datasets with different but overlapping combinations of measures to explore development and change in the latent RDoC constructs being assessed across labs. This will be especially important for determining the extent to which age-related differences are attributable to age-related differences in measurement properties (arising from, e.g., change in general abilities, language acquisition, differences in specific tasks or stimuli) or real change on the underlying latent constructs.

Moore et al. (this issue) provide an excellent demonstration of how RDoC units of analysis like laboratory paradigms that have thus far been underutilized can inform our understanding of RDoC dimensions. They used a battery of well-established Laboratory

Temperament Assessment Battery (Lab TAB) tasks to assess reward responsiveness (a positive valence domain construct), frustrative nonreward, loss, and fear (all negative valence domain constructs) in middle childhood, as well as psychopathology symptoms assessed in both middle childhood and again in adolescence. Critically, they find that reward responsiveness and frustrative nonreward, measured using emotion-eliciting tasks, were more correlated than might be expected given the placement of these constructs in different RDoC systems. This points to the possibility of misspecification in the RDoC matrix, namely missing an underlying approach motivation system that cuts across both reward responsiveness and frustrative nonreward. Alternatively, it may indicate that shared method variance across the laboratory paradigms yields measures of distinct constructs overlap more than anticipated. Moreover, leveraging their genetically informative twin sample, they find greater heritability of reward responsiveness and frustrative nonreward relative to loss and fear constructs, though they appropriately acknowledge this is likely attributable to less reliable measurement of loss and fear constructs—consistent with broader issues in the literature on assessment of internalizing constructs with respect to reliability of measurement and possibly greater heterogeneity in the evocative stimuli that are reliable elicitors of these dimensions.

Kaurin et al. (this issue) take on the challenge of integration across multiple units of analysis, focusing on a key psychosocial factor of adolescence—sensitivity to social exclusion. Their comprehensive assessment battery of social threat (a construct that spans both negative valence and social processes domains) included ecological momentary assessment (EMA) of social interactions and negative affect, attentional bias measured using eye tracking during a dot probe task, sensitivity to social rewards and punishments measured using fMRI during a monetary incentive delay task, and parent- and self-report questionnaires of social threat sensitivity. Of note, this study stands out in its use of multiple ecologically valid methods, but also in that the measures used vary in their known psychometric qualities, making the findings particularly timely and informative. There was little evidence for a robust individual difference signature across these units of analysis, raising questions about how to integrate across multiple units of analysis, and critically, interpret their convergence or lack thereof. Kaurin et al. note that this poor convergence may be attributable to weaker integration across levels of analysis among adolescents relative to adults, but also thoughtfully consider the contribution of poor measurement reliability. We improve our interpretive leverage by recognizing reliability is not simply a measurement property, but a property of the data (this measure in this sample), and that evaluating measures' psychometric properties and construct validity across developmental stages may save us from drawing premature or erroneous conclusions about issues ranging from the association with psychopathology to developmental specificity or change over time and development.

Prevention/intervention/precision science.

The possibility of sensitive periods for the development of neurobehavioral systems of functioning suggests that intervention efforts during those periods may be more effective at preventing or ameliorating psychopathology than during other periods due to heightened neuroplasticity, as articulated by McLaughlin and Gabard-Durnam (this issue). Like most

other neurobehavioral systems, however, the RDoC dimensions are likely not characterized by a discrete sensitive period but are instead subject to experience-driven plasticity across a broader developmental period or even spanning multiple stages of development. We have much to learn about how the RDoC dimensions may be impacted by environmental and contextual exposures and their timing. We also need to consider how individual differences in these dimensions place some people at greater likelihood for exposures, especially owing to tendencies toward a particular environment or context that is further shaped by that context (e.g., reduced reward responsiveness leading to diminished engagement with pleasurable activities, resulting in further blunted reward processing). McLaughlin and Gabard-Durnam also suggest the potential applied utility of screening for exposure to environmental and contextual factors known to be related to RDoC dimensions, rather than reliance solely on screening by brain or behavioral measures. This approach could also be useful in applied settings seeking to develop specialized and personalized treatment programs. It could also be useful in study designs that leverage differences between exposed and unexposed individuals or observations of individuals over time of changing exposure, to explore the causal influences of these environmental and contextual factors on the RDoC dimensions and the development, manifestation, and course of psychopathology. Understanding causal processes and the environmental and contextual contributors to those processes is critical for guiding the most strategic prevention and intervention efforts that minimize the burden and impact of psychopathology across the lifespan.

Critical Issues for Future Developmentally-Informed RDoC Research

A major motivating factor in the development of the RDoC framework was the goal of moving away from reified and psychometrically weak diagnostic categories formed from less representative and less informative samples. Expanding psychopathology research to include an emphasis on transdiagnostic neurobehavioral systems of functioning that builds on basic animal and neuroscientific models has the promise of grounding our current body of evidence in a broader knowledge base. In this Special Section, we bring together cutting-edge research that provides a much needed, explicit injection of development into the RDoC framework. However, we recognize that conducting developmentally-informed RDoC research necessarily adds an additional layer of complexity that we as a field are, by and large, currently ill-equipped to address rigorously. Much of psychopathology is characterized by known risk factors for failures to replicate (e.g., small samples, reliance on measures of unknown or poor reliability, flexible analytic decisions, analysis of multiple dependent variables in the same sample within or across multiple publications, examination and [over-]interpretation of underpowered interaction effects). Drawing upon the decades of empirical research and theory from the psychopathology and developmental science literatures helps to guide carefully considered and informative RDoC research, yet investigations that incorporate developmental principles and processes across ages and developmental stages face many challenges in the context of an incentive structure that at times promotes rapid publication over steadily building a body of evidence (see also the Special Section on Increasing Replicability, Transparency, and Openness in Clinical Psychology, Tackett & Miller, 2019). This Special Section highlights a number of critical areas for RDoC research and for psychopathology more generally. These include issues of

measurement of both the RDoC dimensions and psychopathological constructs across ages and developmental stages, but also environments and contexts; quantitative methods that can accommodate multiple waves of prospective, longitudinal data assessed using multiple methods and informants, across multiple units of analysis; the need to move beyond a correlational framework through the use of study designs that help us get at etiology and mechanisms, an understanding of which is fundamental for developing the most targeted and effective preventive-intervention efforts; and ensuring that the findings from our research samples are generalizable to our actual populations of interest.

At present, developmentally-informed psychopathology research must often rely on measures with unexamined or even inadequate psychometric properties, the downward application of adult measures to ages or developmental periods for which we lack psychometric data, and/or researcher degrees of freedom in creating ad hoc measures and “creatively” applying or scoring existing measures. Moreover, the RDoC goal of inclusion of multiple levels of analysis can lead to selective reporting of confirmatory rather than disconfirmatory findings. Given the frequency of their use at younger ages, considerably more effort needs to be devoted to appropriate quantification of and decision rules about reliability of indices from task-based laboratory and cognitive paradigms, as methods for evaluating reliability that were designed for self-report questionnaires are often not appropriate. We suggest taking a systematic approach to building the knowledge base by (1) developing psychometrically robust, developmentally sensitive measures with useful normative data acquired using cross-sectional designs, and first (2) establishing main effects of age and developmental stage on these measures, along with establishing measurement invariance across age and developmental stage, before moving on to (3) adequately powered tests of developmental moderation of RDoC dimensions on other relevant constructs. Basic data on key developmental parameters and the natural history of RDoC dimensions, including norms, but also relative and absolute (mean-level) stability across important developmental periods, forms the basis for interpreting data from more complex designs testing changes in predictive validity across development, developmental processes that promote stability versus change in RDoC dimensions over time, and the influence of environmental context on developmental trajectories. Notably, efforts to measure environmental and contextual factors have lagged even behind those to measure other relevant constructs. Moreover, too often assumptions are made in inferring that a context or construct is environmentally mediated without first conducting the research needed to verify these assumptions (e.g., genetically informative twin and family studies, quasi-experimental studies), even though much of what we have historically considered “the environment” is at least partially genetically influenced (Kendler & Baker, 2006). Because psychometrically robust measurement is the bedrock of our science, well-established measures of all relevant constructs that have demonstrated reliability and validity in the samples and developmental periods in which they are being applied is fundamental for making solid advances.

Likewise, to capture the development and interface of neurobehavioral systems and psychopathology, within evolving environmental contexts, the quantitative methods we apply must be sufficient not only for modeling dynamic associations between constructs over time, but also the causal effects of constructs on one another. Cross-sectional

investigations can be informative for describing relevant processes, but, thus far, exploration of age differences in RDoC and psychopathology research more broadly has relied on interaction terms in small, cross-sectional samples. Little attention has been paid even to the temporal ordering of constructs (a prerequisite to inferring a causal effect) in longitudinal studies even though considerable effort in developmental science research has been dedicated to analytic approaches that model between- and within-person change over time for causal inference (e.g., Berry & Willoughby, 2017).

The recognition of and desire to appropriately investigate what are likely complex and dynamic causal links between neurobehavioral systems of functioning and psychopathology symptoms and disorders within environmental contexts and across development has not been met with commensurately serious efforts ensure our tests of these ideas are adequately powered in sufficiently large and representative samples. Although there are notable exceptions, as the field is increasingly turning toward consortium-wide efforts to build large, carefully ascertained, nationally representative, samples with both neurobehavioral and psychopathology data assessed across the lifespan (e.g., Adolescent Brain Cognitive Development [ABCD] study, Jernigan, Brown, & Dowling, 2018; Baby Connectome Project [BCP], Howell et al., 2019; Healthy Brain and Child Development [HBCD] study, Volkow, Gordon, & Freund, 2020; Human Connectome Project in Development [HCP-D], Somerville et al., 2018; Human Connectome Project Young-Adult [HCP-YA], Van Essen et al., 2013; Human Connectome Project in Aging [HCP-A], Bookheimer et al., 2019), our samples are still predominantly unselected convenience samples with little attention paid to ascertainment—white, socioeconomically advantaged, well educated, and urban or suburban. Addressing these issues is a critical next step for developmentally-informed RDoC research, and necessary if we are to realize the promise of the RDoC framework.

Conclusion

The papers in this Special Section highlight the generativity of a perspective toward the RDoC framework that draws from a richly defined developmental landscape that includes consideration of developmental processes and principles and the environmental and contextual processes relevant at different ages and developmental stages. Further detailing the causal transactions between individual differences in RDoC dimensions and normative maturational tasks, supportive and hindering contexts, and the potential moderation of associations by developmental history will no doubt produce important information about the development, manifestation, and course of psychopathology and holds great potential for the identification of preventive-intervention targets, the most impactful intervention settings, and environmental and contextual supports for adaptive outcomes.

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