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Resilience in developing systems: Progress and promise as the fourth wave rises

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Abstract

Perspectives based on the first three waves of resilience research are discussed with the goal of informing the fourth wave of work, which is characterized by a focus on multilevel analysis and the dynamics of adaptation and change. Resilience is defined as a broad systems construct, referring to the capacity of dynamic systems to withstand or recover from significant disturbances. As the systems perspective on resilience builds strength and technologies of measuring and analyzing multiple levels of functioning and their interactions improve, it is becoming feasible to study gene–environment interactions, the development of adaptive systems and their role in resilience, and to conduct experiments to foster resilience or reprogram the fundamental adaptive systems that protect development in the context of adversity. Hot spots for future research to study and integrate multiple levels of analysis are delineated on the basis of evidence gleaned from the first waves of resilience research.

The science of resilience in human development emerged from the same confluence of forces in the 1960s and 1970s that gave rise to developmental psychopathology, although conceptual and clinical origins can be traced to early ideas and observations in the history of medicine, psychology, and education (Cicchetti, 2006; Cicchetti & Curtis, 2006; Luthar, 2006; Masten, 1989, 2006; Masten & Obradović, 2006; Sameroff, 2000; Steinberg et al., 2006). Resilience science was shaped in large part by the insights, collaborations, and influences of pioneering scientists and their students, who embarked on a prolonged mission to understand, prevent, and treat mental health problems. These scientists, including Norman Garmezy, Irving Gottesman, Lois Murphy, Michael Rutter, Arnold Sameroff, Alan Sroufe, and Emmy Werner, set out to understand the etiology of mental illnesses or problems such as schizophrenia or autism, as well as the consequences of major threats to development such as premature birth or trauma. With deeply developmental orientations, these pioneers recognized the importance of trajectories characterized by unexpectedly positive adaptation or recovery after adversity in the lives of the young people they studied.

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From the outset, early thinking on resilience, as well as risk and vulnerability, encompassed neurobiological levels of consideration. Lois Murphy, for example, who studied 32 infants longitudinally in a classic developmental study (Murphy, 1962; Murphy & Moriarty, 1976) discussed "autonomic reactivity," "vegetative functioning," and other internal biobehavioral parameters in relation to vulnerability, self-regulation, and resilience. Irving Gottesman championed a developmental view on mental illness in his diathesis–stressor models of schizophrenia and also in his emphasis on epigenetics early in the history of behavior genetics (Gottesman, 1974; Gottesman & Shields, 1972). In these theories, Gottesman proposed genetic and psychosocial levels of risk, vulnerability, and protection, combining over the course of development to influence pathways of individual phenotypic development toward and away from disorder. These multiple-level ideas, however, were ahead of the technology available at the time to measure and test specific hypotheses at the level of genes, brain function, or neurobiological processes. It is not surprising that the study of resilience veered toward behavioral methods and levels of analysis where much progress was made in describing the phenomena, developing reliable measures of constructs and statistical approaches to operationalizing the meaning of resilience, testing behavioral hypotheses, and accumulating a body of general knowledge about variables related to observable resilience phenomena (Masten & Obradović, 2006).

In the meantime, enormous technological advances spurred a revolution in the sciences concerned with genes, brain, and development. These advances are drawing investigators "back to the future" to study risk and resilience from multiple levels of analysis and their interplay (Cicchetti & Blender, 2006; Cicchetti & Curtis, 2006; Curtis & Cicchetti, 2003; Curtis & Nelson, 2003; Lester, Masten, & McEwen, 2006; Luthar, 2006; Masten, 2007a, 2007b; Masten & Curtis, 2000; Masten & Obradović, 2006; Rutter, 2006). As it becomes feasible to measure genes and image the brain in action, excitement has risen for delineating resilience processes across multiple levels of functioning.

Research on resilience characterized by multiple levels of analysis represents the fourth wave of resilience science (Masten & Obradović, 2006; Wright & Masten, 2005). The first wave of research was descriptive but ambitious, seeking to measure resilience phenomenon in different forms and situations, and to identify characteristics of child, family, relationships, or environment that seemed to matter (the correlates of resilience). The "short list" of commonly observed correlates of resilience was a product of the first wave of work (Masten, 1999), although this list has shown remarkable stability over the course of time (Masten & Motti-Stefanidi, in press). At the urging of investigators and reviewers from the first wave, investigators in the second wave of resilience science began the formidable task of uncovering the processes that might account for the observed correlates of resilience. These investigators knew that understanding resilience occurring naturally would be a long-term challenge for multiple reasons, including the scope of the phenomena encompassed by the broad umbrella of resilience, the complexity of human lives, and the imprecision in many of the concepts, measures, and analytic methods available. Moreover, they knew that resilience must be studied longitudinally. Exemplars of the second wave of research include research on attachment relationships and family interactions as potentially protective stress regulators (see Davies & Cummings, 2006; Egeland, 2007; Gunnar, 2006; Masten & Shaffer, 2006; Sroufe, Egeland, Carlson, & Collins, 2005) and research on psychobiological stress reactivity and the self-regulation systems for attention, arousal, emotion, and behavior (see Boyce, 2007; Cicchetti & Curtis, 2006; Gunnar & Vazquez, 2006; Rothbart & Bates, 2006; Rueda, Rothbart, McCandless, Saccomanno, & Posner, 2005). It is interesting to note that developmental research on these potentially protective moderators of adversity has also indicated that the same systems *mediate* the effects of adverse experiences, in that the early organization and development of attachment, stress systems and effortful control, for example, are themselves influenced by adversity and stress, particularly during early development (see Gunnar, 2006).

Meanwhile, there were many children growing up with high odds for suffering and failure who could not wait for the lengthy process of

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basic science. This predicament motivated the third wave of work, focused on experiments to test resilience ideas directly through prevention and intervention. Many of the third-wave investigators were trained in community psychology, clinical psychology, educational psychology, and prevention, with a focus on promoting competence and wellness, as well as primary prevention (Cicchetti, Rappaport, Sandler, & Weissberg, 2000; Masten, Burt, & Coatsworth, 2006; Wang & Gordon, 1994). Some of the best evidence for the mediating or moderating role of specific protective processes in the resilience literature has come from experiments of this kind, and particularly from randomized clinical trials of interventions designed on the basis of resilience research to engage or boost protective processes (Luthar, 2006; Weissberg, Kumpfer, & Seligman, 2003; Yates & Masten, 2004).

As the fourth wave of resilience science grows in magnitude, it is becoming clear that it will overtake and assimilate earlier work, building on the knowledge gained from earlier waves and fed by the energy generated by new technologies and the synergy from integrative theory and methodology. Thus, it is timely to offer some perspectives gleaned as a participant observer in resilience research over the past three decades of research that might be useful for fourth-wave investigators to consider.

Resilience as a Systems Concept

Resilience is a very broad idea referring to the capacity of dynamic systems to withstand or recover from significant disturbances. Resilience can therefore be examined at many levels of analysis, from the molecular to the global, over varying time scales, and also from many disciplinary perspectives, ranging from ecological to computer sciences (Gunderson & Ruttan, in press; Masten & Obradović, in press). In developmental science, resilience usually refers to positive adaptation during or following exposure to adversities that have the potential to harm development. Most developmental research has focused on resilience in individuals, although the concept can also be applied to the systems in which individual development is embedded, such as families (Patterson, 2002), classrooms (Doll, Zucker, & Brehm, 2006), or schools (Wang & Gordon, 1994).

In the developmental literature, several broad categories of phenomena have been studied under the rubric of resilience: (a) developing well in the context of high cumulative risk for developmental problems (beating the odds, better than predicted development), (b) functioning well under currently adverse conditions (stress-resistance, coping), and (c) recovery to normal functioning after catastrophic adversity (bouncing back, self-righting) or severe deprivation (normalization). Recently, there has been renewed attention to the possibility of positive transformation following adversity, particularly in the context of traumatic experiences that may yield a positive reorganization of systems, such that adaptive functioning is actually better than it was before the experience (Masten & Obradović, in press). In each of these cases, resilience is inherently inferential because it depends on identifying adaptive functioning in relation to conditions of risk. Two key judgments must be made: one concerns adaptive behavior or development, and the other concerns the risks or threats to development.

The study of resilience focused attention on adaptive behavior and how to ascertain if development was going well, and spurred advances in the concepts and measurements of developmental tasks, competence, and positive youth development (Masten et al., 2006; Masten & Obradović, 2006). At the heart of any resilience research is this question: is this system doing whatit is supposed to be doing? Developmental investigators added a longer term perspective to this fundamental question as they brought resilience into a developmental framework: is this system developing well?

With the rise of the fourth wave of resilience research, new questions are emerging about how to define positive adaptation at cellular or neural levels and the roles of neural and psychobiological systems that influence adaptive behavior. There is great interest, for example, in the roles of brain plasticity in adaptive functioning and development (Cicchetti & Curtis, 2006; Dahl & Spear, 2004; Lester et al., 2006; Nelson, 1999; Romer & Walker, 2007).

Resilience also focused attention on the nature of threats to humans as living systems, and there have been many advances in concepts and measures related to risks, stressors, stress, deprivation,

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and all the other threats to the viability of human life and development. For example, Kraemer, Stice, Kazdin, Offord, and Kupfer (2001) have delineated the concept of risk and statistical approaches for defining and testing risk and its direct, mediated, and moderating effects. Cumulative risk and the way adversity piles up in the lives of children have been carefully considered by a number of influential investigators, including Sameroff (2006; Sameroff & Chandler, 1975) and Rutter (1979, 1990).

From the perspective of multiple levels of analysis, psychobiological stress researchers have led the way, addressing questions such as the following: How does stress "get under the skin"? How is adverse experience instantiated in brain development or adaptive systems? How does early experience influence gene expression or the development of stress-related regulatory systems (Boyce & Ellis, 2005; Gunnar & Vazquez, 2006; McEwen, 1998; Meaney, 2001; Trevarthen, Aitken, Vandekerckhove, Delafield-Butt, & Nagy, 2006)? Now, with the mapping of the human genome and growth of technologies to measure and study genes and genetic effects, there is returning interest in the delineation of risk, vulnerability, and protection processes at the level of genes, gene–environment interaction, and endophenotypes (Cicchetti, 2006; Gottesman & Hanson, 2005; Hanson & Gottesman, 2007; Rutter, 2007b).

There is a long history of controversies about the meaning of resilience and how to operationalize it in the behavioral sciences, including debates about whether resilience is best defined as a trait, a process, an outcome, a pattern of life course development, narrow or broad, multifaceted or unidimensional, short or long term, and whether resilience should encompass recovery as well as resistance, internal as well as external adaptive functioning, and external as well as internal resources (Luthar, 2006; Masten, 1999; Masten & Obradović, 2006). Many of the controversies surrounding the definition of resilience probably could be addressed by better science (rigorous attention to sharpening concepts, communication, and methodology), along with deeper consideration of the fundamental developmental principles comprising "developmental psychopathology" and "developmental systems theory" (Cicchetti, 2006; Lerner, 2006; Masten, 2006; Rutter, 2006, 2007a). Nonetheless, it could be quite helpful to build a stronger consensus about a working vocabulary of concepts to facilitate the integration of resilience research across frames of scope, level, and time, and ultimately across fields of inquiry. Major disasters, for example, compromise many interdependent systems simultaneously, often including individual lives, social systems, ecological systems, communication systems, and computer systems. Promoting resilience after disaster across multiple systems calls for integration of strategies and ideas across disparate sciences (Masten & Obradović, in press).

Multilevel Dynamics

As a systems perspective on resilience grows stronger, attention has also shifted to *multilevel dynamics*, or the ways in which resilience is shaped by interactions across levels of analysis in development (Cicchetti & Curtis, 2006; Luthar, 2006; Masten & Curtis, 2000; Masten, 2007b). These include gene–environment interaction, social interactions, and coregulation among individuals in relationships and social networks, person–media interactions, and so forth. Developmental theorists have emphasized multilevel dynamics for some time (Cicchetti, 1990; Ford & Lerner, 1992; Gottesman, 1974; Gottlieb, 1998; Sameroff, 2000; Sroufe, 1979, 1997; Thelen & Smith, 1998; Waddington, 1957; Weiss, 1959). Again, however, the technologies for testing such ideas lagged behind the conceptual models. Rapid recent advances in molecular genetics, imaging, statistical modeling, and computer science are bringing a new horizon of research into view. As research on multilevel dynamics becomes more feasible, investigators may find it fruitful to focus their attention on the adaptive processes and systems that have been consistently implicated in the early waves of resilience research, discussed further in the next section.

At the same time, new avenues of research will be opened by the identification of genes that individually or jointly appear to moderate the association of adverse experiences to competence or psychopathology outcomes in development. Ground-breaking studies of gene–environment interactions (Caspi et al., 2002; Kim-Cohen et al., 2006; Rutter, Moffitt, & Caspi, 2006)

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necessarily have focused on establishing basic effects through replication. Once genetic moderators are well-established, resilience-oriented investigators will begin to seek moderators of these gene–adversity effects. Inevitably, some children with the "vulnerable" genotype exposed to adversity will develop well and not succumb to psychopathology, whereas some children with a "protective" genotype nonetheless flounder. Resilience investigators are concerned with variability and "off-gradient" outcomes, with explaining how positive development unfolds despite vulnerability and risk, and why favorable genes and conditions do not always result in positive developmental trajectories.

Integrative Adaptive Systems Implicated in Human Resilience: Hot Spots for Multilevel Analysis

Research on resilience in human development consistently has implicated the same promotive or protective factors associated with more favorable outcomes among children who have faced severe adversities or deprivation (Garmezy, 1985; Luthar, 2006; Masten, 2004; Masten & Coatsworth, 1998; Wright & Masten, 2005). The consistency of the "short list" of factors observed in study after study strongly implicates common underlying processes at work, and therefore suggests that most of the observed resilience in children results from the operation of ordinary human adaptation systems, or "ordinary magic" (Masten, 2001). This simple conclusion does not mean that resilience phenomena or the task of understanding resilience will be simple. Understanding the processes leading to resilience is a formidable challenge, undoubtedly involving highly complex processes, and one that will require an enormous amount of work.

Insofar as adaptation is inherently multilevel (Hanson & Gottesman, 2007), explicating the adaptive processes involved in resilience is going to require integrative research across multiple levels of analysis. The revolution in biological and brain sciences and technologies, combined with statistical advances, is making this agenda feasible, but certainly not easy. The complexity of these processes and the technological know-how exceed the learning capacity of most individual scientists, and therefore are likely to require collaboration across disciplines and sustained time periods.

Despite the challenge, early breakthroughs are engendering a great deal of excitement about the potential benefits of a multilevel, multidisciplinary approach to resilience in development. This energy was evident at the conference on "Resilience in Children" hosted by the New York Academy of Sciences in 2006 (Lester et al., 2006). Moreover, scientists who undertake this integrative agenda will not be starting from scratch. The first three waves of resilience research provide crucial clues to "hot spots" for multilevel work.

Table 1 lists potential hot spots of particular interest for multilevel research based on the human adaptation systems implicated by studies of resilience over the past three decades. It is noteworthy that many of the systems on this list are already garnering intensive research interest, for example, the role in resilience of self-regulation systems as investigated in studies of executive functioning or effortful control (Buckner, Mezzacappa, & Beardslee, 2003; Eisenberg et al., 2004; Lengua & Long, 2002) and related preventive interventions such as the PATHS curriculum (Greenberg, 2006; Greenberg, Riggs, & Blair, 2007).

Research on the impact of early experiences on the development of these fundamental systems is consistent with the idea that adversity may wreak its most lasting and devastating damage to development through its effects on developing adaptive systems. Research on severe deprivation or trauma in early childhood, and their influence on cognitive development and the programming of stress systems illustrates the profound potential effects of adversity on the development of fundamental human adaptive systems (Gunnar, 2006; Nelson & Jeste, in press; O'Connor, 2006; Zeanah, Smyke, & Settles, 2006). In contrast, there is promising new work suggesting that in some cases, it may be possible to "reprogram" these systems to operate more normally when a positive caregiving or training environment is provided (Cicchetti, Rogosch, & Toth, 2006; Fisher, Gunnar, Dozier, Bruce, & Pears, 2006; Gunnar & Fisher, 2006; Rueda et al., 2005).

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Table 1. *"Hot spots" for multilevel integration: Adaptive systems implicated in resilience research*

Health and stress systems
Allostasis, normal immune and HPA function
Information processing and problem-solving systems
Normal cognitive development, IQ
Attachment relationships with parents, friends, and others
Secure attachment, connections to competent and caring adults, mentors, social support
Self-regulation, self-direction, response inhibition systems
Agreeable personality/temperament traits, conscientiousness, lower neuroticism or stress reactivity, effortful control of attention and impulses, executive functioning
Mastery and reward systems
Positive outlook on life, achievement motivation, self-efficacy
Spiritual/religious systems of belief, practice, and support
Believes life has meaning, attachment to spiritual figures, prayer or meditation, religious community support, religious rituals
Family systems
Close relationships with parents, authoritative parenting style, parental support of education, parental supervision, soothing rituals and routines
Peer systems
Friendships and romantic attachments with prosocial, well-regulated peers, positive peer networks
Schools
Opportunities for learning, mastery, and relationships with prosocial adults and peers
Authoritative school and teacher styles, positive school climate, bonding to school
Larger community and cultural systems
Opportunities for mastery and relationships with positive adults and peers, neighborhood collective efficacy, cultural rituals and routines, bonding to organizations with prosocial values and positive role models

Note: Examples of widely reported protective factors on the "short list" are listed below each implicated system.

This list generally suggests that resilience has a great deal to do with what might be termed "regulatory capital," including self-regulation capacities and regulatory capacities built into social and cultural systems (Masten & Coatsworth, 1998; Masten, 2004). The role of arousal modulation systems, reward systems, and rituals is noteworthy across levels of analysis. Religious systems, for example, engage fundamental human adaptive systems in multiple ways, from teaching self-regulation through prayer or meditation, proscribing rules for living and rituals for major life passages, to fostering emotional security through attachment relationships with spiritual figures (Crawford, Wright, & Masten, 2006).

Intervention Research Designed to Promote Resilience and Test Resilience Theory

Resilience research always had a pragmatic mission: to learn better ways of preventing psychopathology and promoting healthy development among children at risk for problems. The combined influences of the prevention science movement and resilience science over the past three decades has revolutionized the models for intervention, bringing positive development and strength-based models into much greater prominence (Cicchetti et al., 2000; Luthar & Cicchetti, 2000; Masten & Coatsworth, 1998; Masten & Gewirtz, 2006; Weissberg et al., 2003). At the same time, resilience scientists recognized the advantages of intervention designs for establishing causal plausibility of their theories. It is not feasible or ethical to randomly assign children to traumatic experiences or to good and poor homes, but it is often feasible and ethical to design randomized trials of preventive interventions based on resilience models. Moreover, as noted previously, many in society are not willing to stand by waiting for a full explication of naturally occurring resilience from science before intervening to help children who are suffering or drifting toward developmental disaster.

As a result, resilience science increasingly comprises intervention studies that are based on resilience frameworks (Masten, 2006; Masten, 2007a; Masten et al., 2006), aiming to help young people and test resilience theories simultaneously. As the interest in multiple levels of analysis grows, preventive interventions are increasingly designing and testing effects at multiple levels, often focusing on the same hot spots of integrative adaptive systems discussed previously, such as self-regulation measured in

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behavior observed in ecologically meaningful contexts (such as the classroom), cognitive performance on laboratory tasks, brain function observed in images, and psychophysiological responding. In addition, the research on developmental tasks and transitions that emerged from research on resilience, as well as developmental psychopathology more broadly, has indicated windows of vulnerability and opportunity for intervention (Dahl & Spear, 2004; Masten, 2004; Masten et al., 2006; Steinberg et al., 2006). Resilience and protection often involves actions that are well timed with respect to development and experience.

Back to the Future

The fourth wave of research on resilience has the potential to bring past theory and data gleaned from decades of earlier work into the future through integrative studies across multiple levels of analysis. It was only when risk, assets, vulnerabilities, and protections could be mapped and measured effectively at multiple levels and the statistical tools were at hand to address complex dynamics that it became feasible to study the processes of resilience in human development. Now a rather daunting agenda looms ahead as the fourth wave swells and carries us into the future. Much work will be needed to understand protective influences across cellular and behavioral levels, a goal that is exciting considerable interest at present. At the same time, enthusiastic fourth-wave riders might do well to remember that there are many additional systems involved in resilience beyond the individual and the immediate environment. As becomes dramatically apparent in major disasters, human life is interdependent on the resilience of many other systems, including ecosystems, computer and communication systems, health care systems, emergency systems, and political systems (Masten & Obradović, in press). Developmental investigators have much to offer science, practice, and policy concerned with resilience in human life, but we also have much to learn from colleagues who study resilience in many other fields.

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