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The Role of Physiological Response in Understanding Resilience Processes in Children's Development

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Introduction

Stress and adversity affect children in different ways. Some children develop behavioral or emotional challenges when exposed to difficult environments, while others overcome challenges and thrive. For decades, researchers have studied this variability in children's developmental outcomes to try to identify individual, family, school, and community processes that help some children to show "resilience" — that is, positive adaptation in the face of adversity.[1] By investigating physiological sensitivity and responses to adversity, researchers can gain more holistic understanding of how the interplay of biological and behavioral adaptations support or undermine children's resilience processes across different contexts.[2-4] Despite focusing on individual differences in adaptations and experiences, developmental psychologists recognize that children's capacity to respond to adversity depends largely on their access to contextual resources and supports as well as systemic processes and social policies.[5-7]

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Research Context

When children are exposed to various types of challenges and stressors — ranging from everyday difficulties to pervasive and chronic adversity— their bodies respond. Physiological responses are a set of highly integrated changes including those related to heart rate, breathing, and stress hormones. By studying differences in children's physiological response, researchers are revealing the dynamic interplay between contextual adversity, biology, and behavioural adaptation. Individual differences in children's physiological responses are complex and dynamic because they can be shaped by early experience, can change over time, and differ depending on the type of challenge. Physiological response can be measured as a relatively brief reaction to an acute stressor (i.e., "reactivity"), or more prolonged response that reflects cumulative responses or adjustments over time. Further, the effect of children's physiological responses on their emotional and behavioral adaptation can vary across different contexts.

Current research has focused on two systems of the body that are activated when children face challenging or stressful situations. The first system is fast-acting, known as the "fight or flight response", and can also help the body recover from a state of arousal and regulate it back to homeostasis. The second system is slow-acting and prepares the body for chronic exposure to stress by suppressing systems that do not promote immediate coping and increasing available energy to manage stress.[8] These systems' responses can be measured using various non-invasive measures such as cardiac readings (e.g., electrocardiogram) or hormone levels (e.g., cortisol) collected from saliva[9] or hair samples.[10]

Key Research Questions

Researchers studying how physiological response is associated with resilience are tackling these key questions:

1. How do children's early adverse experiences relate to their physiological response, and can supportive interventions help?
2. How do children's physiological response and the environment interact dynamically to explain differences in adaptation and resilience?
3. What skills and experiences can help children regulate their physiological arousal and promote positive adaptation?

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Recent Research Results and Gaps

Physiological response as an index of adversity exposure and intervention effectiveness

Children's experiences of adversity may play a role in shaping their physiological stress responses over time.[11] Studies have shown that children's exposure to adversity is associated with dysregulated physiological stress response that is either too high or too low.[12,13] For example, children who grow up with parents who are less sensitive or are abusive often display heightened physiological reactivity to acute stressors.[12,13] Early experiences of fear may sensitize children's systems to react more readily to future threatening situations by heightening their stress response.[14–17] This heightened physiological reactivity may be protective in situations of immediate threat, but over time, is associated with increased susceptibility to psychopathology such as depression or anxiety.[18,19] This association provides evidence of the "biological embedding of adversity" a hypothesis which states that early exposure to negative environments affects the children's central nervous system, and over time may adversely impact their cognitive, social, and behavioural development.[20]

To capture the wear-and-tear of various physiological stress response systems in the context of chronic adversity, researchers have employed a cumulative index of allostatic load.[21] Allostatic load is a way of measuring multiple types of heightened physiological stress response and inflammation (e.g., including heart rate, blood pressure and cortisol levels and immune and metabolic markers) that are linked to poor health outcomes in adulthood.[22,23] Children who experience greater adversity early in life consistently show greater allostatic load which in turn is linked to a broad range of negative outcomes later in life.[24,25] Even youth who are raised in poverty but appear to be well-adapted in their emotions and social behavior show high levels of allostatic load.[26] This finding suggests that resilience can be "skin deep"; physiological markers can reveal the toll adversity takes on the body even when children appear to be thriving.[26] Other ways of measuring wear-and-tear on the body include oxidative stress and metabolic markers, which are also elevated among children who face high levels of adversity.[27–29]

The processes through which adversity "gets under the skin" depend on the intensity, timing, and length of stress and adversity exposure.[20] Thinking about the timing and type of measurement is crucial. Recently, researchers proposed two distinct pathways to further elucidate how adversity can become biologically embedded.[16] This "dimensional model" distinguishes between children's experiences of active threat in their environment versus

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deprivation or lack of access to crucial resources or supports.[16] Other researchers point out that many stressful childhood environments involve both threat and deprivation; these two dimensions are often inextricable and shape stress response systems together.[25] Further, they highlight that measurement should capture children's subjective perceptions of adversity, as not all children may experience a given stressor the same way.[25] Future research that attends to these measurement issues can advance knowledge of children's physiological response and adaptation to adversity.

Physiological markers may also be useful for indicating treatment effectiveness in ways that have relevance for child policy and practice. For example, infants of women who received a mindfulness-based intervention during pregnancy showed more self-regulated behavior and more efficient physiological response and recovery from a stressor.[30] In another study, foster care children who received a therapeutic intervention did not show expected dysregulated cortisol rhythms when they changed placements, compared to their foster peers who did not receive the interventions.[31] These studies suggest that early supportive intervention may reduce physiological risks associated with residential and caregiving instability.[32,33] At the same time, a recent systematic review found that the results of different studies were mixed and depended on the specific physiological stress response system.[33] This finding highlights a need to better understand how to design and target interventions to mitigate the negative impacts of adversity on child physiology and wellbeing. In addition, more research could explore whether children's physiological stress responses explain why certain interventions work for some children but not for others and elucidate how to better design and target services.

Physiological response as a marker of susceptibility to environmental influences

Indices of physiological reactivity to stressful experiences has been conceptualized as a marker of susceptibility to contextual influences. Applying evolutionary principles, researchers theorize that children who show heightened physiological or behavioural reactivity are more sensitive to both positive and negative environments than their peers who exhibit lower reactivity, that is, "for better and for worse".[34,35] High physiological reactivity may be maladaptive in contexts of adversity, but healthy and promotive in contexts of nurturance and protection. For example, children with high levels of physiological reactivity displayed more behavioral challenges when raised in families with high levels of adversity (e.g., conflict, stress, low income), but more positive behavioral adaptation in families with relatively low adversity.[36,37] Framed another way, children with low reactivity showed better adjustment in contexts of adversity.

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While many studies have demonstrated the association between low reactivity and better adjustment in contexts of adversity,[36,37] in some cases, low reactivity could be protective. For example, there is evidence that high physiological response may be protective for children who are exposed to interpersonal conflict.[38] In addition, relatively higher levels of physiological response over time may be protective in circumstances of extreme poverty where stress response systems can become blunted.[39] The adaptive calibration model[2] distinguishes between two profiles of maladjustment in contexts of high adversity: low stress responsivity that is related to callous-unemotional traits (e.g., lack of empathy), and higher stress responsivity that is associated with more anxious patterns of emotion and behavior. This work highlights the plasticity of children's physiological response and the importance of disentangling in which specific conditions high or low response has a buffering effect against adversity.[11]

Given that most research on children's stress physiology has come from the United States context, more research is needed in low- and middle-income countries to provide greater representation of children's experiences worldwide. Further, research from low- and middle-income countries can help us to understand how children's stress physiology interacts with other biological processes including access to nutrition, and pathways of infection and inflammation that may activate or interplay with stress response systems. This research will be strengthened if we also include measures of positive environmental influences and children's adaptive functioning, recognizing the strengths of diverse families from under-resourced communities. Positive and enriching experiences may promote physiological regulation and holistic wellbeing, over and above mitigating the negative effects of adversity.

Skills and experiences that may help children regulate their physiological arousal and promote more optimal responses

Researchers are examining how children's physiology response changes as they encounter, engage with, and recover from contextual challenges. This research increasingly models physiology as a dynamic process that changes over time.[40] By examining the entire trajectory of children's reactivity and subsequent recovery, researchers aim to identify patterns of physiological response that help children to thrive in the face of adversity. Although exposure to high levels of adversity may predispose many children to develop highly sensitive physiological profiles, resilient children may also develop self-regulatory skills that produce fast and efficient recovery from that arousal. For example, children with greater self-regulatory skills showed moderate levels of physiological reactivity during laboratory challenges and recovered more

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quickly.[41,42,43]

Related constructs such as children's executive functioning, coping and coregulation with parents are also important predictors of how children react to and recover from challenges. For example, parents' levels of hair cortisol were not correlated with their children's hair cortisol levels among children with better emotion regulation, suggesting that emotion regulation skills may mitigate transgenerational effects of ongoing physiological stress.[44] Examining how different aspects of physiological response and self-regulation work together will help illuminate processes that promote children's resilience.[6]

The field of applied developmental psychobiology is starting to consider how to leverage research about children's physiology in ways that support their wellbeing. Physiological research may elucidate how unequal educational experiences of children from historically marginalized groups affect their developmental outcomes.[6] In one study, attending child care was associated with a suboptimal, flat cortisol response for Spanish-speaking Latine children, but having a Spanish-speaking teacher seemed to create a more supportive classroom environment that was linked to healthier cortisol response. More studies are needed to identify specific system level changes, practices and protective factors that reduce stress for children who face inequalities in treatment or access to resources.[7] Such work will help to illuminate processes that promote equity.

In addition, low-cost, scalable interventions that teach children skills for coping and self-regulating may be helpful.[45] For instance, a field experiment taught 5 to 12 year old children deep breathing skills via a short video and found that it significantly decreased their physiological activation and calmed the nervous system.[46] Children's appraisal of stressors (i.e., perceptions and beliefs) may also play a significant role in how they physiologically respond and recover.[47]

Conclusion and Implications

Resilience researchers have made significant advances in linking children's physiological reactivity to both adversity exposure and their behavioral functioning. This work has highlighted the importance of examining how the biological embedding of adversity affects children, and how the environment and children's physiological responses interact dynamically to predict development of the life course. By examining the contemporaneous association between

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physiological reactivity and self-regulatory skills, we may be better able to understand the resilience process for children who exhibit high physiological reactivity. Importantly, we must always remember that resilience is a dynamic process, meaning that it is malleable and changes over time.

References

1. Masten AS. Resilience theory and research on children and families: Past, present, and promise. *Journal of Family Theory & Review.* 2018;10(1):12-31. doi:10.1111/jftr.12255
2. Del Giudice M, Ellis BJ, Shirtcliff EA. The adaptive calibration model of stress responsivity. *Neuroscience and Biobehavioral Reviews.* 2011;35:1562-1592. doi:10.1016/j.neubiorev.2010.11.007
3. Ellis BJ, Bianchi JM, Griskevicius V, Frankenhuis WE. Beyond risk and protective factors: An adaptation-based approach to resilience. *Perspectives on Psychological Science.* 2017;12(4):561-587. doi:10.1177/1745691617693054
4. Obradović J. Physiological responsivity and executive functioning: Implications for adaptation and resilience in early childhood. *Child Developement Perspectives.* 2016;10:65-70. doi:10.1111/cdep.12164
5. Masten AS. Resilience from a developmental systems perspective. World Psychiatry. 2019;18(1):101-102. doi:10.1002/wps.20591
6. Obradović J, Armstrong-Carter E. Addressing educational inequalities and promoting learning through studies of stress physiology in elementary school students. *Development and Psychopathology.* 2020;32:1899-1913. doi:10.1017/S0954579420001443
7. Iruka IU, Gardner-Neblett N, Telfer NA, et al. Effects of Racism on Child Development: Advancing antiracist developmental science. *Annual Review of Developmental Psychology.* 2022;4(1):109-132. doi:10.1146/annurev-devpsych-121020-031339
8. Sapolsky R. Why Zebras Don’t Get Ulcers: The Acclaimed Guide to Stress, Stress-Related Diseases, and Coping-Now Revised and Updated. Holt Paperbacks; 2024.
9. Obradović J, Boyce WT. Stress reactivity in child development research. In: Mayes L, Lewis M, eds. *The Cambridge Handbook of Environment in Human Development.* Cambridge University Press; 2012:655-681. doi:10.1017/CBO9781139016827.036

©2024-2026 ABILIO | RESILIENCE

10. Bates R, Salsberry P, Ford J. Measuring stress in young children using hair cortisol: The state of the science. *Biological Research for Nursing*. 2017;19(5):499-510. doi:10.1177/1099800417711583

11. Obradović J. How can the study of physiological reactivity contribute to our understanding of adversity and resilience processes in development? *Development and Psychopathology.* 2012;24:371-387. doi:10.1017/S0954579412000053

12. Gunnar MR. Forty years of research on stress and development: What have we learned and future directions. *American Psychologist.* 2021;76(9):1372-1384. doi:10.1037/amp0000893

13. Engel ML, Gunnar MR. The development of stress reactivity and regulation during human development. In: *International Review of Neurobiology.* Vol 150. Elsevier; 2020:41-76. doi:10.1016/bs.irn.2019.11.003

14. Heim C, Nemeroff CB. The role of childhood trauma in the neurobiology of mood and anxiety disorders: preclinical and clinical studies. *Biological Psychiatry.* 2001;49(12):1023-1039. doi:10.1016/S0006-3223(01)01157-X

15. Gunnar MR, Vazquez D. Stress neurobiology and developmental psychopathology. In: *Developmental Psychopathology: Developmental Neuroscience, Vol. 2, 2nd Ed.* John Wiley & Sons Inc; 2006:533-577.

16. McLaughlin KA, Sheridan MA, Humphreys KL, Belsky J, Ellis BJ. The Value of Dimensional Models of Early Experience: Thinking Clearly About Concepts and Categories. *Perspectives on Psychological Science.* 2021;16(6):1463-1472. doi:10.1177/1745691621992346

17. Sheridan MA, McLaughlin KA. Introduction to the special issue on childhood adversity and neurodevelopment. *Developmental Cognitive Neuroscience*. 2022;54:101082. doi:10.1016/j.dcn.2022.101082

18. Cicchetti D, Rogosch FA. The impact of child maltreatment and psychopathology on neuroendocrine functioning. *Development and Psychopathology.* 2001;13(4):783-804.

19. Boyce WT, Quas J, Alkon A, et al. Autonomic reactivity and psychopathology in middle childhood. *British Journal of Psychiatry.* 2001;179:144-150. doi:10.1192/bjp.179.2.144

20. Hertzman C. The Biological Embedding of Early Experience and Its Effects on Health in Adulthood. *Annals of the New York Academy of Sciences*. 1999;896(1):85-95. doi:10.1111/j.1749-6632.1999.tb08107.x

©2024-2026 ABILIO | RESILIENCE

21. McEwen BS. Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences*. 1998;840(1):33-44. doi:10.1111/j.1749-6632.1998.tb09546.x

22. Brody GH, Lei MK, Chen E, Miller GE. Neighborhood poverty and allostatic load in African American youth. *Pediatrics*. 2014;134(5):1362-1368. doi:10.1542/peds.2014-1395

23. Hostinar CE, Miller GE. Protective factors for youth confronting economic hardship: Current challenges and future avenues in resilience research. *American Psychologist.* 2019;74(6):641-652. doi:10.1037/amp0000520

24. Finlay S, Roth C, Zimsen T, Bridson TL, Sarnyai Z, McDermott B. Adverse childhood experiences and allostatic load: A systematic review. *Neuroscience and Biobehavioral Reviews*. 2022;136:104605. doi:10.1016/j.neubiorev.2022.104605

25. Pollak SD, Smith KE. Thinking Clearly About Biology and Childhood Adversity: Next Steps for Continued Progress. *Perspectives on Psychological Science*. 2021;16(6):1473-1477. doi:10.1177/17456916211031539

26. Brody GH, Yu T, Chen E, Miller GE, Kogan SM, Beach SRH. Is resilience only skin deep?: Rural African Americans' socioeconomic status–related risk and competence in preadolescence and psychological adjustment and allostatic load at age 19. *Psychological Science.* 2013;24:1285-1293. doi:10.1177/0956797612471954

27. Boyce WT, Levitt P, Martinez FD, McEwen BS, Shonkoff JP. Genes, Environments, and Time: The Biology of Adversity and Resilience. *Pediatrics*. 2021;147(2):e20201651. doi:10.1542/peds.2020-1651

28. Shonkoff JP, Boyce WT, Levitt P, Martinez FD, McEwen B. Leveraging the Biology of Adversity and Resilience to Transform Pediatric Practice. *Pediatrics*. 2021;147(2):e20193845. doi:10.1542/peds.2019-3845

29. Horn SR, Leve LD, Levitt P, Fisher PA. Childhood adversity, mental health, and oxidative stress: A pilot study. Seedat S, ed. *PLoS one*. 2019;14(4):e0215085. doi:10.1371/journal.pone.0215085

30. Noroña-Zhou AN, Coccia M, Epel E, et al. The Effects of a Prenatal Mindfulness Intervention on Infant Autonomic and Behavioral Reactivity and Regulation. *Psychosomatic Medicine*. 2022;84(5):525-535. doi:10.1097/PSY.0000000000001066

©2024-2026 ABILIO | RESILIENCE

31. Fisher PA, Van Ryzin MJ, Gunnar MR. Mitigating HPA axis dysregulation associated with placement changes in foster care. *Psychoneuroendocrinology*. 2011;36(4):531-539. doi:10.1016/j.psyneuen.2010.08.007

32. Slopen N, McLaughlin KA, Shonkoff JP. Interventions to improve cortisol regulation in children: A systematic review. *Pediatrics*. 2014;133(2):312-326. doi:10.1542/peds.2013-1632

33. Sullivan ADW, Roubinov D, Noroña-Zhou AN, Bush NR. Do dyadic interventions impact biomarkers of child health? A state-of-the-science narrative review. *Psychoneuroendocrinology*. 2024;162:106949. doi:10.1016/j.psyneuen.2023.106949

34. Boyce WT, Ellis BJ. Biological sensitivity to context: I. An evolutionary–developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*. 2005;17(02). doi:10.1017/S0954579405050145

35. Ellis BJ, Boyce WT. Differential susceptibility to the environment: Toward an understanding of sensitivity to developmental experiences and context. *Development and Psychopathology* . 2011;23(1):1-5. doi:10.1017/S095457941000060X

36. Obradović J, Portilla XA, Ballard PJ. Biological sensitivity to family income: Differential effects on early executive functioning. *Child Development.* 2016;87:374-384. doi:10.1111/cdev.12475

37. Obradović J, Bush NR, Stamperdahl J, Adler NE, Boyce WT. Biological sensitivity to context: The interactive effects of stress reactivity and family adversity on socioemotional behavior and school readiness. *Child Development.* 2010;81(1):270-289. doi:10.1111/j.1467-8624.2009.01394.x

38. Obradović J, Bush NR, Boyce WT. The interactive effect of marital conflict and stress reactivity on externalizing and internalizing symptoms: The role of laboratory stressors. *Development and Psychopathology.* 2011;23:101-114. doi:10.1017/S0954579410000672

39. Armstrong-Carter E, Finch JE, Siyal S, Yousafzai AK, Obradović J. Biological sensitivity to context in Pakistani preschoolers: Hair cortisol and family wealth are interactively associated with girls' cognitive skills. *Developmental Psychobiology.* Published online May 26, 2020. doi:10.1002/dev.21981

40. Obradović J, Finch JE. Linking executive function skills and physiological challenge response: Piecewise growth curve modeling. *Developmental Science.* 2017;20(6):e12476.

©2024-2026 ABILIO | RESILIENCE

doi:10.1111/desc.12476

41. Marcovitch S, Zelazo PD. A hierarchical competing systems model of the emergence and early development of executive function. *Developmental Science*. 2009;12(1):1-18. doi:10.1111/j.1467-7687.2008.00754.x

42. Blair C, Granger D, Razza R. Cortisol reactivity is positively related to executive function in preschool children attending Head Start. *Child Development.* 2005;76(3):554-567. doi:10.1111/j.1467-8624.2005.00863.x

43. Armstrong-Carter E, Sulik MJ, Obradović J. Self-regulated behavior and parent-child co-regulation are associated with young children's physiological response to receiving critical adult feedback. *Social Development.* 2021;30(3):730-747. doi:10.1111/sode.12498

44. Kao K, Tuladhar CT, Meyer JS, Tarullo AR. Emotion regulation moderates the association between parent and child hair cortisol concentrations. *Developmental Psychobiology.* 2019;61(7):1064-1078. doi:10.1002/dev.21850

45. Obradović J, Steyer L, Sulik MJ. Towards a more inclusive, contextualized conceptualization of coping and its relations to executive functions and self-regulation. In: Skinner EA, Zimmer-Gembeck MJ, eds. *The Cambridge Handbook of the Development of Coping.* Cambridge University Press; 2023:351-381.

46. Obradović J, Sulik MJ, Armstrong-Carter E. Taking a few deep breaths significantly reduces children's physiological arousal in everyday settings: Results of a preregistered video intervention. *Developmental Psychobiology*. 2021;63(8). doi:10.1002/dev.22214

47. Lee HY, Jamieson JP, Miu AS, Josephs RA, Yeager DS. An entity theory of intelligence predicts higher cortisol levels when high school grades are declining. *Child Development.* 2019;90(6):849-867. doi:10.1111/cdev.13116

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