

Annual Review of Clinical Psychology

Conceptual and Methodological Issues in Studying Early Adversity and Development

Seth D. Pollak¹ and Karen E. Smith²

¹Department of Psychology, University of Wisconsin–Madison, Madison, Wisconsin, USA;
email: seth.pollak@wisc.edu

²Department of Psychology, Rutgers University, Newark, New Jersey, USA

ANNUAL
REVIEWS **CONNECT**

www.annualreviews.org

- Download figures
- Navigate cited references
- Keyword search
- Explore related articles
- Share via email or social media

Annu. Rev. Clin. Psychol. 2026. 22:187–214

First published as a Review in Advance on
February 10, 2026

The *Annual Review of Clinical Psychology* is online at
clinpsy.annualreviews.org

<https://doi.org/10.1146/annurev-clinpsy-061724-091000>

Copyright © 2026 by the author(s). This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (CC BY-NC-ND 4.0), which permits any noncommercial use, sharing, distribution, and reproduction in any medium or format, provided the original author(s) and source are credited; this license does not permit sharing adapted material derived from this article or parts of it. Images or other third-party material in this article are included in the article's Creative Commons license unless indicated otherwise; see credit lines for license information.



Keywords

early life stress, stress, childhood adversity, neurobiological development, early experience, developmental psychopathology, trauma

Abstract

Early life adversity is associated with many negative health, behavioral, and cognitive outcomes. However, the causal mechanisms underlying these associations remain obscure, making it difficult to design targeted interventions for individuals most at risk. Current approaches focus almost exclusively on event exposures, but given that data using these approaches have been inconsistent, there is a need for new models for characterizing adversity. We propose the Topological Approach to Adversity and Development, which, rather than focusing on the types of events children encounter, prioritizes understanding how children perceive, interpret, and make meaning of their circumstances. A focus on the developmental dimensions that contribute to how individuals interpret and learn to respond to potentially challenging life circumstances could renew and advance mechanistic accounts of childhood adversity. Such an approach has implications for the basic science of human stress responding as well as practical implications for improvements to individual well-being and health.

Contents

INTRODUCTION	188
HOW ADVERSITY IS CONCEPTUALIZED AND MEASURED	189
LIMITATIONS OF EVENT-BASED APPROACHES	
TO MEASURING ADVERSITY	193
Events Do Not Generalize Across Racial, Ethnic, and Cultural Contexts	193
The Kinds of Events Studied May Not Be Relevant for Biology and Development	193
Events Represent “Fuzzy” Categories	194
THE TOPOLOGICAL APPROACH TO ADVERSITY	
AND DEVELOPMENT: SPECIFICITY OF EFFECTS	
AND MECHANISMS OF CHANGE	195
Moving Beyond Events to Capture Meaning	195
What Affects Perceptions of Life Events?	196
Timing	198
Predictability	199
Controllability	200
Social Relationships	200
ADVERSITY REFLECTS LACK OF SAFETY	201
CAPTURING DIMENSIONS OF ADVERSITY: POTENTIAL NEW	
AVENUES FOR ASSESSMENT	202
FUTURE DIRECTIONS	203
APPENDIX 1: THE JINGLE/JANGLE PROBLEM	
IN ADVERSITY RESEARCH	204
APPENDIX 2: LUMPING VERSUS SPLITTING AND SENSITIVITY	
VERSUS SPECIFICITY	205

INTRODUCTION

The idea that extreme negative experiences have far-reaching impacts on development has a long history in psychological science. Many terms have been used to capture this idea, but their definitions vary (Appendix 1). Among the most common terms are stress and adversity, with the general idea being that a moderate range of challenging experiences are normative and promote growth and development, whereas high levels of these experiences cause negative outcomes (O'Connor et al. 2021, Turner et al. 2020). The negative outcomes correlated with adversity are strikingly broad, influencing social behavior, physical health risks ranging from digestive issues to cardiovascular disease to cancer, learning and school achievement, mental health risk across a range of nearly all psychopathologies, and many aspects of neural and physiological development. The scope of these associations is so expansive that it is difficult to find any neural region, biological/physiological system, cognitive process, or social variable that has not been correlated in some way with childhood adversity. These linkages make the topic of childhood adversity highly relevant both for understanding the basic science of human development and learning as well as for addressing factors affecting public health. Yet, the critical problem is that, although the negative impact of adversity on development is well-established, progress in understanding how and why these effects emerge is still limited. This lack of progress reflects, in part, that the modal conceptualizations of what constitutes adversity have not evolved substantially over the past few

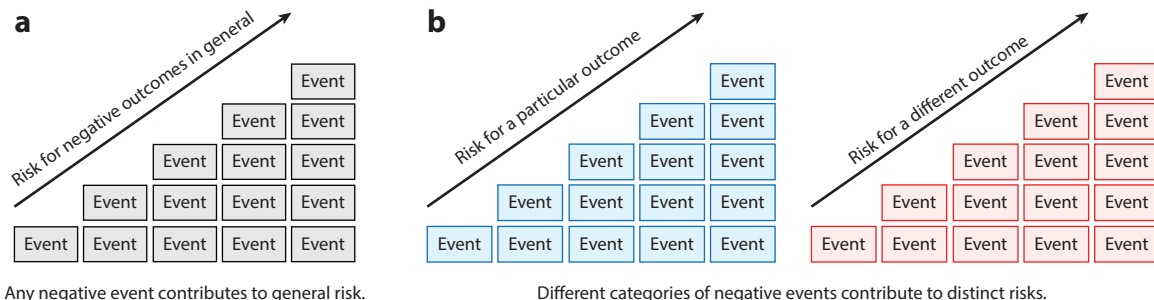


Figure 1

Cumulative models take two basic forms, both based on the number of event exposures. (a) Lumping approaches take all events deemed by researchers to be stressful as similar and to carry a similar weight on negative outcomes. With each additional negative event of any type that the individual encounters, the risk for any type of negative outcome increases. These models offer no specificity in terms of events or outcomes. (b) In splitting approaches, researchers presuppose or speculate about commonalities of some events (e.g., threat or deprivation) and hypothesize that with each additional event in each category, the probability of outcomes associated with that category increases. The challenges are that the categories are of questionable validity and that the data have not shown specific outcomes to be consistently associated with the categories identified so far. Both approaches are essentially similar in merely counting event exposures.

decades. In addition, the methods associated with these conceptualizations were not designed to elicit the types of information that recent evidence suggests is critical for understanding the role of adversity on development. In this review, we describe traditional approaches and point to new directions that will allow researchers to shift from merely describing problems correlated with early life adversity to explaining why and how these factors alter biobehavioral development.

HOW ADVERSITY IS CONCEPTUALIZED AND MEASURED

Cumulative models represent the most common approach used to assess childhood adversity. These models are referred to as cumulative because they rely on traditional questionnaires and checklists to count and sum the number of (purportedly) adverse events to which an individual has been exposed (Oh et al. 2018); the predictor or grouping variable is simply the sum total of a child's event exposures (Buchanan et al. 2023, Evans et al. 2013). In other words, the more items or events the individual endorses or is reported to have, or are documented in records, then the higher their score—which is interpreted as reflecting higher levels of experienced adversity. To obtain these scores, individuals (or their caregivers) are queried directly, or medical/social service records are coded, for the presence of predefined events considered to be potential stressors (**Figure 1**). Events might include circumstances such as being insulted by a caregiver, experiencing physical harm, having insufficient food, losing a parent through abandonment or death, living with someone who is depressed, or having an incarcerated family member. Some commonly used measures include the Life Stressors Checklists (Wethington et al. 1997), the Childhood Experiences of Care and Abuse Questionnaire (Bifulco et al. 2005), the Multidimensional Neglectful Behavior Scale (Kantor et al. 2004), and the Childhood Traumatic Events Questionnaire (Steele et al. 2016). The most widely adopted approach of this variety is called adverse child experiences (ACEs) (Felitti et al. 1998). ACEs have played a critical role both in advancing knowledge of effects of adversity on human development and in translating this knowledge to public health. When the ACEs framework was introduced around 50 years ago, consistent correlational data linking events in people's childhoods with their health issues decades later convinced scientists and the lay public that early childhood experiences are consequential. Indeed, the correlational data are strong: Cumulative measures of adversity have been linked to differences in hippocampal,

prefrontal cortical, and amygdala volumes; connectivity between brain regions implicated in emotion and behavioral regulation; functioning of peripheral stress-response systems; epigenetic changes; and immune system functioning (Kuhlman et al. 2017), as well as an overwhelmingly broad list of health and behavioral outcomes, including low physical activity, obesity, diabetes, cardiovascular disease, heavy alcohol use, poor general health, any form of cancer, gastrointestinal disturbances, psychosomatic problems, frequent tobacco use, respiratory disease, anxiety, early sexual initiation, teen pregnancy, low life satisfaction, depression, illicit drug use, sexually transmitted infections, violence victimization, violence perpetration, and suicide attempts (Hughes et al. 2017). This range of associated outcomes is a double-edged sword, not only highlighting the potential impact of childhood adversity but also reflecting the limitations of current approaches for understanding the specific mechanisms driving the phenomena. What could account for such a widely diverse set of outcomes?

The primary limitation of the cumulative approach is that it has not provided insight into how or why adversity affects development. While it is still possible to report on a correlation between adversity and some new index of biology or behavior, it is not clear what truly new insight these data can provide beyond yet another descriptive data point. We still know relatively little regarding the specific neurobiological mechanisms underlying long-term health and behavioral effects as well as what drives individual differences in responses to adversity (Palacios-Barrios & Hanson 2019). How is it that early stress in childhood is a risk factor for seemingly disparate outcomes with a range that includes irritable bowel syndrome, social competence, telomeres, and learning? Why does almost any negative outcome that scientists choose to measure show some association with early adversity? Why does the directionality of these effects sometimes differ (e.g., reports of both dampened and enhanced peripheral reactivity; Hunter et al. 2011)?

To address these questions, variations of cumulative stress models have attempted to better link event exposures to specific outcomes. These variations have included expanding or altering the list of events that represent potential stressors (Koppold et al. 2024), adding indices of intensity or frequency for the events (Weems et al. 2020), keeping the same types of items on checklists but altering the level or total number of items required (Sadikova et al. 2024), and including multiple sources of measurement for the same events (Machlin et al. 2025). One approach—frequently used by contemporary researchers—seeks to identify unique associations between subtypes of experiences and specific types of outcomes. In an early conceptualization of this type of approach, Pollak et al. (2000) proposed a distinction between a child being deprived of expected inputs (e.g., neglectful caregiving) and childhood experiences marked by unusually high or extreme inputs (e.g., threat or hostility). Subsequent variants of this approach (e.g., McLaughlin & Sheridan 2016) have proposed distinguishing the effects of deprivation (neglect, food insecurity, institutionalization) from threat (physical abuse, sexual abuse, exposure to violence), whereas other models have focused on distinguishing between harshness and predictability (Belsky et al. 2012). These approaches originated from research in nonhuman animals that demonstrated some evidence of specificity between certain types of stressors on discrete neurobiological systems (Goldstein 2010), but as discussed below, do not extend to the complex social phenomena psychologists refer to as adversity. These models often use the word “dimensions” to describe different experiences (e.g., threat, deprivation, unpredictability) and claim to be categorically different from cumulative models (McLaughlin & Sheridan 2016). However, while we concur that a focus on dimensions of experience is promising, current iterations of dimensional approaches remain at their core cumulative models. This is because, in these models, adversity is still ultimately determined on the basis of a sum total of event exposures. The only difference between these so-called dimensional models and more traditional cumulative approaches is that, rather than adding up the number of respondents’ event exposures on the basis of one source (or multiple sources) of measurement,

they are added up separately to make, for example, a threat score and a deprivation score (**Figure 1**).

It is easy to understand why researchers have gravitated toward these approaches. Event-based measures are familiar and easy to use, appear rigorous in terms of specifying the types and durations of events, and feel intuitive (e.g., the more items an individual endorses on a checklist, the higher their amount of adversity). On the face of it, a child being physically beaten by a parent seems like a very different kind of experience from being ignored and not cared for by a parent. But these models make assumptions that are not well-supported by data. The first assumption is that human development remains relatively unperturbed by a minimal number of life challenges, but that the more negative events an individual experiences, the more likely they are to manifest negative outcomes. This approach has also been applied as a threshold model (we can take only so much before we cross a threshold that results in negative outcomes; Hughes et al. 2017), a linear model (with each additional challenge, the probability of negative outcomes becomes greater; Snyder et al. 2024), or quadratic relations (moderate amounts of challenge support resilience, while higher and lower amounts are associated with increased distress; Seery et al. 2010). An issue that is obvious upon reflection, but not often explicitly considered, is that when scientists use an existing category they are also subscribing to a mini-theory. This is because the use of any category (ranging from an age cohort such as adolescence to a descriptor such as trauma or anxiety to a group of behaviors such as caregiving neglect) organizes the observations the researcher deems relevant and highlights certain features as essential versus irrelevant, thereby shaping our expectations and interpretations of behavior. Grouping diverse instances under a common label implicitly assumes causal mechanisms or underlying similarities, even in the absence of confirmatory data (Smith et al. 2024). As an example, there is not sufficient evidence to support the assumption that two children who experienced physical abuse will be more similar overall than one child who was physically abused and another child who was neglected. We certainly need categories to structure our knowledge, but we must also be mindful that they can lead us to miss nuances and ignore or misinterpret data.

The second assumption is that what researchers view as, or consider to be, distinct types of events will be tied to discrete biological processes. For example, presuming that being physically harmed will lead all individuals to feel threatened, and that experience will, in turn, have specific effects on underlying biology. The data generated from this type of approach reflect sensitivity that is too high and specificity that is too low to be useful or to support the abovementioned assumptions (Appendix 2). As noted above, there certainly is some evidence for specificity based on different types of stressors that has emerged from the nonhuman animal literature. But that literature examines simple discrete events such as foot shocks or exposure to cold (Pacák & Palkovits 2001). These are not comparable to the complex kinds of social and interpersonal stressors involving caregiving that are the focus of scientists interested in the effects of adversity on the lives of human children. The outward, observable features of psychological processes, particularly those associated with emotion, do not necessarily map directly onto underlying mechanisms or experiences. Similar external displays can arise from different internal states, and the same internal state can manifest in various ways across individuals or contexts (Feldman Barrett et al. 2025). This lack of one-to-one correspondence between what people might say or do, what they might feel, and how their biology might respond challenges assumptions that there is a direct link or signature between any feeling state, experience, and biological process.

The data supporting distinctions between broad categories of events such as threat versus deprivation are decidedly mixed. Some data support the association between threat and psychopathology as being mediated by alterations in autonomic and hypothalamic–pituitary–adrenal (HPA) axis reactivity, but other evidence indicates very similar effects of threat and deprivation experiences on stress-response systems and the neural systems supporting them (Gee et al. 2013,

Koss & Gunnar 2017, Lawson et al. 2017). There is not consistent evidence for specific effects on reward systems; some studies have found that threat experiences are associated with blunted reward responsiveness (Burani et al. 2023, Suor et al. 2023), whereas others indicate enhanced responsiveness (Hendrikse et al. 2022, Yang et al. 2021). Research directly comparing the effects of threat and deprivation has yielded contradictory results, including the findings that deprivation but not threat reduces reward approach motivation (Dennison et al. 2019) and that threat but not deprivation reduces reward approach motivation (Kasperek et al. 2020). Notably, these studies use comparable indices of threat and deprivation and the same reward task (a monetary incentive delay task), so the differences are not likely caused by methodological differences. There also appear to be greater similarities than differences across maltreatment exposure subtypes on threat conditioning tasks (Ahrenholtz et al. 2021). In a very large population-based study, Gehred et al. (2021) found a strong link between childhood adversity and brain structure in midlife but minimal evidence for specific effects based on adversity types such as threat versus deprivation. These findings are supported by a recent systematic review of the effects of early adversity on reward and threat processing circuitry, which found minimal evidence for specificity dependent on the type or dimension of adversity (Smith et al. 2025); a meta-analysis that found minimal effects of specific adversity types on brain structure (Pollok et al. 2022); and a large longitudinal study that found little evidence for specific effects of adversities on HPA axis and cardiac functioning (Akasaki et al. 2025).

The third assumption inherent in these approaches is perhaps the most serious. Indeed, it best accounts for the lack of consistent findings in the adversity literature and highlights the tremendous need for new approaches in the study of adversity. The problem is the likely erroneous belief that objective events are a common trigger across individuals for adversity-related processes or, simply, that events in people's lives can be a sufficient measure of adversity. This assumption belies evidence. It is apparent from our everyday experiences that individuals can respond to the exact same event in very different ways. Imagine three people, each waiting to deliver a speech in front of an audience. One person might be positively engaged and eagerly anticipating their chance to step up to the microphone and share their ideas with the audience; another individual might be distraught, anxious, and physically uncomfortable, wishing their turn to speak was already finished; and the third individual may be bored and disinterested. Focusing only on the fact they were exposed to a public-speaking event would not explain these differences. This lack of explanatory power in events is reflected in data—when participants are asked to give a speech in laboratory settings (a standard social stress paradigm), there is great variability in patterns of reactivity across stress-response systems (physiological, behavioral, reported experiences; Carosella et al. 2023). Even in nonhuman animal models, where there is some evidence of specificity in responses to adversity, as stressor complexity increases, specificity becomes less reflective of the characteristics of the stressor and more reflective of the type of behavioral response an animal produces (Korte et al. 2005); there is an extremely broad range of individual differences in responses to the same type of event (Goldstein & McEwen 2002). As a result, it is extremely unlikely that all children who experienced the same kind of negative caregiving will have the same kind of biological sequelae. Problems with the use of the term “threat” in adversity research are rooted, in part, in erroneous thinking about the concept of arousal and its implications for cognition and biology (for a full discussion and implications for theories of emotion, see Smith et al. 2024).

These three primary problematic assumptions likely explain why approaches that rely on counting adverse event exposures (or subtypes of these events) alone have not and cannot identify biobehavioral mechanisms accounting for effects of adversity on or explain variation in children's development outcomes. Below, we describe additional limitations inherent in these primary

assumptions that impede our ability to identify specific mechanistic accounts of how adversity influences development and point to a need for new conceptualizations.

LIMITATIONS OF EVENT-BASED APPROACHES TO MEASURING ADVERSITY

Events Do Not Generalize Across Racial, Ethnic, and Cultural Contexts

One problem with using event exposures as an index of an individual's experience of adversity is that the same events are unlikely to be experienced similarly or have the same meaning across cultural, racial, or ethnic backgrounds. Nearly all the major surveys and questionnaires used in the adversity literature were developed by White scientists in Western, developed countries. Emerging research indicates major differences in what people from varying racial and ethnic groups find to be stressful (Jensen et al. 2024, Maguire-Jack et al. 2020). In addition, both the types and prevalence of adverse event exposures appear to differ across racial and ethnic groups, and the differences in these exposures lead to variations in health risks across groups (Zhang & Monnat 2022). As one example, a systematic review of stress associated with police violence exposure found that Black and Latino youth report heightened experiences of traumatic stress and distress following vicarious exposure in comparison to White youth, and Black youth demonstrate higher nightly cortisol levels following a police-related death (Oppenheim et al. 2024). A conceptually related issue in economics concerns whether health and well-being outcomes are best predicted by measures of absolute poverty (determined by a fixed, universal standard of living) versus relative poverty (an assessment of whether an individual is worse off than others in their specific context); this issue is rarely integrated into psychological measures of adversity (Chen et al. 2023). There is also evidence that responses to similar types of events vary greatly depending on culture, which is consistent with the emerging view in emotion research that interpersonal events generate various emotions depending on the cultural context (Mesquita 2022). Responses to laboratory stressors also vary on the basis of cultural differences in how stressors are interpreted. For example, compared with European Americans, individuals from East Asian cultures are more likely to believe that feeling nervous in a demanding situation is useful, and those beliefs result in attenuated cardiovascular responses (Yoo et al. 2022). In summary, individuals from various backgrounds may perceive and experience event exposures in vastly different ways (Lee et al. 2023). Approaches based solely on whether an individual encounters negative events, or the number of such events, will miss variability in how people perceive the events, which is key to understanding health risks (Torres-Harding et al. 2020).

The Kinds of Events Studied May Not Be Relevant for Biology and Development

Another source of misdirection in the field is the assumption that what seems socially relevant in our contemporary context is necessarily relevant to development of the central nervous system. Both specific (e.g., discrete events such as physical abuse, witnessing domestic violence) and categorical (e.g., threat, deprivation) models of event exposures are based on modern, culturally specific norms about how we currently view issues such as parenting and childhood. In other words, they reflect contemporary values and expectations about what types of behaviors are expected and appropriate. When adversity is operationalized in terms of constructs that are modern in an evolutionary sense, then mechanistic evidence must be marshaled to make clear how these features of social life would change the development and functioning of core human biology. After all, evolution moves much more slowly than social mores. Often, this critical link is assumed rather than demonstrated. Designations such as child neglect or physical abuse reflect relatively recent legal statutes that are defined in different ways aligned with changing standards across

different communities, as well as the scope and resources of local child welfare and social service organizations (Dubowitz et al. 2005). What a particular community considers to be violence or sexual abuse is culturally constructed and changes over time, shifting with power relationships and how societies and social scientists define and understand these constructs (Muehlenhard & Kimes 1999). The concept of poverty was developed relatively recently by economists and policy makers to evaluate government services (Meyer & Sullivan 2009). Measures of poverty are defined and applied differently across time and contexts, with continuing debates in economics about exactly how poverty should be measured and determined. These are just a few examples, but it is easy to think of many ways in which the categories and constructs that we currently consider important in adversity research may not map directly onto biological development. These modern categories and constructs are indeed important socially but may not be relevant in terms of the evolutionary history of the human brain. In recent decades, we have witnessed changes in what counts as childhood, the notion of what constitutes a family, norms about child-rearing, and what is considered to be harsh or inappropriate care of children, to name just a few. Socio-legal constructs certainly have practical utility, such as providing access to treatment or services or providing structure to help people communicate about and understand their life experiences. However, as we have argued elsewhere (Smith & Pollak 2021a), while these modern conceptions of what constitutes adversity might well be relevant for human nervous system development, more evidence is needed to move the idea from an assumption to an established fact.

Events Represent “Fuzzy” Categories

A third issue is that categories of experience are often framed in ways that are not valid or useful (Pollak & Smith 2021). To illustrate this problem, imagine a child living with a parent who physically beats them. This situation may be characterized in multiple ways. Most immediate is the obvious physical violence, so one might assume that this act of being physically harmed is the critical feature that distinguishes this experience from other kinds of adversity and thus focus exclusively on physical abuse. Another approach would hold that this situation reflects a threat to the child and that all events deemed to be threats will have distinctly different effects than, for example, acts of deprivation such as neglectful parenting. There is no doubt that the child in this situation is being exposed to extreme hostility and even danger. But can we claim that the only relevant dimension here is physical abuse or threat? Also inherent in this child's situation is a concurrent lack of security, comfort, protection, sensitivity, and parental support—dimensions that are traditionally characterized as deprivation. Trying to separate such a real-life situation into one event type (such as physical abuse) or distinct dimensions of threat versus deprivation is, to paraphrase the philosopher W.V. Quine (1976), like trying to pull apart a gray sweater in search of separate black threads and white threads. This is futile because it is challenging to think of situations marked by deprivation that might not also be threatening or events that are threatening that do not involve some component of a child being deprived in some way. Thus, the distinction is false. And even if there were no conceptual overlap, often there are no data indicating what the child attended to, felt, or thought about these events was construed by the particular child as being a threat. We might know what happened, but we rarely know what a child thought about or how they reacted to what happened. For these reasons, events alone cannot carve up the reality of experience and thus are unlikely to consistently link to biological processes.

While this conceptual problem represents the core flaw of these approaches, there are practical problems as well. Even if one were to dismiss the criticism that threat or deprivation or harshness or unpredictability does not reflect real or meaningful distinctions, there is still the question of the likelihood of a child experiencing only one of these dimensions. Proponents of the

threat–deprivation distinction dismiss this criticism by claiming that it is unlikely that individual children will experience overlap in these types of experiences (Machlin et al. 2025), yet these authors also report that overlap in types of adversity exposure is indeed very high (Green et al. 2010). For these reasons, Pollak & Smith (2021) refer to attempts to distinguish and define subtypes of adversity as “fuzzy categories.” The categories are fuzzy, or ill-defined, because this way of attempting to group event exposures lacks clear boundaries and fails to recognize the real-world complexity of children’s lives. These fuzzy categories likely account for the lack of robust, consistent neurobiological evidence supporting existing models. Moreover, because these models are all based on event exposures, they incorrectly treat events as being experienced by children in similar ways. In doing so, they miss the dimension of experience most likely to account for the responses to these events: whether the individual actually perceives the exposure to events as threatening or adverse.

THE TOPOLOGICAL APPROACH TO ADVERSITY AND DEVELOPMENT: SPECIFICITY OF EFFECTS AND MECHANISMS OF CHANGE

For the reasons outlined above, the emphasis on identifying and counting events to which a child has been exposed (or, in the case of neglect/deprivation, not exposed) is unlikely to move us beyond descriptive and correlational associations or greater specificity. Recent decades have witnessed the publication of an extraordinary number of papers further outlining the myriad processes associated with adversity, but few truly novel or groundbreaking insights into the critical questions of how and why these effects emerge. As we have highlighted, event exposures typically taken as evidence of adversity are limited in that they have been predetermined and assumed to be stressors by adult scientists, from the perspective of the modern, Western, developed world. Yet we know that all individuals do not experience the same events in the same way and that individuals demonstrate wide-ranging variability in their responses to the same events (Lazarus & Folkman 1984, Sapolsky 2015). Two shifts in emphasis show promise for accelerating progress in our understanding of adversity. The first involves decreasing reliance on indices of life events and developing new methods of assessing how individuals interpret the events in their lives. The second is to better understand the developmental factors that affect how individuals perceive and respond to experiences as being adverse (or not). These goals are reflected in the Topological Approach to Adversity and Development, as described below.

Moving Beyond Events to Capture Meaning

There is a long history in stress research that points to a critical role of interpretations or perceptions of events, rather than the events themselves, in shaping variability in stress responses. As noted above, this makes intuitive sense: It is easy to think of situations where individuals experience the same event but do not similarly perceive it or react to it as a stressor. The idea is a simple one: The body does not activate a response to threat until an individual perceives or feels themselves to be threatened. We could, in theory, expose an individual to all sorts of things we consider to be threatening or stressors. But if the recipient does not view themselves as unsafe, there will be minimal psychological or physiological responses to our attempts (McEwen & Akil 2020, Pollak & Smith 2021). Conversely, an individual may trigger a stress response in the absence of any objective external event simply by perceiving themselves as in danger, through rumination over previous experience, or through anxiety about the future (Hilt & Pollak 2013, Ottaviani et al. 2016). It is these interpretations of their circumstances that drive people’s stress responses. That is why even the administration of potent laboratory stress-induction techniques, such the Trier Social Stress Test, consistently yields a significant proportion of participants

who do not show stereotypical biological responses to the stressor: Approximately a third of individuals who undergo the technique are not especially troubled by the public-speaking and performative evaluation component of the task, while others find it extremely threatening and activate physiological systems consistent with their feelings (Harnett et al. 2015, Seery 2011).

For this reason, it is important for the field to move toward methods that capture the wide range of factors that can shape how children perceive and interpret events in their lives. This idea is highlighted by growing research directly examining child and adult reports of adversity. Evidence consistently suggests that child reports of adversity have more predictive power than adult reports of the child's experiences. Youth reports of positive parenting, but not parent reports, moderate the effects of stress exposures on both behavioral outcomes and hippocampal volume; the links between stress exposure, poorer behaviors, and reduced hippocampal volume are strongest for youth reporting lower levels of positive parenting (Kahhalé et al. 2023). Additionally, youth reports of household chaos and unpredictability have been linked to increased externalizing and internalizing behaviors and alterations in emotional learning and decision-making processes (Hunter-Rue et al. 2024, Xu et al. 2023). These effects were specific to youth reports—caregiver reports and other indices of “objective” life events demonstrated no relation. Additionally, child-reported stress is linked to dampened cortisol and blood pressure responses to an acute stressor—again, these effects were specific to child-reported perceived stress and were not observed for either child- or parent-reported stressor exposures (Allwood et al. 2017). Together, these studies point to a need to move away from research relying on environments and experiences alone, and instead toward assessing children's own perceptions of their experiences directly.

Perceptions themselves do not cause health and behavioral problems. Rather, perceptions trigger patterns of responses across neural and biological systems. For example, the way an individual construes an event as adverse can lead to distinct autonomic cardiovascular responses. If individuals consider their personal resources as sufficient to outweigh a situational demand, they evince increased sympathetic cardiac activation, accompanied by increased cardiac output and decreased vascular resistance. But if individuals perceive that same situation as outweighing their personal resources, their increased sympathetic cardiac activity is accompanied by decreased cardiac efficiency, little change in cardiac output, and increased vascular resistance (Mendes & Park 2014). These cardiovascular patterns have been linked to distinct behavioral responses (Jamieson et al. 2012) and likely have implications for later cardiovascular risk; the latter pattern of response is associated with heightened risk. This is not to say that the specific events to which a child is exposed hold no explanatory power or do not shape their experiences of adversity. The problem has been the sole reliance on using what happened to a child without considering how the child experienced the circumstances. As Aldous Huxley (1932, p. 5) famously noted: “Experience is not what happens to a man [*sic*]; it is what a man does with what happens to him.” Events shape our experiences but are not the sole drivers of what constitutes our experience. The meaning, value, and understanding of our experiences are subjective, determined by our interpretations, histories, and contexts. This meaning is also driven and changed by our subsequent experience as we begin responding to events. In essence, our experiences are not only what happened to us but also active constructions influenced by our thoughts, feelings, and actions. Key developmental questions relate to how we determine what dimensions or factors are likely to influence a child's thoughts, feelings, and actions when they confront potentially challenging situations.

What Affects Perceptions of Life Events?

Although perceptions serve a critical role in creating the experience of adversity, they are not likely to be the primary mechanism of developmental change, etiology of pathology, or targets of

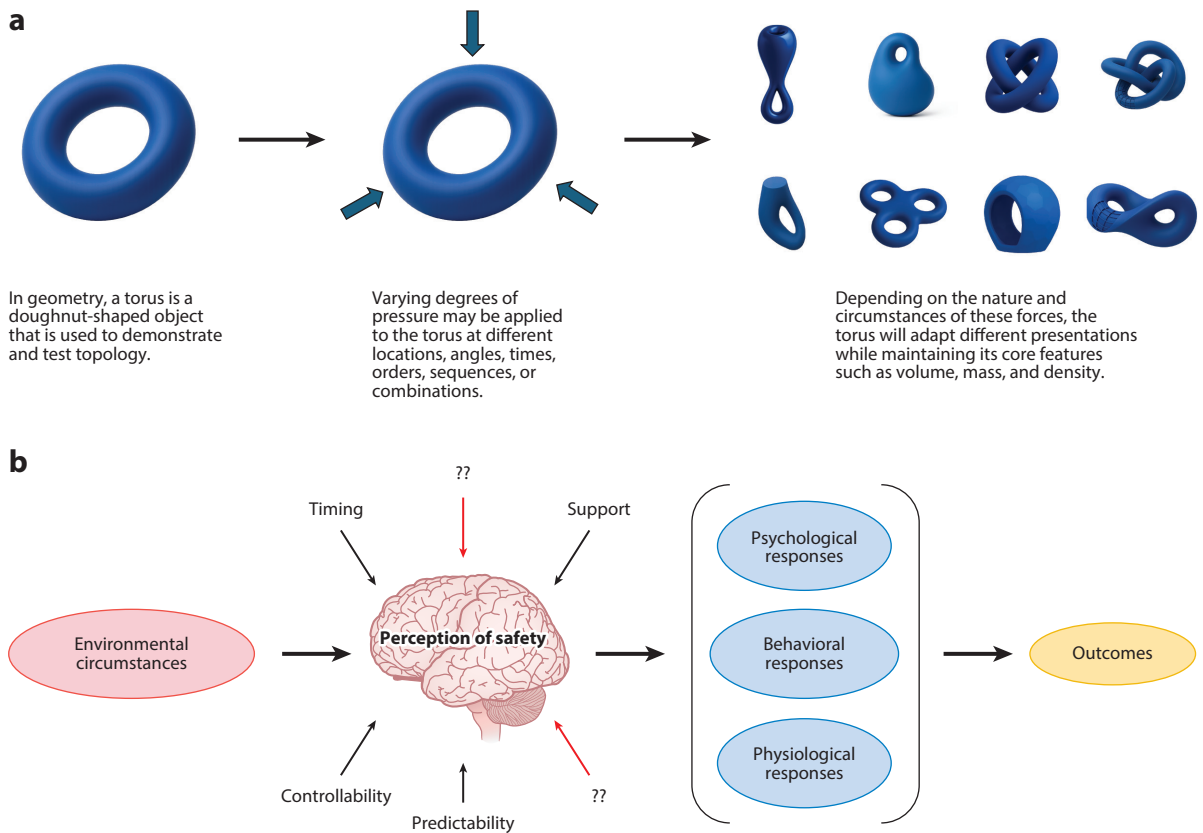


Figure 2

(a) Topology in mathematics serves as a useful analogy for contemporary approaches to understanding adversity and developmental outcomes. (b) In the same way that various pressures can change the presentation of a torus, we can consider the factors and circumstances that affect how children perceive, interpret, and make meaning of their life experiences. Although it is well-known that perceptions form the link between environmental events and biobehavioral outcomes, the perceptions themselves are not the primary developmental variable of interest. Rather, the central questions are how and why individuals come to construe particular events as adverse or not. It is that type of meaning making that shapes the physiological, behavioral, and psychological systems that produce healthy and unhealthy developmental outcomes. Images in panel *a* created in Copilot (December 20, 2025).

intervention. Rather, the target of inquiry will need to focus on identifying the dimensions that contribute to the ways individuals learn to understand and interpret their experiences. In short, we need to understand what has led an individual to their interpretation of and reaction to a circumstance. One new approach to addressing this question is the Topological Approach to Adversity and Development (Pollak & Smith 2021, Smith & Pollak 2021a) (**Figure 2**). In mathematics, topology refers to the fact that an object can undergo dimensional changes such that the object itself is preserved while taking on different shapes, appearances, and functions. In other words, there is an initial structure that maintains its core features (e.g., mass, volume, and density), but various factors can deform that structure along different dimensions, resulting in a variety of distinct outcomes. The analogy here is that geometric problems do not depend on the exact initial shape of the object but instead on how the object is put together and changed on the basis of experience. Rather than a formal model with specific predictions, the Topological Approach to Adversity and Development is meant to reorient and motivate novel lines of inquiry into the role

of adversity on development, with a focus on *how* a potential myriad of dimensions of an individual's developmental history influences how they experience events. This heuristic shifts the focus from the specific types or number of events a child encounters toward the dimensions or factors that shape whether they perceive those events as compromising their safety.

Identifying these dimensions requires that we take a multilevel, integrative approach to the science of adversity. The current era in psychological science has prioritized the identification of biological mechanisms linking early adversity with health outcomes, but nonhuman animal and human models of stress point to multiple levels of analysis in the generation of complex behaviors. Stress responses encompass a complex suite of changes in physiology, cognition, and affect, with each of these systems bidirectionally influencing the others in ways that can affect an individual's perception of events. Across studies of humans and nonhuman animals, there is both a wide range of types of responses to adversity and variability in the degree of responses to adversity, neither of which is driven merely by the type of event the organism encountered (Berntson & Cacioppo 2004, Weissman & Mendes 2021). Several key dimensions affect how an individual will perceive their circumstances, including timing, predictability, controllability, and social relationships. Recent evidence suggests a variety of ways in which these dimensions may affect children's perceptions, understanding of their circumstances, and behavioral responses such as configuring learning and decision-making parameters (Fields et al. 2021, Smith & Pollak 2022, Xu et al. 2023) in ways that have implications for a host of outcomes relevant to health and well-being. These outcomes include self-regulatory processes (Kim & Kochanska 2026, Palacios-Barrios & Hanson 2019, Smith et al. 2023), shifts in emotion understanding (Bérubé et al. 2025, Diaconu et al. 2023, Hartling et al. 2019), and altered executive functioning (Lewis et al. 2024, Mittal et al. 2015, Young et al. 2022). Traditionally, when these dimensions were studied, they were treated as moderators between an event and a response. But because different behavioral patterns, rather than events or stimuli, drive neural responses, these factors appear to be more than moderators. The Topological Approach to Adversity and Development allows us to integrate developmental context and learning histories to uncover both how and why experiences may or may not become adverse, as well as the nature of the sequelae activated for different people given their circumstances.

Below, we outline evidence for the abovementioned dimensions in shaping children's experiences and interpretations of stress. These are neither exclusive nor exhaustive, and this approach does not imply that genetic or personality factors are not part of the puzzle.

Timing

How a child perceives and interprets the events happening to them is dependent on their stage of cognitive development as well as other aspects of developmental timing, including sensory, perceptual, and learning mechanisms. Most critical stress-response systems experience rapid growth during infancy and early childhood; the organization of these systems is scaffolded by inputs from caregivers and the physical environment (Casey et al. 2019, Faig et al. 2023). Developmental timing reflects not only periods when a child is exceptionally receptive to and ready for certain experiences but also periods when children may be overwhelmed or simply unresponsive to those inputs. The general principle is that while a child's body and brain are immature at birth, their healthy development depends on their interaction with the environment: what they experience, how they experience it, and—critically for some aspects of development—when the experiences occur. In many domains, the timing of exposure matters for future learning. Early development is also a time when bodies become conditioned to the degree of stress they must manage. Environments vary in the physical and emotional demands they place on the people living in them—some have extreme temperatures, in others the food supply can swing between feast and famine, and

in still others the number of pathogens encountered can be very high or relatively low. Stress-reactive biological systems become calibrated early in life on the basis of these parameters. While the responses of these systems help preserve life, they are also metabolically costly, so there is a trade-off between adaptation and wear and tear on the body. The experimental evidence that early life is a sensitive period for calibrating the set points for stress-responsive systems comes from research on nonhuman animals, suggesting that this period involves epigenetic programming of stress-regulating genes (Meaney & Szyf 2005). In rodents, offspring of mothers who provide low care have higher stress-reactive systems than offspring of mothers providing very high care. Of course, care in rodents is not identical to care of human infants. Nonetheless, adversity experienced in early childhood appears to be associated with changes in DNA methylation (Romens et al. 2015), whereas recent adversity or accumulation of adversity is not (Dunn et al. 2019). Consistent with these ideas, numerous studies have found that earlier timing of adversity is associated with elevated psychopathology risk in childhood (Vannucci et al. 2025). Currently, we do not know how much difference there needs to be in the harshness of the environment to detect changes in the set point of stress-response systems. Data about the developmental timing of early life adversity—particularly institutionalized rearing, neglect, and physical abuse—have been interpreted as evidence of critical or sensitive periods for socioemotional or stress system development. For various reasons, however, extant data cannot support such specific claims (for discussion, see Woodard & Pollak 2020).

Predictability

Human brains have a remarkable ability to detect statistical regularities (Saffran & Kirkham 2018). Predictability (or unpredictability) in children's lives may range from the level of sensory input (Davis & Glynn 2024) to broader characterizations of the societal, cultural, or public policy influences that affect children's daily lives (Liu & Fisher 2022) and can vary along different subdimensions (Ugarte & Hastings 2024). Predictable inputs from caregivers and the broader environment play a critical role in children's development (Munakata et al. 2023). Even very young infants detect patterns, use them to form expectations about what will happen next, and react when their expectations are violated. Infants then use their incorrect predictions to fine-tune and expand their learning (Frankenhuis & Gopnik 2023, Romberg & Saffran 2013, Ruba et al. 2022, Wismer-Fries & Pollak 2017, Xu et al. 2023). Predictability is so critical to brain development that its effects can be observed even when other important characteristics of care, such as sensitivity and a positive regard for the child, have been controlled for statistically (Glynn & Baram 2019). Lack of predictability in the environment has at least two effects. First, chaotic or irregular environments make it more difficult for children to learn patterns in their lives and in other people's behaviors. Indeed, unpredictable caregiver inputs in infancy and early childhood have been linked to poorer learning, memory, and executive functioning later in childhood, independently of caregiver sensitivity (Davis et al. 2019) and poorer self-regulatory behaviors (Aran et al. 2024). Second, unpredictability leads children to perceive their lives as uncertain or volatile (K.E. Smith, P. Piray, A. Teal, S. Gok & S.D. Pollak, manuscript in revision), resulting in feelings of anxiety that extend the activation of stress-response systems (Soltani & Izquierdo 2019). These physiological states can cause individuals to make decisions aligned with their belief that the world is an unstable place (Gopnik et al. 2020). This extended activation of stress-response systems also alters brain architecture in regions such as the prefrontal cortex, amygdala, and hippocampus, undermining flexible and adaptive regulation and coping (Davis & Glynn 2024). In contrast, relationships that are stereotypically repetitive, highly predictable, and marked by contingent responses foster healthy development of the prefrontal-amygdala-hippocampal systems that help support well-regulated behaviors (Fisher et al. 2016).

Controllability

Tightly linked to, but distinct from, the construct of predictability is that of controllability. Our brains are exquisitely capable of detecting when our actions produce results, and awareness of this association activates neural reward systems. Humans and nonhuman animals will exert effort to maintain control, which, in turn, is associated with increased activation in dopaminergic circuits including the striatum and ventral tegmental area. Additionally, perceived control itself elicits positive subjective value, encoded in the ventromedial prefrontal cortex, and is linked to dampened stress reactivity (for a review, see Wang et al. 2021). Perceived control blunts conditioned threat responses and improves recovery from stress (Hartley et al. 2014), reduces negative affect and increases persistence (Bhanji et al. 2016), reduces the intensity of painful stimuli (Bräscher et al. 2016), and blunts cortisol and neural reactivity to acute social stressors (Harnett et al. 2015, Pruessner et al. 2005). A child's feelings of agency reduce fearfulness (Gunnar-vonGnechten 1978), and early caregiver relationships appear to shape the development of such agency (Champagne & Curley 2005). Several recent findings are consistent with the critical role of perceived control. Perceived controllability of childhood stressors is associated with reduced trauma-related symptomatology in adulthood (Cohodes et al. 2023), and adolescents who report reduced levels of perceived control over stress demonstrate increased amygdala gray matter volume (Fassett-Carman et al. 2022). In slightly younger (8–12-year-old) children, higher perceived control is associated with increased adaptive stress coping (Zimmer-Gembeck et al. 2016).

Social Relationships

For humans, stable, supportive relationships are critical for survival. Three dimensions of social relationships appear to have a central role in whether individuals will perceive a situation as adverse. The first is parent–child sensitivity. The importance of sensitive early relationships to development is well-established. Early sensitive caregiving regulates the development of prefrontal inhibitory circuits involved in threat processing (Gunnar et al. 2015b). Evidence from nonhuman primates and rodents indicates that parental presence inhibits neurobiological threat-response systems (Sanchez et al. 2015), yet when these early relationships are disrupted by insensitive maternal rearing, maternal presence does not buffer against stress (Wisner-Fries et al. 2005). Under these circumstances, rodent pups and primate infants demonstrate enhanced physiological stress responses (Santiago et al. 2018). Similarly, children and adolescents who have a parent present while undergoing laboratory stressors show less cortisol (Hostinar et al. 2015) and amygdala (Gee et al. 2014) reactivity as well as faster recovery following exposure to a stressor (Seltzer et al. 2010). The effects of caregivers' presence on infants' and young children's healthy responses to laboratory stress are most apparent for children whose parents demonstrate high levels of sensitivity (Brown et al. 2020).

Two additional dimensions of social relationships have the potential to shape experiences of adversity. The first is social support, defined as the degree to which an individual perceives themselves as supported by others (Eisenberger 2013). The second is loneliness, the degree to which an individual perceives themselves as lacking sufficient social connections to meet their social needs (Hawkey & Capitanio 2015). Individuals who perceive their social connections as stable and supportive have better mental and physical health and reduced psychological and physiological responses to stress (Hostinar & Gunnar 2015, Shirtcliff et al. 2009). On the basis of this association, supportive relationships are hypothesized to engage prefrontal circuits in processing safety, particularly the ventromedial prefrontal cortex, which in turn inhibits HPA axis responses (Coan et al. 2017). Loneliness appears to shift activation in stress-related circuits, such as by altering connectivity between prefrontal (particularly ventromedial and medial) regions and the amygdala

and elevating autonomic, cardiac, and inflammatory responses (Quadt et al. 2020). Children and adolescents who report higher levels of chronic rejection show heightened activation in neural regions including the dorsal anterior cingulate cortex and anterior insula when being socially excluded (Masten et al. 2012, Will et al. 2016); these reactions are linked to increased experiences of distress (Rotge et al. 2015). Loneliness also moderates responses to adverse events, shifting decision making toward increased avoidance (Smith & Pollak 2022); this finding suggests that these perceptions are critical component for shaping responses to events in children's environments. Directly supporting a link between perceptions of social relationships and experiences of adversity is the finding that adolescents who reported high levels of loneliness report increased levels of perceived stress and demonstrate heightened sensitivity to negative information (Vanhalst et al. 2017). These effects are apparent in the absence of events that would be identified as adverse or stressful using traditional methods. Loneliness emerges as early as 4 years of age (Qualter & Munn 2002), suggesting that it may start to exert effects on experiences of stress early in life that may then have downstream consequences for health risk (Faig et al. 2025). Indeed, perceived social isolation during this period is a unique predictor of later depression and anxiety (Qualter et al. 2010).

ADVERSITY REFLECTS LACK OF SAFETY

Most research on adversity is oriented around the ideas that particular events trigger or activate threat responses and that overactivation of these responses negatively affects development. However, recent formulations consider adversity not as the presence of threat but rather as the absence of perceived safety (Brosschot et al. 2018). This view proposes that organisms' default state is one of active threat monitoring and that environmental cues of safety serve to downregulate potential threat responses via inhibitory processes. When individuals perceive themselves as unsafe, threat responses become deinhibited, thus rapidly heightening reactivity to address a potential threat. In other words, rather than a situation turning on the threat-response system, the threat-response system is always activated and that activation is suppressed only when individuals perceive themselves to be safe; as perceived safety is diminished, the suppression of the threat system is loosened, allowing greater responsiveness. This idea of perceived safety in relation to stress responses has a long history in developmental research. Long before children are able to manage circumstances on their own, their assessments of their abilities to cope with potential challenges is dependent on caregivers who, often merely by their presence, signal safety. This is because consistent, reliable, and sensitive caregiving leads infants to expect that caregivers will protect them from harm (Bourne et al. 2022, Slavich 2022, Smith & Pollak 2021b). These expectations do not form when caregivers are unpredictable or unreliable. The potentially important role of perceived safety is supported by evidence across species and developmental stages, suggesting that safety signals play a critical role in fear and stress learning as well as responding (Callaghan et al. 2019, Sullivan & Opendak 2018). Safety signals increase activity in brain regions such as the ventromedial prefrontal cortex that dampen the activity of threat-responsive circuits (Motzkin et al. 2023). Moreover, perceptions of safety have a strong influence on how individuals evaluate their coping resources, modulating their interpretations and responses to the circumstances they encounter (Jamieson et al. 2018). When children perceive themselves as having safe and supportive caregivers, they employ learning strategies more conducive to their environments (Fields et al. 2021, Xu et al. 2023, Young et al. 2022). But when children perceive themselves as lacking sufficient supportive relationships, this may translate to increased avoidance and overall reduced learning (Smith & Pollak 2022). Based on the strength and consistency of this emerging literature, our current formulation of the Topological Approach to Adversity and Development

views dimensions such as predictability, controllability, and social relationships as contributing to whether individuals are likely to perceive themselves as safe or unsafe in a variety of circumstances. These perceptions or feelings of safety, in turn, determine whether those circumstances constitute adversity.

CAPTURING DIMENSIONS OF ADVERSITY: POTENTIAL NEW AVENUES FOR ASSESSMENT

Adopting the Topological Approach to Adversity and Development requires decreasing our reliance on existing measures that are exclusively about events and instead creating and refining measures that also capture the dimensions that shape children's interpretations of their life events. This is easier said than done. There are compelling reasons why the field relies almost exclusively on event checklists. We already know how to create, use, and combine questionnaires that gather and sum people's event exposures. These measures are familiar, easy, and comfortable for the vast majority of psychological scientists. But if we want to expand our knowledge beyond the status quo, the next generation of research will require tools that reliably ascertain children's own experiences of their life circumstances. While developing these types of measures will not be easy, psychologists have devised creative ways to measure all sorts of abstract, representational knowledge and thinking across many domains and developmental epochs. Although we cannot yet envision how to do so with preverbal infants, there is sufficient evidence that even very young children can describe their perceptions and experiences in ways that provide researchers with meaningful information.

Not all of these measures need to be created *de novo*, as there are already a number of appropriate and well-validated instruments in the field that capture some aspects of this type of information. Children as young as 4 and 5 years have a conceptual understanding of what it means to be lonely, are able to report on their feelings of loneliness, and engage in coping behaviors (e.g., social engagement) in response to feeling lonely (Besevegis & Galanaki 2010, Cassidy & Asher 1992, Qualter & Munn 2002). School-aged children are able to successfully report on perceptions and interpretations of their life events (Williamson et al. 2003), subjective experiences of unpredictability (Glynn et al. 2019), perceptions of parenting behaviors and caregivers (Kahhhalé et al. 2023), and views of their family's social status (Goodman et al. 2001). A handful of recent studies have explicitly sought to measure individuals' own perceptions of adversity and have done so successfully. These projects are generating novel insights by capturing variation in behavioral, health, and biological outcomes that vary by children's perceptions of their life circumstances (Danese & Widom 2020, Rivenbark et al. 2020, Smith & Pollak 2022). There are also existing measures in which young children reliably report on adverse experiences in their lives, such as the Violence Exposure Scale-Revised (Fox & Leavitt 1995) and the Life Stress Interview (Rudolph et al. 2000). Currently, these instruments are designed to code and score objective events in children's lives. But these measures provide evidence that children can, and do, report adversity-relevant information. A proximal and relatively easy future direction would be to simply modify these existing measures to probe and score children's reflections about what these events were like for them in terms of their interpretations of intensity and meaningfulness. Indeed, while the Life Stress Interview coding scheme focuses on identifying and summing events, it incorporates probes about how the child is experiencing those events, which could be further coded to provide insight into their interpretations.

These existing measures leave us sanguine that new assessment measures targeted toward providing insight into children's mental states and what they have construed about their life events are feasible. As an example, the Schedule for Affective Disorders and Schizophrenia for School-Age Children for the Assessment of Preschool Children (Birmaher et al. 2009) queries children

as young as 2 years about complex topics. This measure uses both visual aids and concrete time anchors to help children recount details of their experiences. For example, timelines are created with child-generated responses (“Here was your birthday. . . and here was when your grandpa visited,” or “Here is when the weather was very hot outside, and here is when you started day care”). One can imagine developing novel measures that try to directly assess children’s perceptions of stress, timing, predictability, controllability, and social relationships using concrete anchors related to those topics (e.g., “Here is when you felt really upset about your dog dying, and here is when you felt really excited about your birthday party. . . Show me where you felt when [concrete event] happened”). Methods that probe how children feel, rather than relying on the presupposition of how we think they ought to feel, can be accomplished through play, observations, and concrete visual aids including thermometers, emojis, and spatial graphics. These represent potentially fruitful avenues to advance our understanding of the mechanisms through which adversity shapes development.

FUTURE DIRECTIONS

Scientists have garnered a wealth of accumulated knowledge about the cognitive and biological processes underlying stress responses and have established that early adversity is associated with a critical risk to health and development. The next step will be to generate significant advances in knowledge about how these effects emerge. To produce the specificity in findings needed to generate truly effective interventions, new approaches are necessary. Based on our view of the extant literatures, a promising new direction is an increased focus and integration of data about what shapes and influences the way individuals interpret and make sense of the circumstances they encounter. In this kind of dimensional approach, the dimensions of interest are the factors affecting children’s perceptions of safety, rather than simply subtypes of events. We refer to this new type of approach as topological, in that any type of dimension can be considered if there is reason to believe it might have cascading developmental effects that influence how an individual might come to respond to a potentially stressful event and subsequently experience it as adverse. This shift in focus is not specific to adversity research but rather reflects a contemporary shift in thinking across many fields of psychology. Historically, psychologists have sought general laws of behavior focused on aggregate responses to stimuli, under the assumption that the same stimulus should elicit comparable responses across individuals. Variability has largely been treated as noise, exceptions to the rule, error variance, or individual differences that would need to be the subject of future research to qualify as an effect. But scientists are beginning to view variability as central to understanding human behavior. For example, in the field of emotion, researchers are moving away from the idea that any given stimulus item will elicit a particular emotion or the same emotion across individuals (Hoemann et al. 2021, Ruba & Pollak 2020).

While we have pointed to discrepancies across theoretical frameworks, there are also overlapping trends. There is general agreement on the need to expand beyond cumulative models of adversity toward models that capture different dimensions of experience. And there is now emerging consensus about the critical role of some specific dimensions, such as unpredictability, social support, and controllability on children’s development. Among the most pressing future directions is the need for researchers to decrease their reliance on the identification of the events happening to the child and to focus instead on identifying the proximal factors shaping how the child is interpreting those events. Doing so is difficult, in part, because it represents a shift away from what is ubiquitous and familiar. However, we are already seeing new and creative research moving toward capturing children’s perceptions and experiences. As one promising example, we now appreciate

that unpredictability is not a unitary construct best captured by the presence or absence of any specific event (Liu & Fisher 2022, Ugarte & Hastings 2024, Xu et al. 2023); rather, predictability is generated by both environmental statistics (Walasek et al. 2024) and children's perceptions (Glynn et al. 2019). We have outlined potential directions to expand upon this research, but this is not an exhaustive list, leaving open opportunities for novel and creative innovation toward measurement within the field of adversity.

Reliance solely on overly broad, fuzzy grouping categories transmits the idea that individual differences are relatively unimportant or minor. Expanding our understanding of dimensions of experience can illuminate the individual differences through which neurobiological systems may shape children's future health and behavior. Understanding these mechanisms is critical to providing insight into what types of interventions and policies may be more or less effective for different subsets of individuals.

APPENDIX 1: THE JINGLE/JANGLE PROBLEM IN ADVERSITY RESEARCH

Various terms have been used to describe the issues we discuss here. These include stress, strain, adversity, trauma, violence, maltreatment, threat, deprivation, abuse, neglect, risk, arousal, and allostatic load, as well as combinations of these terms. This inconsistent use of precise terminology results in a “jingle/jangle” problem: The same word can describe different constructs, while different words can refer to the same phenomenon. Clarifying all terms and their relations is beyond the scope of this review (instead, see Remmers et al. 2024, Richter-Levin & Sandi 2021). Here, we use the term “adversity” to refer to situations where individuals perceive themselves to be in chronic situations that challenge their abilities to regulate their thoughts, behavior, and safety. Adversity represents a chronic form of stress, which more broadly refers to demands placed on an individual that require adaptation or change; those demands, referred to as stressors, trigger physiological, psychological, and behavioral changes to address those challenges. The idea of a state of equilibrium, regulation, or allostasis dates to the pre-Socratic philosophers (for a review of the history of stress as a concept, see Agorastos & Chrousos 2022). However, the term “stress” was not introduced to psychology until Selye (1936) borrowed it from physics to describe forces within the body that balance and react to challenges in the form of a nonspecific neuroendocrine response. But this early approach did not account for the wide-ranging variability in organisms' responses to stress (Gunnar et al. 2015a, Kim & Kim 2023, Smith et al. 2017). Contemporary models of stress recognize that some stress responses can be specific but that specificity is shaped by individuals' perceptions of the stressor rather than by the stressor itself (McEwen & Akil 2020, Pollak & Smith 2021, Sapolsky 2015). Colloquially, stress is often thought of as negative, yet it also represents a normal and necessary process that allows individuals to address perceived challenges. It is chronic or extreme stress that has a wide range of negative consequences, for which the term “adversity” is appropriate.

In attempting to make the risks associated with childhood adversity comprehensible to the general public, some researchers began using the term “toxic stress” to describe these latter experiences. However, it is important for scientists to recognize that this is a marketing term, not a scientific one, that is misleading and syllogistic. So-called toxic stress refers to stressful experiences that lead to negative outcomes—but how does one know if a stressor is toxic and will lead to a negative outcome? The circular answer is that stress is toxic only if it led to a negative outcome, rendering such a label unhelpful. The problems inherent in the use of such terms reflect the unsubstantiated idea that some events are, by their very nature, inherently pathognomonic—regardless of how an individual feels, perceives, or reacts to them.

APPENDIX 2: LUMPING VERSUS SPLITTING AND SENSITIVITY VERSUS SPECIFICITY

A heuristic for thinking about how researchers construe adversity is lumping versus splitting. Lumping treats different types of adversity as generally similar. Characterized by the ACE and allostatic load approaches, any event deemed stressful is assumed to have similar effects on the individual; it is the sum of event exposures, not the nature of any particular event, that is the main variable. Splitting approaches attempt to identify specific types or categories of events presumed to have distinct effects. Examples of splitting include foci on threat versus deprivation, harshness versus unpredictability, or exclusive focus or distinctions between categories such as physical abuse, neglect, witnessing domestic violence, or experiencing food insecurity. These approaches also rely on the summing of event exposures, but by category. Lumping relies on the assumption that distinctions between events within a category are less important, whereas splitting assumes both important differences between categories and similarity of events within a category. Lumping is a simpler classification system because it avoids attention to potentially trivial or nonmeaningful differences. Splitting increases the possibility of discovering variability important for understanding mechanisms and individual differences. Problems emerge with both approaches when the classifications are unsound, either by distorting or masking reality or by glossing over critical features. At present, both the lumping and splitting approaches most used in the adversity literature suffer from these problems. This classification problem combines with the issue of sensitivity–specificity trade-offs, resulting in the current difficulties in the study of adversity. Sensitivity refers to correctly identifying true positives—if there is an effect of adversity, will it be detected? Specificity is the exclusion of false positives—will we observe effects that are real, including when no relationships are present? Sensitivity and specificity are always at the expense of the other, particularly in theories of causation and etiology. Sensitivity is essential for detecting risk factors and causal mechanisms underlying developmental problems, but specificity is necessary to distinguish precise critical features and to rule out alternative explanations. The lumping and splitting approaches currently used in adversity research all have very high sensitivity paired with very low specificity, which is why almost any kind of adversity exposure will show a positive correlation with almost any kind of outcome, masking underlying causal mechanisms and producing inconsistent patterns of data. Finding approaches that balance sensitivity and specificity will improve both scientific rigor and clinical utility.

SUMMARY POINTS

1. The classification of adversity has focused on exposure to events, but this approach misses individual differences in how people perceive those events.
2. We do not yet have data confirming that the types of events researchers have typically characterized as adverse necessarily affect central nervous system development, nor is it clear that these types of events are applicable across contexts, cultures, and social groups.
3. Existing data reflect only correlations between gross measures of adversity and a broad variety of negative outcomes, but identifying mechanisms of development requires greater specificity.
4. The Topological Approach to Adversity and Development orients the focus of scientific inquiry on the developmental factors that shape variability in perceptions of threat and safety, which, in turn, can result in experiences of stress.

5. Increased attention to the psychological dimensions that contribute to individuals feeling a sense of safety are key to explaining not only individual differences in how people understand and respond to their experiences but also greater specificity in the developmental effects of adversity.

FUTURE ISSUES

1. A next step in adversity research will be to move beyond the identification of correlations so that scientists are able to explain how and why adversity leads to specific negative health and behavioral outcomes.
2. New measures are needed to understand the dimensions of developmental experiences that influence the way individuals interpret and make sense of the circumstances they encounter.
3. The Topological Approach to Adversity and Development shifts emphasis from merely documenting life events toward a deeper understanding of the range of dimensions that lead individuals to experience potential challenges in their lives as threatening their safety.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

This research was supported by the National Institute of Mental Health under grant R01MH61285 to S.D.P. and by a Rutgers University Research Council Individual Fulcrum Award to K.E.S. The authors thank Jutta Joorman for comments on an earlier draft of this manuscript.

LITERATURE CITED

- Agorastos A, Chrousos GP. 2022. The neuroendocrinology of stress: the stress-related continuum of chronic disease development. *Mol. Psychiatry* 27:502–13. <https://doi.org/10.1038/s41380-021-01224-9>
- Ahrenholtz R, Hiser J, Ross MC, Privratsky A, Sartin-Tarm A, et al. 2021. Unique neurocircuitry activation profiles during fear conditioning and extinction among women with posttraumatic stress disorder. *J. Psychiatr. Res.* 141:257–66. <https://doi.org/10.1016/j.jpsychires.2021.07.007>
- Akasaki M, Steptoe A, Hardy R. 2025. Adverse childhood experiences and diurnal cortisol pattern and heart rate variability in adults. *Psychoneuroendocrinology* 173:107359. <https://doi.org/10.1016/j.psyneuen.2025.107359>
- Allwood MA, Gaffey AE, Vergara-Lopez C, Stroud LR. 2017. Stress through the mind of the beholder: preliminary differences in child and maternal perceptions of child stress in relation to child cortisol and cardiovascular activity. *Stress* 20:341–49. <https://doi.org/10.1080/10253890.2017.1336617>
- Aran Ö, Swales DA, Bailey NA, Korja R, Holmberg E, et al. 2024. Across ages and places: unpredictability of maternal sensory signals and child internalizing behaviors. *J. Affect. Disord.* 347:557–67. <https://doi.org/10.1016/j.jad.2023.11.068>

- Belsky J, Schlomer GL, Ellis BJ. 2012. Beyond cumulative risk: distinguishing harshness and unpredictability as determinants of parenting and early life history strategy. *Dev. Psychol.* 48:662–73. <https://doi.org/10.1037/a0024454>
- Berntson GG, Cacioppo JT. 2004. Heart rate variability: stress and psychiatric conditions. In *Dynamic Electrocardiography*, ed. M Malik, AJ Camm. John Wiley & Sons, Inc.
- Bérubé A, Pearson J, Blais C, Forget H. 2025. Stress and emotion recognition predict the relationship between a history of maltreatment and sensitive parenting behaviors: a moderated-moderation. *Dev. Psychopathol.* 37:281–91. <https://doi.org/10.1017/S095457942300158X>
- Besevegis E, Galanaki E. 2010. Coping with loneliness in childhood. *Eur. J. Dev. Psychol.* 7:653–73. <https://doi.org/10.1080/17405620903113306>
- Bhanji JP, Kim ES, Delgado MR. 2016. Perceived control alters the effect of acute stress on persistence. *J. Exp. Psychol. Gen.* 145:356–65. <https://doi.org/10.1037/xge0000137>
- Bifulco A, Bernazzani O, Moran PM, Jacobs C. 2005. The Childhood Experience of Care and Abuse Questionnaire (CECA.Q): validation in a community series. *Br. J. Clin. Psychol.* 44:563–81. <https://doi.org/10.1348/014466505X35344>
- Birmaher B, Ehmann M, Axelson DA, Goldstein BI, Monk, et al. 2009. Schedule for Affective Disorders and Schizophrenia for School-Age Children (K_SADS_PL) for the assessment of preschool children—a preliminary psychometric study. *J. Psychiatr. Res.* 437:680–86. <https://doi.org/10.1016/j.jpsychires.2008.10.003>
- Bourne SV, Korom M, Dozier M. 2022. Consequences of inadequate caregiving for children's attachment, neurobiological development, and adaptive functioning. *Clin. Child Fam. Psychol. Rev.* 25:166–81. <https://doi.org/10.1007/s10567-022-00386-4>
- Bräscher A-K, Becker S, Hoeppli M-E, Schweinhardt P. 2016. Different brain circuitries mediating controllable and uncontrollable pain. *J. Neurosci.* 36:5013–25. <https://doi.org/10.1523/JNEUROSCI.1954-15.2016>
- Brosschot JF, Verkuil B, Thayer JF. 2018. Generalized unsafety theory of stress: unsafe environments and conditions, and the default stress response. *Int. J. Environ. Res. Public Health* 15:1–27. <https://doi.org/10.3390/ijerph15030464>**
- Brown SM, Schlueter LJ, Hurwich-Reiss E, Dmitrieva J, Miles E, Watamura S. 2020. Parental buffering in the context of poverty: Positive parenting differentiates young children's stress reactivity profiles. *Dev. Psychopathol.* 32:1778–87. <https://doi.org/10.1017/S0954579420001224>
- Buchanan M, Walker G, Boden JM, Mansoor Z, Newton-Howes G. 2023. Protective factors for psychosocial outcomes following cumulative childhood adversity: systematic review. *Br. J. Psychol. Open* 9:e197. <https://doi.org/10.1192/bjo.2023.561>
- Burani K, Brush CJ, Spahr C, Slavich GM, Meyer A, Hajcak G. 2023. Corporal punishment is uniquely associated with a greater neural response to errors and blunted neural response to rewards in adolescence. *Biol. Psychiatry Cogn. Neurosci. Neuroimaging* 8:210–18. <https://doi.org/10.1016/j.bpsc.2022.09.004>
- Callaghan B, Meyer H, Opendak M, Tieghem MV, Harmon C, et al. 2019. Using a developmental ecology framework to align fear neurobiology across species. *Annu. Rev. Clin. Psychol.* 15:345–69. <https://doi.org/10.1146/annurev-clinpsy-050718-095727>
- Carosella KA, Wiglesworth A, Bendežú JJ, Brower R, Mirza S, et al. 2023. Patterns of experience, expression, and physiology of stress relate to depressive symptoms and self-injurious thoughts and behaviors in adolescents: a person-centered approach. *Psychol. Med.* 53:7902–12. <https://doi.org/10.1017/S0033291723002003>
- Casey BJ, Heller AS, Gee DG, Cohen AO. 2019. Development of the emotional brain. *Neurosci. Lett.* 693:29–34. <https://doi.org/10.1016/j.neulet.2017.11.055>
- Cassidy J, Asher SR. 1992. Loneliness and peer relations in young children. *Child Dev.* 63:350–65
- Champagne FA, Curley JP. 2005. How social experiences influence the brain. *Curr. Opin. Neurobiol.* 15:704–9. <https://doi.org/10.1016/j.conb.2005.10.001>
- Chen Y, Fuller J, Ryberg R. 2023. *Knowing the strengths and limitations of poverty measures can help us better understand poverty*. Rep., Child Trends. <https://www.childtrends.org/publications/known-the-strengths-and-limitations-of-poverty-measures-can-help-us-better-understand-poverty>

Proposes a novel theoretical framework in which stress represents a lack of perceived safety rather than the presence of a perceived threat.

Presents evidence that subjective, but not objective, reports of child maltreatment drive later psychopathology risk.

- Coan JA, Beckes L, Gonzalez MZ, Maresh EL, Brown CL, Hasselmo K. 2017. Relationship status and perceived support in the social regulation of neural responses to threat. *Soc. Cogn. Affect. Neurosci.* 12:1574–83. <https://doi.org/10.1093/scan/nsx091>
- Cohodes EM, Sisk LM, Keding TJ, Mandell JD, Notti ME, Gee DG. 2023. Characterizing experiential elements of early-life stress to inform resilience: buffering effects of controllability and predictability and the importance of their timing. *Dev. Psychopathol.* 35:2288–301. <https://doi.org/10.1017/S0954579423000822>
- Danese A, Widom CS. 2020. Objective and subjective experiences of child maltreatment and their relationships with psychopathology. *Nat. Hum. Behav.* 4:811–18. <https://doi.org/10.1038/s41562-020-0880-3>
- Davis EP, Glynn LM. 2024. The power of predictability—patterns of signals in early life shape neurodevelopment and mental health trajectories. *J. Child Psychol. Psychiatry* 65:508–34. <https://doi.org/10.1111/jcpp.13958>
- Davis EP, Korja R, Karlsson L, Glynn LM, Sandman CA, et al. 2019. Across continents and demographics, unpredictable maternal signals are associated with children's cognitive function. *eBioMedicine* 46:256–63. <https://doi.org/10.1016/j.EBIOM.2019.07.025>
- Dennison MJ, Rosen ML, Sambrook KA, Jenness JL, Sheridan MA, McLaughlin KA. 2019. Differential associations of distinct forms of childhood adversity with neurobehavioral measures of reward processing: a developmental pathway to depression. *Child Dev.* 90:e96–113. <https://doi.org/10.1111/cdev.13011>
- Diaconu B, Kohls G, Rogers JC, Pauli R, Cornwell H, et al. 2023. Emotion processing in maltreated boys and girls: evidence for latent vulnerability. *Eur. Child Adolesc. Psychiatry* 32:2523–36. <https://doi.org/10.1007/s00787-022-02132-1>
- Dubowitz H, Newton RR, Litrownik AJ, Lewis T, Briggs E, et al. 2005. Examination of a conceptual model of child neglect. *Child Maltreat.* 10:173–89. <https://doi.org/10.1177/1077559505275014>
- Dunn EC, Soare TW, Zhu Y, Simpkin AJ, Suderman MJ, et al. 2019. Sensitive periods for the effect of childhood adversity on DNA methylation: results from a prospective, longitudinal study. *Biol. Psychiatry* 85:838–49. <https://doi.org/10.1016/j.BIOPSYCH.2018.12.023>
- Eisenberger NI. 2013. An empirical review of the neural underpinnings of receiving and giving social support: implications for health. *Psychosom. Med.* 75:545–56. <https://doi.org/10.1097/PSY.0b013e31829de2e7>
- Evans GW, Li D, Whipple SS. 2013. Cumulative risk and child development. *Psychol. Bull.* 139:1342–96. <https://doi.org/10.1037/a0031808>
- Faig KE, Henech AC, Mousa MS, Smith KE. 2025. How does loneliness impact emotion perception? A systematic review. *Curr. Res. Behav. Sci.* 9:100181. <https://doi.org/10.1016/j.crbeha.2025.100181>
- Faig KE, Smith KE, Dimitroff SJ. 2023. Somatovisceral influences on emotional development. *Emot. Rev.* 15:127–44. <https://doi.org/10.1177/17540739231163180>
- Fassett-Carman AN, Smolker H, Hankin BL, Snyder HR, Banich MT. 2022. Neuroanatomical correlates of perceived stress controllability in adolescents and emerging adults. *Cogn. Affect. Behav. Neurosci.* 22:655–71. <https://doi.org/10.3758/s13415-022-00985-2>
- Feldman Barrett L, Atzil S, Bliss-Moreau E, Chanes L, Gendron M, et al. 2025. The theory of constructed emotion: more than a feeling. *Perspect. Psychol. Sci.* 20:392–420. <https://doi.org/10.1177/17456916251319045>
- Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz A, et al. 1998. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) study. *Am. J. Prev. Med.* 14:245–58
- Fields A, Bloom PA, VanTieghem M, Harmon C, Choy T, et al. 2021. Adaptation in the face of adversity: decrements and enhancements in children's cognitive control behavior following early caregiving instability. *Dev. Sci.* 24:e13133. <https://doi.org/10.1111/desc.13133>
- Fisher PA, Frenkel TI, Noll LK, Berry M, Yockelson M. 2016. Promoting healthy child development via a two-generation translational neuroscience framework: the Filming Interactions to Nurture Development video coaching program. *Child Dev. Perspect.* 10:251–56. <https://doi.org/10.1111/cdep.12195>
- Fox NA, Leavitt LA. 1995. *The Violence Exposure Scale for Children—Revised (VEX-R)*. Clin. Tool, University of Maryland

- Frankenhuis WE, Gopnik A. 2023. Early adversity and the development of explore–exploit tradeoffs. *Trends Cogn. Sci.* 27:616–30. <https://doi.org/10.1016/j.tics.2023.04.001>
- Gee DG, Gabard-Durnam LJ, Flannery J, Goff B, Humphreys KL, et al. 2013. Early developmental emergence of human amygdala-prefrontal connectivity after maternal deprivation. *PNAS* 110:15638–43. <https://doi.org/10.1073/pnas.1307893110>
- Gee DG, Gabard-Durnam L, Telzer EH, Humphreys KL, Goff B, et al. 2014. Maternal buffering of human amygdala-prefrontal circuitry during childhood but not during adolescence. *Psychol. Sci.* 25:2067–78. <https://doi.org/10.1177/0956797614550878>
- Gehred MZ, Knodt AR, Ambler A, Bourassa KJ, Danese A, et al. 2021. Long-term neural embedding of childhood adversity in a population-representative birth cohort followed for 5 decades. *Biol. Psychiatry* 90:182. <https://doi.org/10.1016/j.biopsych.2021.02.971>
- Glynn LM, Baram TZ. 2019. The influence of unpredictable, fragmented parental signals on the developing brain. *Front. Neuroendocrinol.* 53:100736. <https://doi.org/10.1016/J.YFRNE.2019.01.002>
- Glynn LM, Stern HS, Howland MA, Risbrough VB, Baker DG, et al. 2019. Measuring novel antecedents of mental illness: the Questionnaire of Unpredictability in Childhood. *Neuropsychopharmacology* 44:876–82. <https://doi.org/10.1038/s41386-018-0280-9>
- Goldstein DS. 2010. Adrenal responses to stress. *Cell. Mol. Neurobiol.* 30:1433–40. <https://doi.org/10.1007/s10571-010-9606-9>
- Goldstein DS, McEwen BS. 2002. Allostasis, homeostasis, and the nature of stress. *Stress* 5:55–58. <https://doi.org/10.1080/10253890290012345>
- Goodman E, Adler NE, Kawachi I, Frazier AL, Huang B, Colditz GA. 2001. Adolescents' perceptions of social status: development and evaluation of a new indicator. *Pediatrics* 108:e31. <https://doi.org/10.1542/peds.108.2.e31>
- Gopnik A, Frankenhuis WE, Tomasello M. 2020. Introduction to special issue: 'Life History and Learning: How Childhood, Caregiving and Old Age Shape Cognition and Culture in Humans and Other Animals.' *Philos. Trans. R. Soc. B* 375:20190489. <https://doi.org/10.1098/rstb.2019.0489>
- Green JG, McLaughlin KA, Berglund PA, Gruber MJ, Sampson NA, et al. 2010. Childhood adversities and adult psychiatric disorders in the National Comorbidity Survey Replication. I. Associations with first onset of DSM-IV disorders. *Arch. Gen. Psychiatry* 67:113–23. <https://doi.org/10.1001/archgenpsychiatry.2009.186>
- Gunnar MR, Doom JR, Esposito EA. 2015a. Psychoneuroendocrinology of stress: normative development and individual differences. In *Handbook of Child Psychology and Developmental Science*, Vol. 3: *Socioemotional Processes*, ed. ME Lamb, RM Lerner. John Wiley & Sons, Inc. 7th ed.
- Gunnar MR, Hostinar CE, Sanchez MM, Tottenham N, Sullivan RM. 2015b. Parental buffering of fear and stress neurobiology: reviewing parallels across rodent, monkey, and human models. *Soc. Neurosci.* 10:474–78. <https://doi.org/10.1080/17470919.2015.1070198>
- Gunnar-vonGnechten MR. 1978. Changing a frightening toy into a pleasant toy by allowing the infant to control its actions. *Dev. Psychol.* 14:157–62. <https://doi.org/10.1037/0012-1649.14.2.157>
- Harnett NG, Wheelock MD, Wood KH, Ladnier JC, et al. 2015. Affective state and locus of control modulate the neural response to threat. *NeuroImage* 121:217–26. <https://doi.org/10.1016/J.NEUROIMAGE.2015.07.034>
- Hartley CA, Gorun A, Reddan MC, Ramirez F, Phelps EA. 2014. Stressor controllability modulates fear extinction in humans. *Neurobiol. Learn. Mem.* 113:149–56. <https://doi.org/10.1016/j.nlm.2013.12.003>
- Hartling C, Fan Y, Weigand A, Trilla I, Gärtner M, et al. 2019. Interaction of HPA axis genetics and early life stress shapes emotion recognition in healthy adults. *Psychoneuroendocrinology* 99:28–37. <https://doi.org/10.1016/j.psychenue.2018.08.030>
- Hawkey LC, Capitano JP. 2015. Perceived social isolation, evolutionary fitness and health outcomes: a lifespan approach. *Philos. Trans. R. Soc. B* 370:20140114. <https://doi.org/10.1098/rstb.2014.0114>
- Hendrikse CJ, Du Plessis S, Luckhoff HK, Vink M, van den Heuvel LL, et al. 2022. Childhood trauma exposure and reward processing in healthy adults: a functional neuroimaging study. *J. Neurosci. Res.* 100:1452–62. <https://doi.org/10.1002/jnr.25051>
- Hilt LM, Pollak SD. 2013. Characterizing the ruminative process in young adolescents. *J. Clin. Child Adolesc. Psychol.* 42:519–30. <https://doi.org/10.1080/15374416.2013.764825>

- Hoemann K, Nielson C, Yuen A, Gurera JW, Quigley KS, Feldman Barrett L. 2021. Expertise in emotion: a scoping review and unifying framework for individual differences in the mental representation of emotional experience. *Psychol. Bull.* 147:1159–83. <https://doi.org/10.1037/bul0000327>
- Hostinar CE, Gunnar MR. 2015. Social support can buffer against stress and shape brain activity. *AJOB Neurosci.* 6:34–42. <https://doi.org/10.1080/21507740.2015.1047054>
- Hostinar CE, Johnson AE, Gunnar MR. 2015. Parent support is less effective in buffering cortisol stress reactivity for adolescents compared to children. *Dev. Sci.* 18:281–97. <https://doi.org/10.1111/desc.12195>
- Hughes K, Bellis MA, Hardcastle KA, Sethi D, Butchart A, et al. 2017. The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. *Lancet Public Health* 2:e356–66. [https://doi.org/10.1016/S2468-2667\(17\)30118-4](https://doi.org/10.1016/S2468-2667(17)30118-4)
- Hunter AL, Minnis H, Wilson P. 2011. Altered stress responses in children exposed to early adversity: a systematic review of salivary cortisol studies. *Stress* 14:614–26. <https://doi.org/10.3109/10253890.2011.577848>
- Hunter-Rue DS, Miller P, Hanson JL, Votruba-Drzal E. 2024. Relations between adolescent perceptions of household chaos and externalizing and internalizing behaviors in low- and middle-income families. *J. Res. Adolesc.* 34:1500–16. <https://doi.org/10.1111/jora.13016>
- Huxley A. 1932. *Texts and Pretexts: An Anthology with Commentaries*. Harper & Brothers Publishers
- Jamieson JP, Hangen EJ, Lee HY, Yeager DS. 2018. Capitalizing on appraisal processes to improve affective responses to social stress. *Emot. Rev.* 10:30–39. <https://doi.org/10.1177/1754073917693085>
- Jamieson JP, Nock MK, Mendes WB. 2012. Mind over matter: Reappraising arousal improves cardiovascular and cognitive responses to stress. *J. Exp. Psychol. Gen.* 141:417–22. <https://doi.org/10.1037/a0025719>
- Jensen TM, Bernard D, Lanier P. 2024. Conceptualizing adverse childhood experiences as a latent factor: tests of measurement invariance across five racial and ethnic groups. *Child Dev.* 95:e170–85. <https://doi.org/10.1111/cdev.14050>
- Kahhalé I, Barry KR, Hanson JL. 2023. Positive parenting moderates associations between childhood stress and corticolimbic structure. *PNAS Nexus* 2:pgad145. <https://doi.org/10.1093/pnasnexus/pgad145>
- Kantor GK, Holt MK, Mebert CJ, Strau M, Drach KM, et al. 2004. Development and preliminary psychometric properties of the Multidimensional Neglectful Behavior Scale–Child Report. *Child Maltreat.* 9:409–28. <https://doi.org/10.1177/1077559504269530>
- Kasperek SW, Jenness JL, McLaughlin KA. 2020. Reward processing modulates the association between trauma exposure and externalizing psychopathology. *Clin. Psychol. Sci.* 8:989–1006. <https://doi.org/10.1177/2167702620933570>
- Kim EJ, Kim JJ. 2023. Neurocognitive effects of stress: a metaparadigm perspective. *Mol. Psychiatry* 28:2750–63. <https://doi.org/10.1038/s41380-023-01986-4>
- Kim J, Kochanska G. 2026. Multifinality in pathways from early ecological adversity to children's future self-regulation: elucidating mechanisms, moderators, and their developmental timing. *Dev. Psychopathol.* 38:47–60. <https://doi.org/10.1017/S0954579425000148>
- Koppold A, Ruge J, Hecker T, Lonsdorf T. 2024. The many faces of early life adversity—content overlap in validated assessment instruments as well as in fear and reward learning research. *Meta-Psychology* 8:3958. <https://doi.org/10.15626/MP.2023.3958>
- Korte SM, Koolhaas JM, Wingfield JC, McEwen BS. 2005. The Darwinian concept of stress: benefits of allostasis and costs of allostatic load and the trade-offs in health and disease. *Neurosci. Biobehav. Rev.* 29:3–38. <https://doi.org/10.1016/j.neubiorev.2004.08.009>
- Koss KJ, Gunnar MR. 2017. Early adversity, the hypothalamic-pituitary-adrenocortical axis, and child psychopathology. *J. Child Psychol. Psychiatry* 59:327–46. <https://doi.org/10.1111/jcpp.12784>
- Kuhlman KR, Chiang JJ, Horn S, Bower JE. 2017. Developmental psychoneuroendocrine and psychoneuroimmune pathways from childhood adversity to disease. *Neurosci. Biobehav. Rev.* 80:166–84. <https://doi.org/10.1016/j.neubiorev.2017.05.020>
- Lawson GM, Camins JS, Wisse L, Wu J, Duda JT, et al. 2017. Childhood socioeconomic status and childhood maltreatment: distinct associations with brain structure. *PLOS ONE* 12:e0175690. <https://doi.org/10.1371/journal.pone.0175690>

- Lazarus RS, Folkman S. 1984. *Stress, Appraisal, and Coping*. Springer
- Lee H, Masuda T, Ishii K, Yasuda Y, Ohtsubo Y. 2023. Cultural differences in the perception of daily stress between European Canadian and Japanese undergraduate students. *Personal. Soc. Psychol. Bull.* 49:571–84. <https://doi.org/10.1177/01461672211070360>
- Lewis LR, Lopez RA, Hunt RH, Hodel AS, Gunnar MR, Thomas KM. 2024. Impacts of early deprivation on behavioral and neural measures of executive function in early adolescence. *Brain Cogn.* 179:106183. <https://doi.org/10.1016/j.bandc.2024.106183>
- Liu S, Fisher PA. 2022. Early experience unpredictability in child development as a model for understanding the impact of the COVID-19 pandemic: a translational neuroscience perspective. *Dev. Cogn. Neurosci.* 54:101091. <https://doi.org/10.1016/j.dcn.2022.101091>
- Machlin L, Sheridan MA, Tsai AP-T, McLaughlin KA. 2025. Assessment of early-life adversity and trauma—cumulative risk and dimensional approaches. *J. Child Psychol. Psychiatry* 66:1748–64. <https://doi.org/10.1111/jcpp.14170>
- Maguire-Jack K, Lanier P, Lombardi B. 2020. Investigating racial differences in clusters of adverse childhood experiences. *Am. J. Orthopsychiatry* 90:106–14. <https://doi.org/10.1037/ort0000405>
- Masten CL, Telzer EH, Fuligni AJ, Lieberman MD, Eisenberger NI. 2012. Time spent with friends in adolescence relates to less neural sensitivity to later peer rejection. *Soc. Cogn. Affect. Neurosci.* 7:106–14. <https://doi.org/10.1093/scan/nsq098>
- McEwen BS, Akil H. 2020. Revisiting the stress concept: implications for affective disorders. *J. Neurosci.* 40:12–21. <https://doi.org/10.1523/JNEUROSCI.0733-19.2019>
- McLaughlin KA, Sheridan MA. 2016. Beyond cumulative risk: a dimensional approach to childhood adversity. *Curr. Dir. Psychol. Sci.* 25:239–45. <https://doi.org/10.1177/0963721416655883>
- Meaney MJ, Szyf M. 2005. Environmental programming of stress responses through DNA methylation: life at the interface between a dynamic environment and a fixed genome. *Dialogues Clin. Neurosci.* 7:103–23. <https://doi.org/10.31887/DCNS.2005.7.2/mmeaney>
- Mendes WB, Park J. 2014. Neurobiological concomitants of motivational states. In *Advances in Motivation Science*, ed. AJ Elliot. Academic Press
- Mesquita B. 2022. *Between Us: How Cultures Create Emotions*. W.W. Norton & Company
- Meyer BD, Sullivan JX. 2009. Five decades of consumption and income poverty. NBER Work. Pap. 14827
- Mittal C, Griskevicius V, Simpson JA, Sung S, Young ES. 2015. Cognitive adaptations to stressful environments: when childhood adversity enhances adult executive function. *J. Personal. Soc. Psychol.* 109:604–21. <https://doi.org/10.1037/pspi0000028>
- Motzkin JC, Hiser J, Carroll I, Wolf R, Baskaya MK, et al. 2023. Human ventromedial prefrontal cortex lesions enhance the effect of expectations on pain perception. *Cortex* 166:188–206. <https://doi.org/10.1016/j.cortex.2023.04.017>
- Muehlenhard CL, Kimes LA. 1999. The social construction of violence: the case of sexual and domestic violence. *Personal. Soc. Psychol. Rev.* 3:234–45. https://doi.org/10.1207/s15327957pspr0303_6
- Munakata Y, Placido D, Zhuang W. 2023. What's next? Advances and challenges in understanding how environmental predictability shapes the development of cognitive control. *Curr. Dir. Psychol. Sci.* 32:431–38. <https://doi.org/10.1177/09637214231199102>
- O'Connor DB, Thayer JF, Vedhara K. 2021. Stress and health: a review of psychobiological processes. *Annu. Rev. Psychol.* 72:663–88. <https://doi.org/10.1146/annurev-psych-062520-122331>
- Oh DL, Jerman P, Purewal Boparai SK, Koita K, Briner S, et al. 2018. Review of tools for measuring exposure to adversity in children and adolescents. *J. Pediatr. Health Care* 32:564–83. <https://doi.org/10.1016/j.pedhc.2018.04.021>
- Oppenheim S, Webb L, Testa A, Fix RL, Clary L, et al. 2024. Police violence exposure and traumatic stress among youth: a systematic review. *Trauma Violence Abuse* 25:3662–79. <https://doi.org/10.1177/15248380241255735>
- Ottaviani C, Thayer JF, Verkuil B, Lonigro A, Medea B, et al. 2016. Physiological concomitants of perseverative cognition: a systematic review and meta-analysis. *Psychol. Bull.* 142:231–59. <https://doi.org/10.1037/bul0000036>
- Pacák K, Palkovits M. 2001. Stressor specificity of central neuroendocrine responses: implications for stress-related disorders. *Endocr. Rev.* 22:502–48. <https://doi.org/10.1210/edrv.22.4.0436>

- Palacios-Barrios EE, Hanson JL. 2019. Poverty and self-regulation: connecting psychosocial processes, neurobiology, and the risk for psychopathology. *Compr. Psychiatry* 90:52–64. <https://doi.org/10.1016/j.comppsych.2018.12.012>
- Pollak SD, Cicchetti D, Hornung K, Reed A. 2000. Recognizing emotion in faces: developmental effects of child abuse and neglect. *Dev. Psychol.* 36:679–88. <https://doi.org/10.1037/0012-1649.36.5.679>
- Pollak SD, Smith KE. 2021. Thinking clearly about biology and childhood adversity: next steps for continued progress. *Perspect. Psychol. Sci.* 16:1473–77. <https://doi.org/10.1177/174569162111031539>
- Pollok TM, Kaiser A, Kraaijenvanger EJ, Monninger M, Brandeis D, et al. 2022. Neurostructural traces of early life adversities: a meta-analysis exploring age- and adversity-specific effects. *Neurosci. Biobehav. Rev.* 135:104589. <https://doi.org/10.1016/j.neubiorev.2022.104589>
- Pruessner JC, Baldwin MW, Dedovic K, Renwick R, Mahani NK, et al. 2005. Self-esteem, locus of control, hippocampal volume, and cortisol regulation in young and old adulthood. *NeuroImage* 28:815–26. <https://doi.org/10.1016/j.NEUROIMAGE.2005.06.014>
- Quadt L, Esposito G, Critchley HD, Garfinkel SN. 2020. Brain–body interactions underlying the association of loneliness with mental and physical health. *Neurosci. Biobehav. Rev.* 116:283–300. <https://doi.org/10.1016/j.neubiorev.2020.06.015>
- Qualter P, Brown SL, Munn P, Rotenberg KJ. 2010. Childhood loneliness as a predictor of adolescent depressive symptoms: an 8-year longitudinal study. *Eur. Child Adolesc. Psychiatry* 19:493–501. <https://doi.org/10.1007/s00787-009-0059-y>
- Qualter P, Munn P. 2002. The separateness of social and emotional loneliness in childhood. *J. Child Psychol. Psychiatry* 43:233–44. <https://doi.org/10.1111/1469-7610.00016>
- Quine WV. 1976. *The Ways of Paradox and Other Essays*. Harvard University Press
- Remmers MCC, Reijs RP, Hoebe CJPA. 2024. Defining and distinguishing early life stress, trauma, adversity, toxic and chronic stress and allostatic load: a descriptive review. *Scand. J. Public Health* 53:670–84. <https://doi.org/10.1177/14034948241260105>
- Richter-Levin G, Sandi C. 2021. Labels matter: Is it stress or is it trauma? *Transl. Psychiatry* 11:385. <https://doi.org/10.1038/s41398-021-01514-4>
- Rivenbark J, Arseneault L, Caspi A, Danese A, Fisher HL, et al. 2020. Adolescents' perceptions of family social status correlate with health and life chances: a twin difference longitudinal cohort study. *PNAS* 117:23323–28. <https://doi.org/10.1073/pnas.1820845116>
- Romberg AR, Saffran JR. 2013. Expectancy learning from probabilistic input by infants. *Front. Psychol.* 3:610. <https://doi.org/10.3389/fpsyg.2012.00610>
- Romens SE, McDonald J, Svaren J, Pollak SD. 2015. Associations between early life stress and gene methylation in children. *Child Dev.* 86:303–9. <https://doi.org/10.1111/cdev.12270>
- Rotge JY, Lemogne C, Hinfrey S, Huguet P, Grynszpan O, et al. 2015. A meta-analysis of the anterior cingulate contribution to social pain. *Soc. Cogn. Affect. Neurosci.* 10:19–27. <https://doi.org/10.1093/scan/nsu110>
- Ruba AL, Pollak SD. 2020. The development of emotion reasoning in infancy and early childhood. *Annu. Rev. Dev. Psychol.* 2:503–31. <https://doi.org/10.1146/annurev-devpsych-060320-102556>
- Ruba AL, Pollak SD, Saffran JR. 2022. Acquiring complex communicative systems: statistical learning of language and emotion. *Top. Cogn. Sci.* 14:432–50. <https://doi.org/10.1111/tops.12612>
- Rudolph KD, Hammen C, Burge D, Lindberg N, Herzberg D, Daley S. 2000. Toward an interpersonal life-stress model of depression: the developmental context of stress generation. *Dev. Psychopathol.* 12:215–34. <https://doi.org/10.1017/S0954579400002066>
- Sadikova E, Weissman DG, Rosen ML, Robinson E, Lengua LJ, et al. 2024. Identifying cognitive, affective, and developmental mechanisms linking threat and deprivation with adolescent psychopathology. *J. Child Psychol. Psychiatry* 66:612–23. <https://doi.org/10.1111/jcpp.14067>
- Saffran JR, Kirkham NZ. 2018. Infant statistical learning. *Annu. Rev. Psychol.* 69:181–203. <https://doi.org/10.1146/annurev-psych-122216-011805>
- Sanchez MM, McCormack KM, Howell BR. 2015. Social buffering of stress responses in nonhuman primates: maternal regulation of the development of emotional regulatory brain circuits. *Soc. Neurosci.* 10:512–26. <https://doi.org/10.1080/17470919.2015.1087426>
- Santiago AN, Lim KY, Opendak M, Sullivan RM, Aoki C. 2018. Early life trauma increases threat response of peri-weaning rats, reduction of axo-somatic synapses formed by parvalbumin cells and perineuronal

net in the basolateral nucleus of amygdala. *J. Comp. Neurol.* 526:2647–64. <https://doi.org/10.1002/cne.24522>

Sapolsky RM. 2015. Stress and the brain: individual variability and the inverted-U. *Nat. Neurosci.* 18:1344–46. <https://doi.org/10.1038/nn.4109>

Seery MD. 2011. Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neurosci. Biobehav. Rev.* 35:1603–10. <https://doi.org/10.1016/j.neubiorev.2011.03.003>

Seery MD, Holman EA, Silver RC. 2010. Whatever does not kill us: cumulative lifetime adversity, vulnerability, and resilience. *J. Personal. Soc. Psychol.* 99:1025–41. <https://doi.org/10.1037/a0021344>

Seltzer LJ, Ziegler TE, Pollak SD. 2010. Social vocalizations can release oxytocin in humans. *Proc. R. Soc. B* 277:2661–66. <https://doi.org/10.1098/rspb.2010.0567>

Selye H. 1936. A syndrome produced by diverse nocuous agents. *Nature* 138:32. <https://doi.org/10.1038/138032a0>

Shirtcliff EA, Coe CL, Pollak SD. 2009. Early childhood stress is associated with elevated antibody levels to herpes simplex virus type 1. *PNAS* 106:2963–67. <https://doi.org/10.1073/pnas.0806660106>

Slavich GM. 2022. Social safety theory: understanding social stress, disease risk, resilience, and behavior during the COVID-19 pandemic and beyond. *Curr. Opin. Psychol.* 45:101299. <https://doi.org/10.1016/j.copsyc.2022.101299>

Smith KE, Graf E, Faig KE, Dimitroff SJ, Rockwood F, et al. 2023. Perceived control, loneliness, early-life stress, and parents' perceptions of stress. *Sci. Rep.* 13:13037. <https://doi.org/10.1038/s41598-023-39572-x>

Smith KE, Pollak SD. 2021a. Rethinking concepts and categories for understanding the neurodevelopmental effects of childhood adversity. *Perspect. Psychol. Sci.* 16:67–93. <https://doi.org/10.1177/1745691620920725>

Smith KE, Pollak SD. 2021b. Social relationships and children's perceptions of adversity. *Child Dev. Perspect.* 15:228–34. <https://doi.org/10.1111/cdevp.12427>

Smith KE, Pollak SD. 2022. Early life stress and perceived social isolation influence how children use value information to guide behavior. *Child Dev.* 93:804–14. <https://doi.org/10.1111/cdev.13727>

Smith KE, Woodard K, Pollak SD. 2024. Arousal may not be anything to get excited about. *Emot. Rev.* 17:3–15. <https://doi.org/10.1177/17540739241303499>

Smith KE, Xu Y, Pollak SD. 2025. How childhood adversity affects components of decision making. *Neurosci. Biobehav. Rev.* 169:106027. <https://doi.org/10.1016/j.neubiorev.2025.106027>

Smith R, Thayer JF, Khalsa SS, Lane RD. 2017. The hierarchical basis of neurovisceral integration. *Neurosci. Biobehav. Rev.* 75:274–96. <https://doi.org/10.1016/j.neubiorev.2017.02.003>

Snyder KS, Luchner AF, Tantleff-Dunn S. 2024. Adverse childhood experiences and insecure attachment: the indirect effects of dissociation and emotion regulation difficulties. *Psychol. Trauma Theory Res. Pract. Policy* 16(Suppl. 1):S20–27. <https://doi.org/10.1037/tra0001532>

Soltani A, Izquierdo A. 2019. Adaptive learning under expected and unexpected uncertainty. *Nat. Rev. Neurosci.* 20:635–44. <https://doi.org/10.1038/s41583-019-0180-y>

Steele H, Bate J, Steele M, Dube SR, Danskin K, et al. 2016. Adverse childhood experiences, poverty, and parenting stress. *Can. J. Behav. Sci.* 48:32–38

Sullivan RM, Opendak M. 2018. Developmental and neurobehavioral transitions in survival circuits. *Curr. Opin. Behav. Sci.* 24:50–55. <https://doi.org/10.1016/j.cobeha.2018.03.005>

Suor JH, Granros M, Calentino AE, Phan KL, Burkhouse KL. 2023. The interplay of childhood maltreatment and maternal depression in relation to the reward positivity in youth. *Dev. Psychopathol.* 35:168–78. <https://doi.org/10.1017/S0954579421000857>

Torres-Harding S, Torres L, Yeo E. 2020. Depression and perceived stress as mediators between racial microaggressions and somatic symptoms in college students of color. *Am. J. Orthopsychiatry* 90:125–35. <https://doi.org/10.1037/ort0000408>

Turner AI, Smyth N, Hall SJ, Torres SJ, Hussein M, et al. 2020. Psychological stress reactivity and future health and disease outcomes: a systematic review of prospective evidence. *Psychoneuroendocrinology* 114:104599. <https://doi.org/10.1016/j.psyneuen.2020.104599>

Discusses the critical role of perception in shaping variability in stress responses.

Proposes a topological approach as an alternative to address limitations of traditional models of childhood adversity.

Demonstrates that adverse events exposures are associated with shifts in decision-making behaviors only if children also report high levels of loneliness.

- Ugarte E, Hastings PD. 2024. Assessing unpredictability in caregiver–child relationships: insights from theoretical and empirical perspectives. *Dev. Psychopathol.* 36:1070–89. <https://doi.org/10.1017/S0954579423000305>
- Vanhalst J, Gibb BE, Prinstein MJ. 2017. Lonely adolescents exhibit heightened sensitivity for facial cues of emotion. *Cogn. Emot.* 31:377–83. <https://doi.org/10.1080/02699931.2015.1092420>
- Vannucci A, Fields A, Heleniak C, Bloom PA, Harmon C, et al. 2025. Machine learning for identifying caregiving adversities associated with greatest risk for mental health problems in children. *Nat. Ment. Health* 3:71–82. <https://doi.org/10.1038/s44220-024-00355-6>
- Walasek N, Young ES, Frankenhuys W. 2024. A framework for studying environmental statistics in developmental science. *Psychol. Methods.* <https://doi.org/10.1037/met0000651>
- Wang KS, Yang Y-Y, Delgado MR. 2021. How perception of control shapes decision making. *Curr. Opin. Behav. Sci.* 41:85–91. <https://doi.org/10.1016/j.cobeha.2021.04.003>
- Weems CF, Russell JD, Herringa RJ, Carrion VG. 2020. Translating the neuroscience of adverse childhood experiences to inform policy and foster population level resilience. *Am. Psychol.* 76:188–202. <https://doi.org/10.1037/amp0000780>
- Weissman DG, Mendes WB. 2021. Correlation of sympathetic and parasympathetic nervous system activity during rest and acute stress tasks. *Int. J. Psychophysiol.* 162:60–68. <https://doi.org/10.1016/j.ijpsycho.2021.01.015>
- Wethington E, Brown GW, Kessler RC. 1997. Interview measurement of stressful life events. In *Measuring Stress*, ed. S Cohen, RC Kessler, LU Gordon. Oxford University Press
- Will G, van Lier PAC, Crone EA, Güroğlu B. 2016. Chronic childhood peer rejection is associated with heightened neural responses to social exclusion during adolescence. *J. Abnorm. Child Psychol.* 44:43–55. <https://doi.org/10.1007/s10802-015-9983-0>
- Williamson DE, Birmaher B, Ryan ND, Shiffrin TP, Lusk JA, et al. 2003. The Stressful Life Events Schedule for children and adolescents: development and validation. *Psychiatry Res.* 119:225–41. [https://doi.org/10.1016/S0165-1781\(03\)00134-3](https://doi.org/10.1016/S0165-1781(03)00134-3)
- Wisner-Fries AB, Pollak SD. 2017. The role of learning in social development: illustrations from neglected children. *Dev. Sci.* 20:e12431. <https://doi.org/10.1111/desc.12431>
- Wisner-Fries AB, Ziegler TE, Kurian JR, Jacoris S, Pollak SD. 2005. Early experience in humans is associated with changes in neuropeptides critical for regulating social behavior. *PNAS* 102:17237–40. <https://doi.org/10.1073/pnas.0504767102>
- Woodard K, Pollak SD. 2020. Is there evidence for sensitive periods in emotional development? *Curr. Opin. Behav. Sci.* 36:1–6. <https://doi.org/10.1016/j.cobeha.2020.05.004>
- Xu Y, Harms MB, Green CS, Wilson RC, Pollak SD. 2023. Childhood unpredictability and the development of exploration. *PNAS* 120:e2303869120. <https://doi.org/10.1073/pnas.2303869120>
- Yang R, Yu Q, Owen CE, Ibarra Aspe G, Wiggins JL. 2021. Contributions of childhood abuse and neglect to reward neural substrates in adolescence. *NeuroImage Clin.* 32:102832. <https://doi.org/10.1016/j.nicl.2021.102832>
- Yoo J, Martin J, Niedenthal P, Miyamoto Y. 2022. Valuation of emotion underlies cultural variation in cardiovascular stress responses. *Emotion* 22:1801–14. <https://doi.org/10.1037/emo0000964>
- Young ES, Frankenhuys WE, DelPriore DJ, Ellis BJ. 2022. Hidden talents in context: cognitive performance with abstract versus ecological stimuli among adversity-exposed youth. *Child Dev.* 93:1493–510. <https://doi.org/10.1111/cdev.13766>
- Zhang X, Monnat SM. 2022. Racial/ethnic differences in clusters of adverse childhood experiences and associations with adolescent mental health. *SSM Popul. Health* 17:100997. <https://doi.org/10.1016/j.ssmph.2021.100997>
- Zimmer-Gembeck MJ, Van Petegem S, Skinner EA. 2016. Emotion, controllability and orientation towards stress as correlates of children's coping with interpersonal stress. *Motiv. Emot.* 40:178–91. <https://doi.org/10.1007/s11031-015-9520-z>

Finds that children's perceptions of unpredictability, but not parent or child reports of objective events, affect children's decision-making.
