HHS Public Access

Author manuscript

J Clin Child Adolesc Psychol. Author manuscript; available in PMC 2022 April 01.

Published in final edited form as:

J Clin Child Adolesc Psychol. 2020 ; 49(3): 341–352. doi:10.1080/15374416.2020.1753205.

Developmental Psychopathology and the Research Domain Criteria: Friend or Foe?

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Abstract

Developmental psychopathology (DP) is a conceptual approach to the study of the origins and course of individual patterns in the development of psychopathology across the lifespan. The Research Domain Criteria (RDoC) aim to study dimensions of neurobiology and behavior to construct a new classification of psychopathology that will advance the understanding and treatment of mental disorders. In this commentary, we describe aspects of overall convergence and divergence between these two approaches. Developmental psychopathology and the RDoC overlap, in that they both (a) study the full range of variation from normality to psychopathology, (b) aim to understand the origins and mechanisms underlying psychopathology, (c) use multiple units of analysis to study salient domains of functioning, and (d) emphasize the importance of using reliable and valid measurement. There are also several differences between these perspectives. For example, RDoC is exclusively dimensional, whereas DP studies both continuities and discontinuities. According to RDoC, mental disorders are brain disorders and neurocircuitry is primary, whereas DP asserts that the development of psychopathology results from dynamic transactions among neurobiology, psychology, and social contexts. We conclude by identifying ways to leverage the DP and RDoC perspectives to advance progress in both, particularly regarding research and intervention for children and adolescents.

Keywords

Developmental Psychopathology; Research Domain Criteria; Children and Adolescents

The primary goal of this Special Section is to present a developmentally informed perspective on the Research Domain Criteria (RDoC). The central purpose of RDoC has been to provide a framework for translating knowledge from basic science into real-world methods for reducing mental illness (Insel et al., 2010). RDoC aims to construct a new classification of psychopathology based on dimensions of neurobiology and behavior in order to advance the understanding and treatment of mental disorders (Sanislow et al., 2010). Although development was not explicitly included within the original RDoC matrix, a central goal of RDoC presumably was to understand the *neurodevelopmental origins* of mental illness (Morris & Cuthbert, 2012).

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In recent years, the National Institute of Mental Health (NIMH) RDoC website added a brief description about development, stating that: "While RDoC calls for the study of circuit-based functional dimensions as studied across multiple units of analysis, two additional aspects represent equally important elements of the RDoC framework: (1) neurodevelopmental trajectories and (2) interactions with the environment." (https://www.nimh.nih.gov/research/research-funded-by-nimh/rdoc/developmentaland-environmental-aspects.shtml). At present, RDoC is supposed to focus systematically on development and the environment, their interactions, and their relations to specific circuits and functions.

Although the NIMH now recognizes the role of development and the environment in the evolution of psychopathology (Garvey et al., 2016), it lacks a prescription for how to integrate these constructs into the RDoC matrix. The NIMH RDoC website highlights the notion of "developmental trajectories" and suggests that development might be considered "a third dimension in the matrix," but provides little guidance regarding what this revised matrix would look like or how to use it in research. Rather, NIMH intends to "liberate" investigators to define the developmental events and timeframes that are most appropriate for their particular research question (Cuthbert, 2014).

There have been several attempts to incorporate development and the environment into the RDoC matrix, often by suggesting the addition of new levels/dimensions (e.g., Franklin, Jamieson, Glenn, Nock, 2015; Mittal & Wakschlag, 2017; Woody & Gibb, 2015). For example, Woody and Gibb (2015) proposed a four-dimensional model in which the traditional RDoC domains and units of analysis must be understood in terms of developmental and contextual influences. In particular, the constructs that comprise RDoC change over time regarding both the individual and the disorder. Similarly, Mittal and Wakschlag (2017) diagramed a four-dimensional RDoC framework that maintained the two original axes of Domains/Constructs and Units of Analysis, but added Development and Environment/Context. They asserted that: "future efforts to conduct research in this innovative system will need to place equal weight on each of the four factors" (p. 31), and recognize that developmental influences are dynamic and will interact with the other RDoC Dimensions (Mittal & Wakschlag, 2017).

Franklin et al. (2015) questioned a fundamental assumption of RDoC—that mental disorders are brain disorders. They proposed, rather, that RDoC should have a broader view of development that includes multiple causes beyond its primary focus on neurocircuitry. The emphasis on neuroscience in RDoC, although clearly important, seems to miss the equally important contribution of development and the environment in the etiology of psychopathology. In contrast, in response to the critique that the RDoC framework is reductionist and overemphasizes neural circuits and genetics, Kaufman et al. (2015) noted that the literature on neuroplasticity and epigenetics makes this concern unwarranted, "as one cannot study neural circuits and genetics without considering experience" (p. 617).

Other notable attempts to integrate developmental psychopathology and RDoC have occurred in empirical articles (e.g., Ip et al., 2019), conceptual papers (e.g., Casey et al., 2014; Luyten & Fonagy, 2018; Musser & Raiker, 2019) and special issues of journals,

such as *Development and Psychopathology* (e.g., Beauchaine & Cicchetti, 2016) and the *Journal of Affective Disorders* (Vaidyanathan & Pacheco, 2017). Musser and Raiker (2019) examined associations between ADHD and RDoC domains of cognition (e.g., working memory) and positive valence (e.g., reward systems) across behavioral and neurocircuitry levels of analysis. Luyten and Fonagy (2018) proposed an integrative developmental cascade model inspired by RDoC suggesting that depression emerges out of a series of interacting impairments in three core biobehavioral systems or domains; stress regulation, reward, and social cognition (e.g., mentalizing). Importantly, they highlighted several RDoC constructs and domains that are relevant to understanding the emergence of depression during adolescence including agency, autonomy, and achievement.

The articles in the current Special Section build on these prior studies and highlight important ways to approach RDoC from a developmental perspective. In particular, Clarkson et al. (2020) and De Los Reyes et al. (2020) addressed questions about the convergence of measures of the constructs both within and across the various RDoC units of analysis. An aim of our commentary is to highlight similarities and differences between Developmental Psychopathology (DP) and RDoC. These perspectives are not in competition; rather, they are mostly compatible and complementary. Although some principles of DP already are reflected within the aims of RDoC, others are not yet part of the RDoC framework.

Given that RDoC is still evolving, the overarching goal of this commentary is to inform future work on the RDoC framework so that it more explicitly incorporates some of the DP perspective. Toward that end, we first provide a brief background on DP, and then identify potential commonalities, as well as areas of divergence between the two models. We conclude by identifying some future research areas and implications for clinical practice. This commentary is neither an endorsement of the DP perspective nor a condemnation of RDoC. Rather, we aim to describe how both models can be leveraged to inform future research and interventions not only with children and adolescents, but also with adults across the lifespan.

Developmental Psychopathology (DP)

DP is defined as a “conceptual approach that involves a set of research methods that capitalize on developmental and psychopathological variations to ask questions about mechanisms and processes” (Rutter, 2013, p. 1201). In 1984, Sroufe and Rutter formalized the field of developmental psychopathology by outlining several key principles. Central to their formulation was that DP involves the study of the origins and course of individual patterns of behavioral maladaptation. The focus was on the *how* of developmental processes that underlie continuity and change, rather than on the study of any particular age or stage of development. Indeed, researchers interested in understanding the mechanisms that underlie, maintain, or alter maladjustment *are* developmental psychopathologists, regardless of the age of the study participants. In this sense, RDoC is largely compatible with DP, even though DP is not an explicit feature of the matrix. Table 1 presents several key principles of developmental psychopathology, and if and how these principles are represented in RDoC. As illustrated in the table, there are several areas of overlap between the two models, although some of the specific mechanisms and particular focal areas of interest vary across

the perspectives. Below we discuss a few of the aspects of the DP model that may inform and advance the RDoC framework.

Continuity and Discontinuity

A central principle of DP is continuity (Rutter & Sroufe, 2000), which is fundamental to understanding the causes and course of psychopathology. The first type of continuity involves the distinction between normal and abnormal, or typical and atypical. The second type of continuity refers to changes across development along the lifespan continuum. We review these issues in light of their relevance to both the DP and RDoC models.

Continuity and discontinuity between normality and psychopathology.

This type of continuity concerns in the phenomenology as well as in the underlying mechanisms. Is the construct of interest dimensional or categorical; does it vary in level rather than in kind? Rutter and Sroufe (2000) argued against having a false debate about whether there are continuities between normal and abnormal or whether the presence of a "disorder" marked a qualitative discontinuity. Rather, both could be the case. The important issue was *what mechanisms* account for the continuities and discontinuities between normal and abnormal behavior (Rutter, 1986).

For some conditions, both continuity and discontinuity are possible for the same phenomenology (Rutter & Sroufe, 2000). For example, intelligence extends across the range from profound disability to superior levels of functioning. The causes of variation in IQ from mild disability to normal to high functioning are on a continuum, whereas some severe and profound intellectual disabilities (e.g., Fragile X syndrome; Down syndrome) result from discrete genetic mutations that reflect discontinuity (McHugh & Slavney, 1998).

Similarly, the symptom of depression can range from normal sadness to severe, intolerable distress. In contrast to the diagnosis of major depressive disorder as defined in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-5*; American Psychiatric Association, 2013) that requires at least five of nine possible symptoms, the number of depressive symptoms can range along a continuum from 0 to 9. In contrast, questions remain as to whether the highly heritable bipolar disorder is a distinct entity rather than being at the far end of the severity continuum. Thus, DP is concerned with understanding the mechanisms that account for both continuous variation and discontinuous pathologies; it is not limited to any particular nosology, nor is it a classification system on its own.

Another discontinuity with respect to depression is the change in prevalence by gender and age (Rutter, 2013). In particular, the sex ratio of depression tends to be equal in childhood, but depression is two times more common in females than in males starting in adolescence (e.g., Hankin et al., 1998). Biological and social maturation associated with puberty presumably contribute to these changes in the rates of depression during adolescence (Angold et al., 1999). A critical challenge for psychopathology researchers from either a DP or RDoC perspective is to explain what accounts for apparent continuity in symptoms of depression, but the discontinuity in prevalence rates for women starting in adolescence and continuing throughout adulthood. Overall, DP is concerned with understanding the

mechanisms underlying both continuous variation and discontinuous pathology. DP is not limited to any particular nosology, nor is it a classification system on its own.

In contrast, RDoC is a research classification system that also studies the full range of variation from normal to abnormal to understand what is typical versus pathological, but it promotes an explicitly dimensional approach to psychopathology (Cuthbert & Insel, 2013; Garvey et al., 2016). That is, RDoC is committed to exclusively investigating psychopathology along a continuum rather than as categorical disorders. The goal has been to "develop, for research purposes, new ways of classifying mental disorders based on dimensions of observable behavior and neurobiological measures" (Cuthbert & Insel, 2013, p. 4). Thus, DP and RDoC share the emphasis on the continuity of psychopathology from normal variation to abnormal functioning, but DP considers the study of discontinuities to be as important and informative as the continuities. As such, DP provides a broader and more flexible approach to studying the link between typical development and pathology, and is compatible with both the *DSM-5* and the RDoC systems of classifying psychopathology.

Continuity and discontinuity of psychopathology across the development.

A second principle central to DP involves the identification and understanding of the coherence of disorders from early to later development as well as changes in patterns of adaptation over the lifespan. The development of psychopathology is not static, but rather is an active, dynamic process resulting from both biological maturation and evolving interactions with the environment. Individuals do not simply react passively to the environment, but instead play an active role in shaping their experiences based on their genetic vulnerabilities and ongoing processing of information about their circumstances. In turn, their biology is shaped by their experiences. This emergent interactive process among biology cognitions, behavior, and the environment continues over the lifespan and accounts for variability in psychopathology over time. As such, the DP perspective is particularly interested in understanding the natural course of maladjustment across development and what accounts for changes over time.

Two forms of developmental continuity are especially relevant to DP – homotypic and heterotypic (Rutter et al., 2006; Shevlin et al., 2017). Both homotypic and heterotypic continuity have been found among various forms of psychopathology in children and adolescents (e.g., Copeland et al., 2009; Wichstrømet al., 2017) and in adults (e.g., Lahey et al., 2014). In homotypic continuity, individuals manifest the same symptoms or disorder(s) across time; that is, symptoms at one point in development predict themselves over time. Some evidence of homotypic continuity has been found for depressive symptoms from preschool into adolescence (Gaffrey et al., 2018) and from adolescence into adulthood (Yaroslavsky et al., 2013; although see Weiss & Garber, 2003 for a discussion of phenotypic changes in depression from childhood to adolescence). Observed homotypic continuity could be due to the persistence of the same mechanisms over time. Additionally, the occurrence of the symptoms themselves at one point may perpetuate their occurrence at a later time. For example, the persistence of stress may sustain depressive symptoms or the depression itself may generate additional stressors that then maintain the disorder (Hammen, 1991).

Another example of homotypic continuity is when symptoms or disorders do not look the same over time phenotypically, but they presumably have similar correlates or mechanisms. For example, the precise forms of aggressive behaviors change as children mature (e.g., Bradshaw et al., 2018; Underwood et al., 2009). That is, the specific age-dependent developmental pattern of aggression in children involves more physical aggression in early and middle childhood (e.g., biting, punching), but more verbal and relational aggression in late childhood and adolescence. These aggressive behaviors look different across childhood, but the underlying "trait" of aggression shows stability across childhood into adolescence and beyond (e.g., Bradshaw et al., 2018; Stanger et al., 1997).

On the other hand, heterotypic continuity is when one behavior, symptom cluster, or disorder predicts a different form of behavior, symptoms, or disorders in the same individual at a later point in time (Rutter et al., 2006). That is, there is coherence in the underlying organization or meaning of the behaviors across development (Sroufe & Rutter, 1984). Heterotypic continuity is consistent with models that view psychopathology as subject to change from one form of psychopathology to another over time (Nolen-Hoeksema & Watkins, 2011). This perspective is consistent with transdiagnostic approaches to psychopathology, which focus less on the specific symptoms and more on broad domains of functioning presumed to underlie symptom change. In general, heterotypic continuity is concerned with whether longitudinal associations among psychiatric symptoms and disorders are attributable to shared etiological processes rather than symptom homogeneity. In a study of heterotypic continuity in children, Wichstrøm et al. (2017) found that symptoms of behavioral disorders (e.g., oppositional defiant disorder) predicted an increase in the risk of ADHD symptoms, and ADHD symptoms predicted increased risk of later anxiety disorder symptoms. Wichstrøm et al. proposed that most of the continuities of symptoms they observed were due to unmeasured, time-invariant mechanisms – like genetics or stable parenting practices – present throughout childhood rather than the result of earlier symptoms of one disorder predicting similar symptoms of the same disorder across time. Similarly, Lahey et al. (2015) suggested that underlying genetic liabilities may predispose individuals to particular dimensions of psychopathology whose manifestations change over time, possibly due to changes in the environment. Thus, heterotypic continuity may provide insights into the processes underlying psychiatric comorbidity. When one set of symptoms or disorders precedes a different set of symptoms or disorders, which sometimes characterizes anxiety and depression, this is temporal comorbidity (Garber & Weersing, 2010). DP focuses on both stability and change in symptoms and disorders over time and on identifying the mechanisms underlying these trajectories. Although informative, the various types of continuity are basically descriptive, not explanatory. Continuity and discontinuity of psychopathology from childhood through adulthood should be studied with prospective longitudinal designs, multiple time points, and representative and diverse populations. When either homotypic or heterotypic continuity is found, the next step is to identify the mediating mechanisms that explain it.

In contrast, for the most part, RDoC tends to be static, ignoring natural histories and the different stages of disorders, and has not addressed changes in the presentation or course of the constructs over development (Ross & Margolis, 2019). Few studies of adults have addressed the issues of homotypic or heterotypic continuities (see Lahey et al., 2014, for an

exception). Psychopathology is not static, but rather, it involves dynamic changes resulting from both biological maturation and interactions with the environment.

The recent NIMH modification of the RDoC website to address some of these issues notes that: “Understanding developmental trajectories across various phases of the life span represents a critical consideration that is implicit to the RDoC framework.” https://www.nimh.nih.gov/research/research-funded-by-nimh/rdoc/developmental-and-environmental-aspects.shtml. One example of a “life-span” question suggested by the NIMH would be to study the mechanisms underlying developmental changes in systems for fear and distress across puberty, which might partially explain the increase in the onset of internalizing symptoms during adolescence.

Although few RDoC-specific studies have been guided explicitly by this important DP principle of the continuity of psychopathology across the lifespan, some studies have applied RDoC constructs to children. For example, Ip et al. (2019) showed that poor executive control and emotion understanding in children at age 3 predicted rising versus stably low trajectories of co-occurring internalizing and externalizing symptom patterns when children were ages 5 to 10 years old. Using prospective designs to test continuities and trajectories of mechanisms and symptoms over the course of development is one promising means of merging DP and RDoC, and making development and the environment more central features of RDoC.

Heterogeneity of Psychopathology

Explaining the heterogeneity of psychopathology is a critical challenge for both DP and RDoC. DP emphasizes that there are diverse origins, processes, and outcomes in the developmental pathways to psychopathology. According to the DP perspective, multiple factors presumably can contribute to the same outcome (equifinality), and a single common risk process can predict multiple outcomes (multi-finality). In equifinality, the same end state can result from various initial conditions and through different processes (Cicchetti & Rogosch, 1996).

Importantly, for the majority of psychopathological conditions, there is not one single causal pathway that is primary; rather a variety of developmental progressions may eventuate in common outcomes. Multiple overlapping or interacting variables likely produce these endpoints. This perspective may be particularly useful when studying more homogeneous subgroups within a broader psychopathological condition, such as subtypes of psychoses.

Multi-finality is concerned with the heterogeneity of psychopathological outcomes given some combination of shared etiological processes (e.g., genes, neurobiology, or environments). For example, two individuals might have a common experience such as exposure to trauma early in childhood, but they end up with different psychiatric conditions (e.g., post-traumatic stress disorder; major depression; anti-social personality), or even no disorder at all. These individuals might have had similar distal childhood experiences, but the more proximal processes that followed likely differed over the course of development.

Because no single causal variable explains any specific psychiatric outcome, more multifaceted, interactive models are needed to capture the complexity of the development of psychopathology. Thus, the same risk factors (e.g., trauma; loss) may lead to or be associated with different outcomes depending on the combination of other variables such as the person's neurobiological and genetic vulnerabilities, environmental contexts, and individual strengths and deficiencies (e.g., intelligence, competencies and coping responses). A central goal of DP has been to determine what individuals who share a common vulnerability, but one develops psychopathology whereas the other does not.

In RDoC, a primary aim has been the search for transdiagnostic models of psychopathology that identify the processes underlying multiple disorders. Nolen-Hoeksema and Watkins (2011) specified that transdiagnostic models should be able to explain the mechanisms by which transdiagnostic risk factors lead to multiple disorders (i.e., multi-finality), and why some individuals with a particular transdiagnostic risk factor develop one set of symptoms, whereas others with the same risk factor develop a different set of symptoms (i.e., divergent trajectories). Such models also should articulate the mechanisms that link distal and proximal risk factors to each other and to the psychopathologies they presumably explain. Thus, the search for transdiagnostic processes is central to RDoC and is consistent with the developmental approach to discovering the multiple shared and unshared mechanisms underlying and maintaining various forms of psychopathology across the lifespan.

Levels and Units of Analysis

DP conceptualizes "mental illnesses as involving dysfunction among multiple and transacting developmental processes" (Cichetti & Toth, 2009, p. 20), rather than as primarily "brain disorders." Cicchetti and Toth asserted that mental disorders are dynamic and should be studied using an interdisciplinary perspective and a multiple levels of analysis approach, which involves bidirectional and transactional interactions among genetic, neurobiological, social, psychological, and environmental (pre- and postnatal) influences over the life course. This multiple levels of analysis approach facilitates one of the major goals of DP, which is to understand the full complexity of psychopathology and the mechanisms underlying individual patterns of adaptation through studying the whole organism (Sroufe & Rutter, 1984). Brain development is experience-dependent and involves transactions among biology, psychology, and social environments. The concurrent examination of biological, psychological, and environmental–contextual processes and their interplay at different developmental periods provides an integrative conceptualization of the developmental course of psychopathology (e.g., Beauchaine, & Gatzke-Kopp, 2012).

The multiple levels of analysis perspective in DP includes neurobiological systems (e.g., genetic, autonomic, hormonal, neural), psychological constructs (e.g., social, emotional, motivational), and environmental influences. Examples of the various methods of inquiry include self-report, other informant report, behavior, psychophysiology, and neuroimaging. Thus, this developmental approach overlaps with the multiple units of analysis component of the RDoC matrix.

In RDoC, every construct is defined across multiple units of analysis. RDoC encourages the integration of the various levels of information from genomics to self-report. The original RDoC units of analysis included genes, molecules, cells, circuits, physiology, behaviors, self-reports, and paradigms. As of May 2017, however, the NIMH RDoC website removed references to specific genes and no longer supports a candidate gene approach. Instead, the NIMH RDoC has expressed a preference for adequately powered genome wide association studies.

RDoC provides a structure that allegedly places equal weight on neural circuits and behavioral functions to formulate an integrative model rather than giving primacy to either neuroscience or behavior. Basic science (i.e., neuroscience and behavioral science) serves as the starting point in studies of disruptions of the normal range of operations of these various systems, with an emphasis on the mechanisms underlying degrees of dysfunction. The guiding principle during the construction of the RDoC matrix was that “Behavioral science studies what the brain evolved to do, and neuroscience studies how the brain implements it” (Cuthbert & Insel, 2013, p. 6).

A few differences also exist between the multiple levels of analysis perspective in DP and the multiple units of analysis approach in RDoC. First, DP does not give preference to any particular level of analysis. Indeed, the DP perspective asserts that brain development is experience-dependent and involves transactions among biology, psychology, and social environments. Biology influences how individuals respond to their experiences but, in turn, biology is shaped by those experiences. Thus, DP highlights bidirectional relations across the various levels of analysis.

In contrast, RDoC emphasizes the centrality of the brain and neuroscience. Despite the claim by the RDoC system that it does not simply involve biomarkers or endophenotypes, a common criticism of RDoC has been its primary focus on neurocircuitry (Cicchetti & Toth, 2009; Franklin et al., 2015; Iacona, 2016). Although neuroscience is critical for understanding psychopathology, the brain is part of the etiological complexity that involves multiple interdependent and transactional processes represented by the different units of analysis.

Second, until recently RDoC overlooked other important contributors to psychopathology such as development and the environment, which are integral components of the multiple levels of analysis approach in DP. Although RDoC now acknowledges the importance of development and the environment, it provides little guidance about how to integrate them into the matrix.

Third, the issue of convergence across units of analysis has not been a major focus in RDoC. The meta-analysis by Clarkson et al. (2020; this issue) was the first, to our knowledge, to examine correspondence between different levels of analysis within the RDoC social processing domain in studies of children and adolescents. The 33 studies in their review contrasted at least two levels of analysis, most of which compared subjective report methods to other units of analysis. Overall, they found little correspondence between the RDoC units of analysis, except between the subjective-by-circuit unit pair. The mostly non-significant

findings might have been due to the small number of studies for each unit-pair comparison available, and the lack of consistency in the measures of the constructs within and across domains. Such lack of correspondence of indices of similar constructs across multiple levels of analysis is fairly common in the DP literature, particularly when comparing questionnaires, psychophysiology, and behavioral tasks of constructs within and across social, emotional, and cognitive domains.

Several important questions are relevant to the broader issue of whether there is convergence across the RDoC units of analysis. First, to what extent should we expect correspondence among measures of a construct across these units of analysis? Is it possible for the units to measure different components of a common construct, but show only minimal correlation between any two of the units? Some of the low correspondence likely is due to limitations of measurement. Therefore, a first step should be to establish the reliability and validity of the measures within a unit of analysis before testing for convergence across units.

A related question is whether it is necessary to have correspondence across all units of analysis for all constructs within a domain. When guided by the RDoC matrix, do researchers need to measure every construct using every unit of analysis? Should researchers select which units to study, in part, based on the extent of convergence among them? The meta-analysis by Clarkson et al. (2020) provides some insight on how researchers have typically gone about studying this issue. They identified studies that only compared two units at a time, suggesting that it may be difficult for researchers to test all possible RDoC units simultaneously. It is not clear that within RDoC research in general, and with children in particular, how often investigators have examined the convergence of measures of the target construct across multiple units of analysis. Future research should explore the correspondence among units of analysis for other RDoC domains in addition to social processing (e.g., negative valence; positive valence; cognitive systems) in children as well as adults.

Third, what does it mean when there is high versus low congruence across units of analysis? Research on emotion provides a good example here. According to a functionalist perspective, coherence across measures of various emotion response systems (e.g., psychophysiology, behavior, subjective report) is optimal for organisms to cope with the challenges they encounter (Levinson, 1994). Empirical evidence of such response coherence, however, has been mixed (Barrett, 2006). In particular, studies of whether individuals who report greater levels of subjective emotional experience also exhibit greater levels of behavioral and physiological responses have yielded inconsistent findings (e.g., Lanzetta et al., 1976; Mauss et al., 2005; Notarius & Levenson, 1979). Differences in coherence among emotion response systems have been explained in terms of moderators including variability in individual characteristics such as “body” awareness (Sze et al., 2010), whether participants were in a state of elevated emotion at the time of the assessment, and if the units were measured simultaneously and continuously over time (Mauss et al., 2005). Thus, uncovering the reasons for lack of congruence across units of analysis can inform our understanding of the constructs and domains they presumably measure.

Finally, several questions about the convergence of the units of analysis follow from the DP perspective. For instance, we do not yet understand how the constructs and the units of analysis develop. Additionally, it is possible that the strength of the associations varies across the levels of analysis, and that these associations change with development. As suggested by De Los Reyes et al. (2020), there also may be differences in these associations based on informants. For example, perhaps self-reports will correlate with other units of analysis as children's ability to understand and use language emerges.

We also might expect that the dysfunctions in some of the constructs as measured by the various units of analysis (and by different raters) might emerge at different points in development. As there are changes in one unit of analysis, other units of analysis also may change, and these variations may occur across development. Thus, developmental psychopathologists are interested in not only the concurrent convergence across the levels of analysis, but also in how these units unfold in relation to each other over time. Taken together, the extant research suggests that both DP and RDoC recognize the importance of measuring mechanisms and psychopathology using multiple methods within a particular unit of analysis and utilizing multiple units of analysis that range from the brain to behavior. The DP perspective highlights some additional research gaps that could be addressed within the RDoC system.

Measurement

A strong principle shared by both DP and RDoC is that investigators should use reliable and valid measures that generate replicable findings. We especially need psychometrically sound procedures for assessing individual differences across all units of analysis – from neural processing to social cognitive functioning. From a developmental perspective, it is critical that measures are age-appropriate, normed on representative samples, and capture behavioral consistency and change across age and developmental stages.

Especially relevant to children is the need to assess and integrate multiple sources of information about a child including self-report, parent report, peer report, and teacher ratings (Des Los Reyes et al., 2020). Multiple informants (e.g., romantic partners, coworkers) are used much less frequently with adults, but they could provide another worthwhile source of information. The findings described in the paper by De Los Reyes and colleagues in this Special Section provide helpful insights into this issue with regard to children, particularly regarding potential variation in these associations as a function of different informants.

Interventions

The ultimate goal of the RDoC initiative is to translate findings from basic science about the mechanisms underlying psychopathology into specific targets of interventions aimed at reducing and preventing mental illness (Cuthbert, 2014). Similarly, research in DP has emphasized the importance of identifying risk processes as targets of intervention, particularly for prevention before the onset of symptoms. Intervention trials can be especially informative about causal processes and mechanisms of change over time.

Using a high-risk design, which is a primary research strategy in DP (Rutter & Sroufe, 2000), several randomized controlled trials have been successful in preventing depressive symptoms and disorders in at-risk offspring of depressed parents (e.g., Compas et al., 2009; Garber et al., 2009). For example, Compas et al. (2010) showed that changes in children's coping and in observed parenting behaviors significantly mediated the effect of a family-based cognitive behavioral intervention on at-risk children's levels of psychopathology. This prevention trial had many DP features including the use of multiple methods and units of analysis, a high-risk sample, longitudinal design, and continuous measures of mediators and outcomes. Interestingly, despite having been designed and completed prior to the RDoC initiative, the Compas et al. prevention trial was consistent with the RDoC framework.

Since the introduction of RDoC, NIMH grant funding of randomized controlled clinical trials has moved away from pure efficacy trials that test *whether* a treatment works to a focus on the *mechanisms* underlying the psychopathology as targets of interventions. One grant mechanism that requires this approach is RFA-MH-18-704: *Development of Psychosocial Therapeutic and Preventive Interventions for Mental Disorders* (R61/R33-Clinical Trial Required). This funding opportunity supports the creation and testing of innovative psychosocial interventions for novel targets or intervention strategies. Although the targets do not have to be from the RDoC framework, applications that use an RDoC approach tend to be reviewed favorably. This RFA gives some examples of relevant targets including modifiable behavioral, cognitive, affective, or interpersonal factors or processes, neural circuits or neural activity subserving specific behaviors or cognitive processes, or other neurobiological mechanisms associated with risk for, causation of, or maintenance of a mental disorder. Because this grant mechanism is still relatively new, however, few intervention trials based on the RDoC framework have been completed, especially in youth. Although studies of children and adolescents are welcome, there is nothing particularly developmental about this RFA.

An example of a treatment program framed from an RDoC perspective is the Training for Awareness, Resilience, and Action (TARA) designed to reduce internalizing symptoms in adolescents (Blom et al., 2017). Blom et al. used a dimensional and transdiagnostic approach to their sample selection and measurement of outcomes. TARA targets specific mechanisms based on neuroscience findings with depressed adolescents. The program targets the RDoC domains of sustained threat, loss, social processes, and reward learning. The TARA intervention involves training in autonomic and emotional self-regulation, interoceptive awareness, and relational skills. Preliminary findings indicate a significant increase in cognitive flexibility and mindfulness, and improvements in symptoms of depression, anxiety, and sleep disturbance.

Overall, probably the weakest link between DP and the RDoC is intervention. One goal of RDoC is to individualize treatment through "precision medicine," whereas studies of treatment, per se, are not a central focus of DP. Rather in DP, intervention research is used to study the mechanisms that account for effective treatments and to identify the basic developmental processes underlying the disorder that can be modified through intervention.

A decade before NIMH introduced RDoC, Rutter and Sroufe (2000) declared that intervention research should do more than simply show differences between the experimental and control conditions. Rather, they recommended that controlled intervention trials should demonstrate that "within the treated group, there is a systematic dose-response relationship between changes in the postulated mediated mechanism and changes in the target feature of psychopathology" (p. 287). This is indeed a central requirement of the RFA-MH-18-704 grant mechanism formulated with RDoC in mind.

Future Directions

Even with the important advances and insights gained thus far, several potential directions remain for merging DP and RDoC. First, a major limitation of RDoC in its current form is the absence of information about the development and trajectories of the constructs in the domains. Despite the fact that more than half of mental illness in adults begins before age 20 (Kessler et al., 2005), many of the constructs in the RDoC matrix are based on a relatively limited body of empirical research, particularly in youth (Drury & Cuthbert, 2015). A critical direction for future research is to map out developmental changes in the various RDoC domains and units of analysis over time. For example, how and when do the domains and units of analysis change and what processes drive these changes. Relatedly, more work is needed to determine how growth in one unit of analysis (e.g., neurocircuitry) relates to changes in other units (e.g., behavior, psychophysiology).

Second, there likely are sensitive periods during which exposure to adversity will have an especially strong impact on children's development. This is consistent with the concept of hierarchical motility, in which continuity in functioning results from earlier patterns of behavior that are integrated into subsequent adaptation. That is, early experiences have unique and persistent effects on developmental sequelae. As suggested by the growing body of research on adverse childhood experiences (e.g., Edwards et al., 2003; Kessler et al., 2010), insults to the system likely have differential effects on individuals in early childhood as compared to late adolescence. Exposure to trauma early in development has serious and sustained negative consequences for adjustment across childhood and into adulthood (Kaufman et al., 2015). Yet, we lack information about how stable these outcomes are, and how malleable they are to interventions at different developmental periods. Further investigation into these issues may elucidate the optimal times during which to intervene.

Third, additional work is needed to determine the most relevant RDoC constructs and domains for understanding the development of different forms of psychopathology over the life course. Future studies should identify other constructs and domains to add to the RDoC matrix to represent the salient developmental tasks (e.g., moral development, emotional competence, self-regulation prosocial behavior) that individuals need to negotiate as they mature into fully functioning human beings. These, in turn, may be targets of intervention aimed at reducing risk for mental health across the lifespan (Sroufe & Rutter, 1984).

Conclusions and Clinical Implications

We will leave it to the reader to weigh the various merits and limitations of merging DP and RDoC. For the most part, these perspectives seem compatible and complementary rather than in competition. Much can be learned from each approach. RDoC clearly could benefit from explicitly incorporating principles of DP into their research agenda. RDoC also could promote a more balanced emphasis on neurobiology, behavior, and the environment. DP researchers could expand the constructs and domains that they typically study, map out their developmental course, and identify the neurocircuitry associated with these domains.

In addition to informing future research, such alignment in these models may provide helpful insights regarding clinical application through treatment and prevention efforts related to children's mental health. For example, although schools are the de facto mental health service setting for children and youth (Atkins et al., 2010; Zima et al., 2005), few school-based mental health service providers have received training in RDoC or follow these DP principles when selecting evidence-based approaches. Thus, the clinical utility and translation of such approaches with youth in applied settings remains to be tackled.

The RDoC model provides insights regarding the utility of transdiagnostic approaches to address multiple types of mental health challenges in children (Clifford et al., 2020) and may inform the increased use of modular and common-elements focused interventions (e.g., Chorpita et al., 2005). These approaches are especially helpful in applied service settings for children where there is inadequate access to mental health clinicians, limited expertise with evidence-based interventions to address precise targets or mechanisms, and few resources and little time to support the dissemination of such programs (Atkins et al., 2010). In fact, these practices are increasingly used to address multiple risk and protective factors simultaneously, in a developmentally sensitive and modularized fashion, and thus hold great promise for implementation in schools and other settings that are low in mental health resources.

Although the current language and terminology used in RDoC would likely require some explication and application in order to increase uptake of this framework in school settings by practitioners aiming to prevent emotional and behavioral problems from escalating (see Zalta & Shankman, 2016), the overall approach may be a good fit to educational environments. For example, many school-based clinicians prefer to use more general terms to describe symptoms (e.g., emotional regulation problems) or to focus on mechanisms (e.g., attention problems) rather than use mental health diagnoses (e.g., ADHD). Similarly, the negative valence system aligns well with the increasing trend toward the use of trauma-informed and brain-focused approaches in school-based programming. Given the strong tradition of behavioral interventions in schools, programs targeting the positive valence systems within RDoC may be especially helpful for addressing the range of behavioral and mental health problems observed in schools. These are just a few of the potential connections and implications of the RDoC framework for use in applied settings like schools. This line of work, however, requires greater emphasis, attention, and investment to fully realize the potential value of RDoC for addressing mental health problems in children and adolescents from a developmental psychopathology perspective.

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Table 1.

Core Principles of the Developmental Psychopathology and the Research Domain Criteria

Principles	Developmental Psychopathology (DP)	Research Domain Criteria (RDoC)
Continuity and Discontinuity	Explicit focus on the full range of functioning from normality to psychopathology	RDoC is committed to understanding the full range of variation, from normal to abnormal
	• Continuities and discontinuities of psychopathology across the full range of development. • Homotypic and heterotypic continuity	Understanding developmental trajectories across various phases of the life span is *now* a critical consideration *implicit* to the RDoC framework.
Dimensions vs. Categories	DP emphasizes dimensions, but also recognizes discontinuities and categories	RDoC incorporates an explicitly dimensional approach to psychopathology
Levels of Analysis	Psychopathology involves dysfunction among multiple and transacting developmental processes using a multiple-levels-of-analysis approach and an interdisciplinary perspective	• Every construct is defined across multiple units of analysis • Integration across many levels of information from genomics to self-report
Measurement	• Multiple measures • Multiple informants • Convergence across measures	Multiple reliable and valid measures of the fundamental components of mental disorders
Constructs and Domains	*Salient developmental tasks:* Moral Development, Self-regulation, Social Relationships, Prosocial Behaviors, Empathy, Social Cognitions	Negative Valence Systems, Positive Valence Systems, Cognitive Systems, Social Processes, Arousal and Regulatory Systems, Sensorimotor Systems
Origins and Mechanisms	• To understand the origins and course of psychopathology • Dedicated to the discovery of mediating mechanisms	• To understand neurodevelopmental origins of psychopathology • Psychological constructs reflect neurodevelopmental mechanisms implicated in psychopathology
Age/Development	• Lifespan perspective. • Defines age biologically, socially, and psychologically	Focus has been mostly on adults Some work noting the importance of development later in life.
Comorbidity and Heterogeneity	• Equifinality • Multi-finality	• Transdiagnostic • Identify shared causal processes
Environment	• Context is intricately involved in development • Meaning of behavior can only be determined within the total context	Environmental influences *now* are considered another critical element of the RDoC matrix, but provide no guidelines for how to incorporate environment into the matrix
Design and Sampling	• High risk samples • Prospective, longitudinal designs • Intervention trials can test causality	Select participants based on units of analysis and domains/ construct, not diagnoses
Intervention	• Use of prevention trials as experiments	Focus on individualized treatment: ‘precision medicine’