

# Stressor Appraisal as an Explanation for the Influence of Extra-Individual Factors on Psychological Resilience

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## Introduction

Individual or, more specifically, psychological resilience has recently been defined as the maintenance and/or quick recovery of mental health during and after times of adversity, such as trauma, difficult life circumstances, challenging life transitions, or physical illness (Kalisch et al., 2017). To understand how this definition overlaps with definitions from other disciplines, a brief history of the concept of resilience is necessary.

At its origins in the 1970s, one strong assumption in individual resilience research was that people stay mentally healthy despite stressor exposure because they have a certain type of personality that protects them against the deleterious influences of negative life events or circumstances (Block & Block, 1980; Kobasa, 1979). For instance, a popular term in the early days of resilience research was *hardy personality*, a character structure including dispositions for high commitment, controllability beliefs, and acceptance of, and appetite for, change and challenge (Kobasa, 1979). It became clear relatively quickly, though, that no single set of traits, let alone any single, unitary individual characteristic, was sufficient to explain, or predict, mental health outcomes in stressor-exposed individuals. Instead, resilience appeared to be linked to a multitude of character-like, less stable traits, skills, behaviors, and beliefs, each of which exert only a limited influence on psychological outcomes (Masten & Garmezy, 1985; Werner & Smith, 1989). Depending on which model of resilience a researcher adhered to, these traits might include self-esteem, optimism, attachment style, communication

ability, spirituality, or emotion regulation skills. The lists of potential resilience factors were soon extended to comprise extra-individual factors as well, such as social support or cultural influences (e.g., McCubbin et al., 1998). It was also noted that the characteristics of the stressor itself (e.g., acute versus chronic, interpersonal vs. nonpersonal, direct vs. indirect exposure; Bonanno, Romero, & Klein, 2015) play a role.

Acknowledging the complexity of resilience was a big step forward and also opened the door toward shifting model building from a trait to a process perspective. The mere insight that mental health maintenance may involve spirituality or social support implies that resilience cannot be a stable, fixed phenotype, simply because neither spirituality nor social support are personality traits. They may grow or decline over time, meaning resilience may grow or decline over time as well. More so, if some resilience factors can vary over a life time, they are most likely malleable, meaning one may even learn to become resilient, and it may perhaps even be possible to train resilience.

Resilience researchers have therefore emphasized for at least two decades that resilience involves a process—or processes—of change, or adaptation to adverse life circumstances (Bonanno et al., 2015; Kent, Davis, & Reich, 2014; Luthar, Cicchetti, & Becker, 2000; Rutter, 2012; Sapienza & Masten, 2011). Change obviously occurs whenever an individual acts (outwardly or mentally) in an effort to cope, and such changes at the individual level nearly always co-occur with changes at the level of the environment, to the extent that they constitute person–environment interactions. Observing such changes, however, does not contradict the trait perspective, as even a hardy person would cope with a challenge, for instance, by committing himself or herself more to the new situation or by greeting it with a positive attitude. The point is that, having overcome the challenge, he or she would be just as hardy as before. These types of changes can be considered homeostatic adaptation processes that do not modify an individual's or an environment's capacity for coping.

More relevant from a theoretical point of view are those observations that document long-lasting and more profound changes to an individual's internal make-up. Indeed, the claim of lasting individual adjustment, or allostasis, during and after stress exposure now has a strong empirical foundation (Kalisch et al., 2017). The claim may at first appear trivial, as adversity oftentimes leads to disease (which arguably is a change) but becomes very meaningful if a lasting change is observed in individuals who do not become ill despite adversity (i.e., they do not change or change only temporarily with regard to their mental health). For example, some individuals who are mentally unaffected by a disaster, a serious accident, or severe illness develop a deeper appreciation of life or personal relationships. Some even adopt a more spiritual or religious belief system, a phenomenon that has become known as posttraumatic growth (Johnson & Boals, 2015; Joseph & Linley, 2006; Tedeschi & Calhoun, 2004). Overcoming stressor exposure and remaining in good mental health can also go along with the emergence of new strengths or competencies (Luthar et al., 2000). Furthermore, individuals who were exposed to a moderate number of negative life events in their past have also been found in some studies to be more functional in daily life, to exhibit higher levels of life satisfaction, and to be less reactive to laboratory stressors than individuals with no or negligible exposure (Seery, Holman, & Silver, 2010; Seery, Leo, Lupien, Kondrak, & Almonte, 2013). These latter observations suggest that stressor exposure can immunize against the

effects of future stressors, a phenomenon that has since become known as *stress immunization*, *stress inoculation*, or the *steeling effect*. Among the most unexpected finding from longitudinal analyses in stressor-exposed populations, however, is that some individuals even become less depressed, anxious, or stressed when they experience adversity; that is, they adapt to a degree that their mental health improves (Mancini, 2019).

Beyond the psychological level of analysis, it is now also clear from epigenetic and gene expression studies that change in people who show stable mental health can even involve the molecular level (Boks et al., 2015; Breen et al., 2015). For instance, one study analyzing messenger RNA levels in white blood cells drawn from American soldiers before and after exposure to war zone trauma found an increase in the expression of genes presumably involved in wound healing and hemostasis, which was also associated with these soldiers not developing posttraumatic stress disorder (PTSD) as a consequence of their deployment (Breen et al., 2015). Notably, the differential effect relative to the group that did develop PTSD could not be explained by group differences in war zone trauma severity.

None of these empirical studies establish causality between the observed change and the maintenance of mental health. However, there are now numerous studies in rodent stress models in which more or less specific manipulations of nervous system functions have been shown to contribute to the maintenance of normal, adaptive behavior after periods of severe event-like or prolonged stress exposure (Cathomas, Murrough, Nestler, Han, & Russo, 2019; Friedman et al., 2014; Krishnan et al., 2007; Maier, 2015; Russo, Murrough, Han, Charney, & Nestler, 2012). A prominent case is the adjustment in the expression of certain ion channels in midbrain dopamine neurons that only occurs in animals whose dopamine neurons initially react to a repeated social defeat situation with a pronounced increase in their excitability, only to then normalize back to excitability levels comparable to those of nonstressed control animals. This happens precisely because the initial neuronal excitability increases cause changes in ion channel expression that in turn cause reductions in neuronal excitability. After stressor exposure, these animals produce normal hedonic and social behavior. Other animals that reacted to defeat with clearly less pronounced excitability increases never enter the homeostatic excitability readjustment process and also develop anhedonia and social interaction deficits (Friedman et al., 2014). Remarkably, manipulations of ion channel expression can restore normal behavior in these animals.

One commonality between these animal studies and the molecular human studies cited before is the availability of a clear outcome. In Breen et al. (2015), all analyzed soldiers were free from PTSD before deployment, then experienced comparable war zone trauma exposure, and then either did or did not develop PTSD. This allowed for simply comparing those who maintained mental health (resilient, no PTSD) to those showing clear mental health deterioration (nonresilient, PTSD). In the animal studies, animals exposed to, for instance, a well-controlled, standardized form of social defeat could be compared in their postdefeat anhedonic and social behavior to nondefeated control animals, allowing for animals behaving like controls to be classified as resilient and those showing long-term maladaptive behavioral changes as susceptible or nonresilient. Like in the soldier study, stressor exposure was comparable (controlled) between resilient and nonresilient groups. We can, therefore,

exclude differences in stressor exposure as a trivial explanation for the observed behavioral differences.

Very surprisingly, there are only a few human resilience studies using a longitudinal mental health outcome and controlling for stressor exposure that identify either resilience factors (in the sense of trait-like or nontrait-like predispositions that are measured at baseline and predict good outcomes) or processes of change (as may occur over the course of the observation period and statistically relate to good outcomes). (For an overview of existing prospective-longitudinal studies, see Kalisch et al., 2017.) The vast majority of human resilience studies uses cross-sectional designs in which one of the many existing resilience questionnaires (Windle, Bennett, & Noyes, 2011) is correlated with some other variable of interest, such as a personality trait, a skill, habit, belief, extra-individual factor, etc. Such cross-sectional resilience questionnaire studies are now also more and more frequently conducted with biological variables of interests, such as gene variants or measures of brain function or structure (Berg et al., 2017; Bradley, Davis, Wingo, Mercer, & Ressler, 2013; Kong, Ma, You, & Xiang, 2018; Kong, Wang, Hu, & Liu, 2015; Shao, Lau, Leung, & Lee, 2018; Shi et al., 2016; Waaktaar & Torgersen, 2012; Waugh, Wager, Fredrickson, Noll, & Taylor, 2008).

There is a stunning circularity in these approaches. The development of a resilience questionnaire usually involves insights from qualitative and sometimes quantitative work that leads the authors to formulate their own resilience model, based on the factors they believe constitute resilience. Accordingly, a resilience questionnaire may include items indexing emotion regulation ability, optimistic outlook, or self-efficacy beliefs, if those constructs figure in the authors' resilience model. If a study using the questionnaire shows a correlation of the questionnaire with another measure of emotion regulation, optimism, or self-efficacy, this is interpreted as support for the tested resilience model. Not much better, if a resilience questionnaire happens to show a correlation with, say, resting-state functional connectivity in a network of brain regions supporting emotion regulation, this is often interpreted as revealing the neurobiological basis of resilience.

There are two additional major problems with the cross-sectional questionnaire approach. First, none of the existing questionnaires has yet been found to be a reliable and strong predictor of good mental health despite adversity. That is, even if a study were to identify a new variable whose correlation with the questionnaire is not just the result of circular reasoning (say, a gene polymorphism), it would still be entirely unclear if this newly identified resilience factor has any role in how people overcome adversity. The second additional problem is a deeper one and ultimately the cause of the first. As pointed out by Mancini and Bonanno (2009), cross-sectional application of resilience questionnaires is based on the assumption that resilience can be measured in the absence of stressors and an individual's reaction to the stressor. If, however, staying mentally healthy despite adversity involves processes of change; if these processes presumably vary from individual to individual; if they most likely affect, or occur at, the biological, psychological, social, and cultural levels (given the complex picture of the previously described resilience factors); and, finally, if stressor exposure itself can be experienced individually very differently, then it is simply highly unlikely that it will ever be possible to predict long-term mental health outcomes following adverse events or life phases with very high accuracy. Complex dynamic systems are notoriously difficult to

predict (e.g., the weather<sup>1</sup>). Together, this means that findings from cross-sectional correlations with resilience questionnaires cannot be interpreted as representing resilience factors. And this in turn means that individual resilience research has a serious problem.

We would like to emphasize that we are not arguing here against attempts to predict mental health outcomes, which, if successful, may have enormous benefit for disease prevention. We also believe that even prediction tools with only moderate or good prediction accuracy would be of great value, given the very poor predictions afforded by existing methods in psychiatry and clinical psychology. We are also confident that prediction accuracy will soon increase massively due to progress in the fields of digital phenotyping, machine learning, and other areas of data science as well as in the fields of biology and neuroscience. Encouraging examples can be found in the PTSD literature (Schultebraucks & Galatzer-Levy, 2019). Apart from their practical value for medicine, the more sophisticated prediction tools that are anticipated may at some point even be useful for resilience research by providing much better surrogate markers for mental health outcomes under adversity than resilience questionnaires. Nevertheless, a correlation of a variable of interest with whatever prediction instrument or surrogate marker can in principle never provide more than a starting hypothesis that that variable may be related to resilience. To show this, it is inevitable to test the influence of the variable in an observational or, if possible, a longitudinal data set following an intervention.

Such longitudinal testing must necessarily include a difficult period in the lives of the subjects and an observation of what this does to their mental health. This is because one wants to know what helps people stay healthy *despite* adversity, which logically requires the existence of adversity (Kalisch et al., 2017; Mancini & Bonanno, 2009). Further, longitudinal testing must include an as-good-as-possible characterization and, ideally, quantification of the experienced adversity or stressor exposure. This is because if one person gets a tooth pulled and then jumps 10 points on a PTSD scale, that person is surely less resilient than a person that loses his or her family in a car accident and ends up in a wheel-chair and also jumps 10 points on the same scale. Both show the same mental health change, but if one did not in some way normalize mental health changes to stressor exposure, that outcome would not be informative about resilience in any way. Another illustration of the importance of normalizing mental health changes to stressor exposure is the example of a two times as large mental health deterioration in person A than person B, while person A has experienced two times as much stressors. Here, the explanation for the individual differences in mental health change is a trivial one and consists in the individual's different levels of stressor exposure but does not reflect differences in resilience (Kalisch et al., 2017; Kalisch, Müller, & Tüscher, 2015).

As a consequence of all these different considerations, it may be prudent to abandon definitions of resilience based on any particular trait or traits (which surely do not predict resilient outcomes) or on any nontrait-like resilience factor or factors (whose predictive power we currently do not know) and also on presumed processes of change (which most likely play an important role but which we are only beginning to understand). We propose, instead, an outcome-based definition that simply looks at mental health changes over the course of a difficult time and relates them to the amount or level of difficulty experienced. Hence, resilience

defined as the maintenance or quick recovery (because anyone can have a temporary emotional setback) of mental health during and after adversity or, in other words, long-term mental health stability despite adversity (Kalisch et al., 2017). (We note that this definition can interchangeably be applied to other outcomes than mental health, such as personal functioning, performance, or developmental achievements. We here restrict ourselves to mental health outcomes for the sake of simplicity.)

This definition is a purely pragmatic one that emphasizes operationalization in longitudinal measurement. (For a more detailed discussion on practical implications and the requirements the definition poses on longitudinal testing, as well as for more details about how to quantify resilience in longitudinal studies, see Kalisch et al., 2015, 2017, 2019). The deliberately technical nature of the definition also means that it is entirely atheoretical (i.e., it does not propose any specific factor or mechanism as being resilience). Basing a definition of resilience on a specific factor or mechanism would not only be premature given our current knowledge (see previous discussion), but it would also unnecessarily divide the community and lead, mutually, to exclusion of researchers with different mechanistic models. In the absence of an objectively measurable outcome, different models could never be pitched against each other to decide which one explains the outcome better. Instead, a resilience definition based on, for example, model 1, but not model 2, would necessarily always confirm model 1 and disconfirm model 2. Next to producing circularity, such a definition would also preclude new discoveries.

The future of resilience research, as we see it, consists of longitudinal studies in which mental health and stressor exposure are monitored repeatedly and at high temporal resolution, to thus quantify the influence of stressors on mental health. The same methodology is required to identify potential resilience factors, which also need to be measured repeatedly and at high sampling frequency to thus describe and quantify how they affect (dampen) negative influences of stressors on mental health in a time-variant fashion. Mathematical-statistical approaches harnessing dynamic systems theory may be particularly suited to analyze the data generated by these studies and to eventually identify key processes of adjustment to adversity (Kalisch et al., 2019). The entire focus of this approach is on detecting and understanding beneficial processes of adaption. It is entirely possible, or even likely given current knowledge, that these processes will differ from individual to individual and also depend on the type of adversity and type of mental health outcome studied. A youth with a history of childhood maltreatment (an extra-individual factor) may achieve a depression-free life through different processes than the processes that protect a soldier traumatized in war against PTSD. Nevertheless, it can be hoped that over the course of time a certain pattern, or systematology of processes, may be discovered. That is, certain generic or typical pathways of successful adaptation may emerge, at least within categories of individuals, adversity and outcomes. Along the way, the shift described in this chapter from the trait to the outcome perspective constitutes a complete abandonment of the idea that resilience is a unitary construct or common cause for mental health under strain. Resilience is better conceptualized as a range of protective processes that results in maintained mental health in response to many different external stressors that can occur at many different systemic levels (Kalisch et al., 2019).



## Can a Multisystemic Approach Benefit Psychological Resilience Research? The Case for Reductionism

Even a perfectly happy and relaxed human being is a system complex enough to defy understanding. Understanding how human beings successfully respond to adversity would appear an even more daunting task. When considering the methodological demands to contemporary resilience research that we have discussed previously, one would be tempted to argue that, before even trying to integrate psychological resilience research into a broader context of other systems that affect human resilience and are affected by human resilience, it should be a priority to understand the laws that, in the first instance, govern psychological resilience. One system at a time is a sober and pragmatic position of reductionism that we believe is necessary to advance the field.

Reductionism, although intuitively appealing to researchers that struggle not to despair of the complexity of human resilience, is not, however, typically used as an orienting principle in a research area that is defined by studying how a system (the human mind) defends itself against an extra-systemic challenge (a natural disaster, an act of violence, a disease of the body, etc.). Reductionism may even appear a hopeless position, if one adds into the picture the social and cultural influences that may facilitate resilience.

We will nevertheless defend a position of reductionism in the remainder of this chapter. We will argue that, at least at the present moment, psychological resilience research is well advised to focus on intra-individual mechanisms of resilience (those that occur within the mind) and that it should only include extra-individual factors (those extraneous to the mind, including those occurring within the body) where this is absolutely necessary. Opening up to the wide range of extra-individual factors that arguably affect human mental health under adverse conditions would do nothing to clarify the key determinants of human resilience, but would instead only lead to further confusion in a field that already suffers from confusion regarding definitions, measures, and levels of analysis. To make this more than an emotional rejection of complexity, we will propose a theoretical framework that affords an integration of the effects of extra-individual factors on resilient outcomes via intra-individual (mental, cognitive, neural) mediators. Extra-individual factors, while important even in this reductionistic model, only impact resilience to the extent that their effects are transmitted via intra-individual effect paths. Because intra-individual factors exert a more proximal causal influence on resilience than extra-individual factors, the framework is justified to ignore extra-individual influences altogether, where the goal of a given study is to contribute to a truly mechanistic understanding of resilience. In other words, a reductionistic framework aims at a parsimonious explanation of resilience. Further, the approach we propose here has the potential to lead to the identification of targets for efficient and effective intervention based on the reasoning that manipulating proximal factors is likely to have a stronger influence on mental health outcomes than manipulating distal factors.

Before outlining in more detail our reductionist proposal, we will argue first that the inclusion of extra-individual factors is not only not necessary to understand resilience but

in one specific case even undermines the very idea of resilience. The argument starts with an analysis of the role of stressors in resilience. Because, as pointed out, most stressors are extra-systemic influences, the case of stressors is the one instance where the defense line of reductionism apparently has its weakest spot. How can one ignore extra-systemic influences on resilience when resilience is about adapting to extra-systemic influences?

In our historical overview of the development of the resilience concept from a trait construct to an outcome, we have emphasized how crucial it is for the measurement of resilience as an outcome to characterize and quantify stressor exposure. Resilience cannot be measured in the absence of stressors and mental health changes have to be normalized somehow to stressor exposure for none or only moderate mental health deterioration in a stressed individual to still count as mental health despite adversity (i.e., resilience).

To illustrate, let us assume a financially strained single mother who receives financial support through a government program aimed at underprivileged members of society. Under the influence of year-long financial restrictions (the stressor), the woman has begun to show first signs of depression (the mental health variable), a downward path that comes to a halt when she is moved to a better apartment with her child and provided the means to finance some of her child's social activities. The government might claim it has installed a resilience-promoting program for single parents and that the money provided from the public is a resilience factor. From a resilience point of view, however, the government has simply allowed the mother to reduce her stressor exposure. For example, by changing neighborhood, mother (and child) may witness or experience less criminality, and by now being able to afford a cinema visit or a school trip for her child, mother and child may have fewer strenuous conflicts. In the overall equation, the mother's improvement in mental health may simply be commensurate with her reduction in stressor load. There would be no reason to classify her as now more resilient. What would be right to say, though, is (provided a systematic effect, of course) that the government program is a mental health program.

The scenario is more than a hypothetical one. For instance, several studies have provided evidence that financial assets predict maintenance of mental health despite onset of physical disability (McGiffin, Galatzer-Levy, & Bonanno, 2019). In line with psychosocial resource models of mental health and resilience (Hobfoll, 2002), these data can be interpreted to show that wealth and related socioeconomic variables are resilience factors. Wealth, however, is essentially a means to buffer against stressors, providing relief. A wealthy disabled individual may afford better medical treatment, may be able to better equip his household or to pay for domestic help to compensate for loss of functioning, and may still be able to take part in social life because he has the money to pay for transportation. In sum, there is less stressor exposure. If, however, resilience is to do well despite adversity, then taking away stressors can by no means count as a resilience measure. If anything, reducing overall stressor exposure reduces the individual's need to withstand and adjust. In its extreme, complete absence of stressor exposure may even be associated with poorer mental health and other desirable outcomes (such as psychosocial function, life satisfaction, or stress reactivity in laboratory conditions) than moderate exposure, as is evidenced by the previously discussed steeling effect.

A similar logic can be applied to other presumed resilience factors that can be more straightforwardly classified as extra-individual than financial resources. Social support, for



instance, can consist in a neighbor doing the shopping for a sick person, a group of colleagues defending an employee against false allegations from a superior, or a family member making an interest-free loan during a financial crisis. All of these are effectively stressor exposure reductions. On an instrument that measures stressors, the supported individual would score lower. Actions or circumstances that improve housing or environmental conditions, reduce crime, or boost the economy could only then rightfully qualified as resilience factors if they were shown to improve the ratio between mental health burden and stressor burden, that is, to moderate the effects of stressors on mental health. In other words, resilience is to be mentally healthy if conditions are poor.

## A Parsimonious Intra-Individual Theory of Resilience

The previous example of social support as a protective factor for mental health will serve us as an entry point into a brief presentation of an intra-individual, mechanistic theory of resilience, which we believe can both guide psychological resilience research and potentially explain the effects of extra-individual factors on resilience (provided these effects exist and do not merely reflect stressor buffering). Social support most likely benefits mental health not only by providing material resources. It also may shape cognitions. In the biblical story of Job, the critical turning point back to mental health is reached when the words of Job's friend Elihu help Job to change his perspective on what happened to him and why it happened. Elihu does nothing to improve Job's material or physical condition. He acts exclusively through passionate argumentation. Eventually, Elihu's intervention (and subsequently God's) changes the way Job reacts to his calamity. Because Job returns to mental health after temporary disturbance even though his external circumstances do not improve (immediately), Job's story meets all the criteria for being a resilience story. (It is also a nice example of resilience resulting from a process of change, in this case, a change in mindset.)

There is another potential effect path through which social support may promote resilience. Following failure to demonstrate a positive role of social support in various studies and evidence that social support can sometimes have no or negative effects on mental health, resilience researchers have worked out an apparently comparatively more important positive role of perceived social support. Perceived social support is the belief or conviction that one is embedded in a strong supportive network and may be able to fall back on family or friends if needed. Thereby, high social support perceptions presumably allow one to adopt a more relaxed perspective on many difficult situations. (For a concise overview of the social support literature, but also a nuanced perspective on the effectiveness of perceived social support, see Nickerson et al., 2017).

In both scenarios, an extra-individual factor's effect on resilience is mediated by an intra-individual factor, namely by how an individual perceives, and reacts to, a threat. The extra-individual factor (Elihu's intervention, the social support network) is distal; the intra-individual factor is proximal in its causality. The examples can also be used to illustrate why relying on proximal intra-individual factors afford more explanatory power than relying on

distal extra-individual factors. Job did get quite some social support already before Elihu entered the scene. Numerous friends provided Job advice, but they were either too selfish or too unwise or Job was simply not open to their arguments. In any case, things for Job only got worse. Social support that does not meet the needs of the stressed person or is more of a burden than a help (for instance, because one feels one has to be grateful to the helper or because the helper makes demands or criticizes the victim or uses the situation for self-enhancement) is unlikely to promote resilience. Rather, social support furthers resilience if and only if it helps the victim of bad fortune better cope with the bad situation. This means that statistical relationships between social support and resilience can only be moderate at best. By contrast, good measures of the mediating intra-individual factor or factors (to be defined more precisely in the remainder of the section) should explain considerably more variance in resilience.

This is not to say that an intervention from another person may not be *the* decisive event in a process of adjustment to adversity. To the contrary, from qualitative and quantitative studies, there is enough evidence indicating the important role played in many lives by trusted others (Werner & Smith, 1989). This argument can be extended to the presumably very important role for cultural influences, such as inspiring works of religion, philosophy, or art, encouraging traditions and belief systems and contact with role models. It would be short-sighted to dismiss these influences on resilience, but at the same time it would also be short-sighted to ignore that these influences impact different individuals very differently. A holy scripture that inspires one person to bear torture and execution with a song on her lips can be the source of fear of eternal damnation for the other. Music that uplifts the teenager is usually a hassle for his parents. And the example of a resilient public person may motivate one person to follow in her path and make another feel weak and worthless in comparison.

So what is the common denominator? What is the final end-path to resilience? The same question needs to be answered not only with regards to resilience factors located outside the individual but also to those factors inside the person that may well affect resilience but are unlikely to do so directly. For instance, there is initial evidence that a certain composition of the gut microbiome may protect mental health and perhaps even promote resilience (Reber et al., 2016). (In a way, gut bacteria could also be seen as extra-individual, of course, at least if they are incorporated through diet.) Other studies indicate an important contribution of the immune system (Cathomas et al., 2019). However, any peripheral bodily function and even any gene expressed in our brains can only affect resilience if it somehow affects those systems or functions in our brain/mind that make us more or less sad, anxious, desperate, or hypervigilant.

To provide a classification of distal versus proximal resilience factors and to guide our own research toward those factors with a high likelihood to have a strong impact on resilient outcomes, the first author (Raffael Kalisch) together with Marianne Müller and Oliver Tüscher have proposed that various resilience factors converge in how individuals regulate their stress responses (Kalisch et al., 2015). Individuals who either learn over the course of a process of adjustment to stressors or who already are able to more or less optimally regulate stress reactions are likely to overcome difficult circumstances with minimal mental health impairments.

This basic tenet is derived from a functional analysis of stress, according to which stress responses are primarily adaptive reactions to potential threats to an organism's needs and goals that serve to protect the organism from harm and to preserve physiological homeostasis (Sterling & Eyer, 1988; Weiner, 1992). Albeit in principle protective, stress responses are also costly by consuming energy, time, and cognitive capacity, by interfering with the pursuit of other important goals and by placing a burden on an individual's social, financial, and health resources. This implies that, if very intense, repeated, or chronic stress responses can become harmful themselves, as exemplified in the concept of "allostatic load" (McEwen & Stellar, 1993). For these reasons, the organism needs regulatory mechanisms or "brakes" that fine-tune stress responses to optimal levels and, thus, preserve their primary adaptive function while at the same time assuring efficient deployment of resources. Stress-regulatory mechanisms prevent a response overreaction in amplitude or duration; they shut off stress responses once a threat has vanished (i.e., response termination or recovery occurs), and they counteract response generalization. Rather than acting on the acute stress response, stress-regulatory mechanisms may also have an influence on how individuals respond to future exposures to the same or other stressors, by affecting, for instance, postexposure evaluation or memory formation processes. Such flexible and adjustable responses to stressors (Ragland & Shulkin, 2014) limit resource consumption and maintains general functioning, thereby allowing for the concurrent pursuit of other goals. Ultimately, optimized stress responses prevent the accumulation of allostatic costs and reduce the likelihood of developing lasting dysfunctions under stressor exposure (Kalisch et al., 2015). Hence, any biological, psychological, social, and cultural adaptation processes most likely promote resilience in so far as they promote optimal stress response regulation. While some individuals may enter adverse life situations with already efficient regulation capacities, most individuals presumably still improve or even develop such capacities through their confrontation with stressors.

## Optimal Stress Response Regulation via Positive Appraisal

This functional analysis permits us to focus investigation of protective adaptation processes on adaptations in the cognitive and neural mechanisms that underpin stress response regulation. A useful theoretical framework to approach these mechanisms is appraisal theory, which holds that the type, extent, and temporal evolution of emotional reactions, including acute and chronic stress responses, are not determined by simple, fixed stimulus-response relationships but by subjective and context-dependent appraisal (evaluation, analysis, interpretation) of the relevance of a stimulus or situation for the needs and goals of the organism (Arnold, 1960; Lazarus & Folkman, 1984; Scherer, 2001). Stress or threat responses, in particular, result from the appraisal of a situation as potentially harmful and as exceeding coping resources (Lazarus & Folkman, 1984). Both unconscious and conscious processes can contribute to this "meaning analysis." Unconscious, nonverbal appraisal is presumably at the heart of phylogenetically old threat processing that also exists in animals. Conscious and explicit appraisal may be more dominant in unfamiliar and ambiguous situations and

is restricted to humans (Leventhal & Scherer, 1987; Robinson, 1998). Regardless of human or nonhuman, appraisal processes have a neurobiological foundation (Kalisch & Gerlicher, 2014; Sander, Grandjean, & Scherer, 2005).

Combining these general considerations on stress and appraisal, our theory, termed “positive appraisal style theory of resilience” (PASTOR), proposes that individuals with a generalized tendency to appraise potentially threatening stimuli or situations in a non-negative (nonpessimistic, noncatastrophizing) fashion are less likely to produce exaggerated, repeated, inflexible, and persistent stress responses and may thus be better protected against many long-term deleterious effects of trauma or chronic stressors (Kalisch et al., 2015). A positive appraisal style, on average, reduces the values that an individual attributes to stressors on the key threat appraisal dimensions threat magnitude or cost, threat probability, and coping potential to levels that realistically reflect the threat or even slightly underestimate it. In mildly aversive situations, positive appraisal is easily achieved by a class of neurocognitive processes or mechanisms that we have termed “positive situation classification,” consisting of the comparison of a current situation with earlier, successfully managed ones (“I have been there before—and I survived.”). It may also refer to the recurrence of a positive cultural stereotype that eventually leads to the relatively effortless activation of pre-existing positive appraisal patterns. For instance, grown up in a family that cultivates optimism and self-efficacy, one may be inclined to respond to a challenge with the assumption that the worst things usually never happen or that one will find a way to deal with it. However, in many aversive situations, negative appraisals are triggered automatically and are therefore largely unavoidable, presumably reflecting an evolutionarily determined preference for protection and defense. In such situations, positive appraisal and concomitant stress response regulation depend on the individual’s ability to positively reappraise (re-evaluate) a situation. Reappraisal processes/mechanisms can range from unconscious, automatic/effortless, implicit, nonverbal, and nonvolitional to conscious, effortful, explicit, verbal, and volitional. They may reflect decreases in the actual threat value of a situation, for example in fear extinction, when a fear-conditioned stimulus (CS) that originally predicted threat (the unconditioned stimulus) is no longer followed by the unconditioned stimulus. Two other such “safety learning” processes are discrimination (e.g., between a threat-predictive CS+ and a nonpredictive and hence non-dangerous CS–) and recovery after stressor termination. The function of these processes is to avoid unnecessary, costly stress responses. Another class of reappraisal processes changes the relative weighting of the negative and positive aspects present in any situation toward a more positive interpretation. One example is volitional (cognitive) reappraisal (Gross, 1998). Reappraisals do not necessarily have to occur at the time of stressor exposure but may also be achieved in retrospect, thereby counteracting the consolidation or overgeneralization of aversive memories or generating competing positive memories. Finally, the positive adjustment of appraisals in strongly aversive situations (re-appraisal proper) also requires a capacity to inhibit the interference resulting from competing negative appraisals and from the accompanying aversive emotional reactions. Hence, in addition to positive situation classification, positive reappraisal (proper) and interference inhibition are two other broad classes of neurocognitive processes whose efficiency and effectiveness together shape an individual’s appraisal style.

In the context of this current volume, it may be worth pointing out that human stress responses are multifaceted, and since humans are social animals, adaptive stress responses often include efforts of help-seeking, affiliation, negotiation, and cooperation. Stress responses may also involve changing, or even exchanging, one's goals, if maintaining them would lead to disaster. Successfully recruiting social support and negotiating social interactions is evidently dependent on the responsiveness and resourcefulness of the social environment; changing one's goals can hardly be thought of without reference to the possibilities provided and the norms defined by one's society and culture. At the same time, assessing the possibilities for coping available in a given sociocultural context and calculating their potential costs and benefits, while taking into account one's own assets, competencies, and resources, are again just an inherent part of the stress response. Catastrophizing (i.e., overestimating threat magnitude/cost), pessimism (overestimating threat probability), and helplessness (underestimating coping potential) all lead to biased calculations that undermine any adaptive responding, including where responding involves exploitation of sociocultural resources. Others may be seen as a source of threat or burden rather than help, the benefits coming from social interactions may be neglected, or one's own ability to interact positively or to negotiate successfully may be misjudged. Avoiding a negative appraisal style is thus paramount for benefiting from extra-individual resilience factors. On the other hand, realistic or perhaps even slightly too positive appraisal will facilitate and energize adaptive social behavior (as well as any nonsocial ways of coping) that may include learning and benefiting from others, finding friends, and building networks.

To summarize, then, an appraisal style is first determined (a) by the efficacy and efficiency of certain neurocognitive processes that produce appraisal outputs (i.e., appraisal contents or values on the different dimensions of threat appraisal) in situations of potential threat and (b) by an individual's memory of her own threat experiences and extra-individually determined norms that commend particular appraisal outputs in particular situations. Second, an appraisal style is malleable and may change over time as the efficacy and efficiency of the underlying neurocognitive processes change (e.g., by training) and as new memories of one's own experiences accumulate and other sociocultural norms and reaction patterns are integrated into one's memory schemata. And, third, an appraisal style governs an individual's typical appraisal outputs, but it does not determine each appraisal output in each particular threat situation. (I may generally believe I am a good copier, but I may well come to the conclusion in a specific situation that I cannot cope with the situation at all.) Appraisal style is a subjective bias that colors appraisal and therefore probabilistically determines the likelihood of breakdown from allostatic load costs that accumulate over extended periods of time when individuals produce stress reactions. A positive appraisal style reduces this likelihood except if stressor exposure is so overwhelming that lasting stress reactions are unavoidable. In that case, any organism will eventually break down (Neuner et al., 2004).

PASTOR theoretically affords a way to explain both extra-personal and noncognitive (bodily) intrapersonal influences on resilience via a common end-path. Noncognitive biological factors (the gut microbiome, the immune system, genes, etc.) are likely to affect appraisal style by affecting the working of neurocognitive appraisal processes. As an example,

there is first evidence suggesting that the immune system may interact with the function of the nucleus accumbens, a brain region important for generating positive evaluations (Menard et al., 2017). Extra-individual social or cultural factors may predominantly shape typical appraisal output patterns through memory. Examples may be when the culture of a family predisposes its children to produce benign threat estimates (see previous discussion) or when individuals with long-term stable, supportive social networks tend to appraise their coping potential as high because they have experienced many times that they can rely on others. Because PASTOR is a probabilistic theory that focuses on average effects, it is not optimally suited to explain the sometimes pronounced effects on resilience of single extra-individual interventions (like Elihu from the biblical story of Job), but even those are considered to be transmitted via appraisal. After all, Job finally realizes that he had been proud and self-righteous and adopts a much more humble identity, for which loss, defeat, and disease are no longer vital threats. The latter is a reminder that threat appraisal is necessarily always in relation to the individual's needs and goals that may be threatened in a given situation.

## Conclusion

At its very essence, resilience needs to be qualified by words like *despite* or *although*. One stays well despite adversity, although life is conjuring up new challenges. There is a leitmotiv of independence and autonomy, even self-empowerment, inherent in resilience. Even if others may help me gain, or persevere, it is still *my* independence that defines my resilience. If multisystemic resilience research wants to understand how the (personal or nonpersonal) “other” can provide effective help, it must understand the pathways through which that help translates into benefits for mental health. Since mental health itself is an inherently individual construct, those pathways must at some point converge within the individual. PASTOR is an attempt to identify this intra-individual point of convergence.

## Key Messages

1. Psychological resilience is the maintenance and/or quick recovery of mental health during and after times of adversity. Thus, psychological resilience is defined as an outcome.
2. Psychological resilience cannot be determined in the absence of adversity.
3. Staying mentally healthy despite adversity (i.e., a resilient outcome) involves processes of change or adaptation. To describe these processes, prospective longitudinal studies are required in which mental health, adversity, and potential resilience factors are measured repeatedly and with high temporal resolution.
4. Extra-individual resilience factors are assumed to only impact resilience to the extent that their effects are transmitted via intra-individual effect paths. Hence, intra-individual resilience factors exert a comparatively more proximal causal influence on resilience.
5. Positive stressor appraisal is a potential key intra-individual resilience mechanism.



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## Note

1. The weather is probably a less complex system compared to a human brain/mind in a human body in a human society in a natural environment.

## References

- Arnold, M. B. (1960). *Emotion and personality*. New York, NY: Columbia University Press.
- Berg, C. J., Haardörfer, R., McBride, C. M., Kilaru, V., Ressler, K. J., Wingo, A. P., . . . Smith, A. (2017). Resilience and biomarkers of health risk in black smokers and nonsmokers. *Health Psychology, 36*(11), 1047–1058. doi:10.1037/hea0000540
- Block, J. H., & Block, J. (1980). The role of ego-control and ego-resiliency in the organization of behavior. In W. A. Collins (Ed.), *Development of cognition, affect and social relations: The Minnesota Symposia on Child Psychology* (Vol. 13, pp. 39–101). New York, NY: Lawrence Erlbaum.
- Boks, M. P., van Mierlo, H. C., Rutten, B. P. F., Radstake, T. R. D. J., De Witte, L., Geuze, E., . . . Vermetten, E. (2015). Longitudinal changes of telomere length and epigenetic age related to traumatic stress and post-traumatic stress disorder. *Psychoneuroendocrinology, 51*, 506–512. doi:10.1016/j.psyneuen.2014.07.011
- Bonanno, G. A., Romero, S. A., & Klein, S. I. (2015). The temporal elements of psychological resilience: An integrative framework for the study of individuals, families, and communities. *Psychological Inquiry, 26*(2), 139–169. doi:10.1080/1047840X.2015.992677
- Bradley, B., Davis, T. A., Wingo, A. P., Mercer, K. B., & Ressler, K. J. (2013). Family environment and adult resilience: Contributions of positive parenting and the oxytocin receptor gene. *European Journal of Psychotraumatology, 4*. doi:10.3402/ejpt.v4i0.21659
- Breen, M. S., Maihofer, A. X., Glatt, S. J., Tylee, D. S., Chandler, S. D., Tsuang, M. T., . . . Woelk, C. H. (2015). Gene networks specific for innate immunity define post-traumatic stress disorder. *Molecular Psychiatry, 20*, 1538–1545. doi:10.1038/mp.2015.9
- Cathomas, F., Murrough, J. W., Nestler, E. J., Han, M.-H., & Russo, S. J. (2019). Neurobiology of resilience: Interface between mind and body. *Biological Psychiatry, 86*(6), 410–420. doi:10.1016/j.biopsych.2019.04.011
- Friedman, A. K., Walsh, J. J., Juarez, B., Ku, S. M., Chaudhury, D., Wang, J., . . . Han, M.-H. (2014). Enhancing depression mechanisms in midbrain dopamine neurons achieves homeostatic resilience. *Science, 344*(6181), 313–319. doi:10.1126/science.1249240
- Gross, J. J. (1998). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality & Social Psychology, 74*(1), 224–237.
- Hobfoll, S. E. (2002). Social and psychological resources and adaptation. *Review of General Psychology, 6*(4), 307–324. doi:10.1037/1089-2680.6.4.307
- Johnson, S. F., & Boals, A. (2015). Refining our ability to measure posttraumatic growth. *Psychological Trauma: Theory, Research, Practice, and Policy, 7*(5), 422–429. doi:10.1037/tra0000013
- Joseph, S., & Linley, P. A. (2006). Growth following adversity: Theoretical perspectives and implications for clinical practice. *Clinical Psychology Review, 26*(8), 1041–1053. doi:10.1016/j.cpr.2005.12.006

- Kalisch, R., Baker, D. G., Basten, U., Boks, M. P., Bonanno, G. A., Brummelman, E., . . . Kleim, B. (2017). The resilience framework as a strategy to combat stress-related disorders. *Nature Human Behaviour*, 1(11), 784–790. doi:10.1038/s41562-017-0200-8
- Kalisch, R., Cramer, A. O. J., Binder, H., Fritz, J., Leertouwer, I., Lunansky, G., . . . van Harmelen, A.-L. (2019). Deconstructing and reconstructing resilience: A dynamic network approach. *Perspectives on Psychological Science*, 14(5), 765–777. doi:10.1177/1745691619855637
- Kalisch, R., & Gerlicher, A. M. V. (2014). Making a mountain out of a molehill: On the role of the rostral dorsal anterior cingulate and dorsomedial prefrontal cortex in conscious threat appraisal, catastrophizing, and worrying. *Neuroscience & Biobehavioral Reviews*, 42, 1–8. doi:10.1016/j.neubiorev.2014.02.002
- Kalisch, R., Müller, M. B., & Tüscher, O. (2015). A conceptual framework for the neurobiological study of resilience. *Behavioral and Brain Sciences*, 38. doi:10.1017/S0140525X1400082X
- Kent, M., Davis, M. C., & Reich, J. W. (2014). Introduction. In M. Kent, M. C. Davis, & J. W. Reich (Eds.), *The resilience handbook* (pp. xii–xix). New York, NY: Routledge.
- Kobasa, S. C. (1979). Stressful life events, personality, and health: An inquiry into hardiness. *Journal of Personality and Social Psychology*, 37(1), 1–11.
- Kong, F., Ma, X., You, X., & Xiang, Y. (2018). The resilient brain: Psychological resilience mediates the effect of amplitude of low-frequency fluctuations in orbitofrontal cortex on subjective well-being in young healthy adults. *Social Cognitive and Affective Neuroscience*, 13(7), 755–763. doi:10.1093/scan/nyy045
- Kong, F., Wang, X., Hu, S., & Liu, J. (2015). Neural correlates of psychological resilience and their relation to life satisfaction in a sample of healthy young adults. *NeuroImage*, 123, 165–172. doi:10.1016/j.neuroimage.2015.08.020
- Krishnan, V., Han, M.-H., Graham, D. L., Berton, O., Renthal, W., Russo, S. J., . . . Nestler, E. J. (2007). Molecular adaptations underlying susceptibility and resistance to social defeat in brain reward regions. *Cell*, 131(2), 391–404. doi:10.1016/j.cell.2007.09.018
- Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York, NY: Springer.
- Leventhal, H., & Scherer, K. R. (1987). The relationship of emotion to cognition: A functional approach to a semantic controversy. *Cognition and Emotion*, 1, 3–28.
- Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The construct of resilience: A critical evaluation and guidelines for future work. *Child Development*, 71(3), 543–562.
- Maier, S. F. (2015). Behavioral control blunts reactions to contemporaneous and future adverse events: Medial prefrontal cortex plasticity and a corticostriatal network. *Neurobiology of Stress*, 1, 12–22. doi:10.1016/j.ynstr.2014.09.003
- Mancini, A. D. (2019). When acute adversity improves psychological health: A social-contextual framework. *Psychological Review*, 126(4), 486–505. doi:10.1037/rev0000144
- Mancini, A. D., & Bonanno, G. A. (2009). Predictors and parameters of resilience to loss: Toward an individual differences model. *Journal of Personality*, 77(6), 1805–1832. doi:10.1111/j.1467-6494.2009.00601.x
- Masten, A. S., & Garmezy, N. (1985). Risk, vulnerability, and protective factors in developmental psychopathology. In B. B. Lahey & A. E. Kazdin (Eds.), *Advances in clinical child psychology* (pp. 1–52). doi:10.1007/978-1-4613-9820-2\_1
- McCubbin, H. I., Fleming, W. M., Thompson, A. I., Neitman, P., Elver, K. M., & Savas, S. A. (1998). Resiliency and coping in “at risk” African-American youth and their families. In H. I. McCubbin, E. A. Thompson, A. I. Thompson, & J. A. Futrell (Eds.), *Resiliency in African-American families* (pp. 287–328). Thousand Oaks, CA: SAGE.
- McEwen B. S., & Stellar, E. (1993). Stress and the individual: Mechanisms leading to disease. *Archives of Internal Medicine*, 153(18), 2093–2101. doi:10.1001/archinte.1993.00410180039004
- McGiffin, J. N., Galatzer-Levy, I. R., & Bonanno, G. A. (2019). Socioeconomic resources predict trajectories of depression and resilience following disability. *Rehabilitation Psychology*, 64(1), 98–103. doi:10.1037/rep0000254
- Menard, C., Pfau, M. L., Hodes, G. E., Kana, V., Wang, V. X., Bouchard, S., . . . Russo, S. J. (2017). Social stress induces neurovascular pathology promoting depression. *Nature Neuroscience*, 20(12), 1752–1760. doi:10.1038/s41593-017-0010-3

- Neuner, F., Schauer, M., Karunakara, U., Klaschik, C., Robert, C., & Elbert, T. (2004). Psychological trauma and evidence for enhanced vulnerability for posttraumatic stress disorder through previous trauma among West Nile refugees. *BMC Psychiatry*, 4(1), 34. doi:10.1186/1471-244X-4-34
- Nickerson, A., Creamer, M., Forbes, D., McFarlane, A. C., O'Donnell, M. L., Silove, D., . . . Bryant, R. A. (2017). The longitudinal relationship between post-traumatic stress disorder and perceived social support in survivors of traumatic injury. *Psychological Medicine*, 47(1), 115–126. doi:10.1017/S0033291716002361
- Ragland, G. B., & Shulkin, J. (2014). Introduction to allostasis and allostatic load. In M. Kent, M. C. Davis, & J. W. Reich (Eds.), *The resilience handbook: Approaches to stress and trauma* (pp. 44–52). New York, NY: Routledge.
- Reber, S. O., Siebler, P. H., Donner, N. C., Morton, J. T., Smith, D. G., Kopelman, J. M., . . . Lowry, C. A. (2016). Immunization with a heat-killed preparation of the environmental bacterium *Mycobacterium vaccae* promotes stress resilience in mice. *Proceedings of the National Academy of Sciences of the United States of America*, 113(22), E3130–E3139. doi:10.1073/pnas.1600324113
- Robinson, M. D. (1998). Running from William James' bear: A review of preattentive mechanisms and their contributions to emotional experience. *Cognition and Emotion*, 12, 667–696. doi:10.1080/026999398379493
- Russo, S. J., Murrrough, J. W., Han, M.-H., Charney, D. S., & Nestler, E. J. (2012). Neurobiology of resilience. *Nature Neuroscience*, 15(11), 1475–1484. doi:10.1038/nn.3234
- Rutter, M. (2012). Resilience as a dynamic concept. *Development and Psychopathology*, 24(2), 335–344. doi:10.1017/S0954579412000028
- Sander, D., Grandjean, D., & Scherer, K. R. (2005). A systems approach to appraisal mechanisms in emotion. *Neural Networks*, 18(4), 317–352. doi:10.1016/j.neunet.2005.03.001
- Sapienza, J. K., & Masten, A. S. (2011). Understanding and promoting resilience in children and youth. *Current Opinion in Psychiatry*, 24(4), 267–273. doi:10.1097/ycp.0b013e32834776a8
- Scherer, K. R. (2001). Appraisal considered as a process of multilevel sequential checking. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.), *Appraisal processes in emotion: Theory, methods, research* (pp. 92–120). New York, NY: Oxford University Press.
- Schultebraucks, K., & Galatzer-Levy, I. R. (2019). Machine learning for prediction of posttraumatic stress and resilience following trauma: An overview of basic concepts and recent advances. *Journal of Traumatic Stress*, 32(2), 215–225. doi:10.1002/jts.22384
- Seery, M. D., Holman, E. A., & Silver, R. C. (2010). Whatever does not kill us: Cumulative lifetime adversity, vulnerability, and resilience. *Journal of Personality and Social Psychology*, 99(6), 1025–1041. doi:10.1037/a0021344
- Seery, M. D., Leo, R. J., Lupien, S. P., Kondrak, C. L., & Almonte, J. L. (2013). An upside to adversity?: Moderate cumulative lifetime adversity is associated with resilient responses in the face of controlled stressors. *Psychological Science*, 24(7), 1181–1189. doi:10.1177/0956797612469210
- Shao, R., Lau, W. K. W., Leung, M.-K., & Lee, T. M. C. (2018). Subgenual anterior cingulate-insula resting-state connectivity as a neural correlate to trait and state stress resilience. *Brain and Cognition*, 124, 73–81. doi:10.1016/j.bandc.2018.05.001
- Shi, L., Sun, J., Wei, D., & Qiu, J. (2019). Recover from the adversity: Functional connectivity basis of psychological resilience. *Neuropsychologia*, 122, 20–27. doi:10.1016/j.neuropsychologia.2018.12.002
- Sterling, P., & Eyer, J. (1988). Allostasis: A new paradigm to explain arousal pathways. In S. Fisher & J. Reason (Eds.), *Handbook of life stress, cognition and health* (pp. 629–649). New York, NY: John Wiley.
- Tedeschi, R. G., & Calhoun, L. G. (2004). Posttraumatic growth: Conceptual foundations and empirical evidence. *Psychological Inquiry*, 15(1), 1–18. doi:10.1207/s15327965pli1501\_01
- van Rooij, S. J. H., Stevens, J. S., Ely, T. D., Fani, N., Smith, A. K., Kerley, K. A., . . . Jovanovic, T. (2016). Childhood trauma and COMT genotype interact to increase hippocampal activation in resilient individuals. *Frontiers in Psychiatry*, 7, 156. doi:10.3389/fpsy.2016.00156
- Waaktaar, T., & Torgersen, S. (2012). Genetic and environmental causes of variation in trait resilience in young people. *Behavior Genetics*, 42(3), 366–377. doi:10.1007/s10519-011-9519-5
- Waugh, C. E., Wager, T. D., Fredrickson, B. L., Noll, D. C., & Taylor, S. F. (2008). The neural correlates of trait resilience when anticipating and recovering from threat. *Social Cognitive and Affective Neuroscience*, 3(4), 322–332. doi:10.1093/scan/nsn024

- Weiner, H. (1992). *Perturbing the organism: The biology of stressful experience*. Chicago, IL: University of Chicago Press.
- Werner, E. E., & Smith, R. S. (1989). *Vulnerable but invincible: A longitudinal study of resilient children and youth*. New York, NY: Adams Bannister Cox.
- Windle, G., Bennett, K. M., & Noyes, J. (2011). A methodological review of resilience measurement scales. *Health and Quality of Life Outcomes*, 9, 8. doi:10.1186/1477-7525-9-8