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## Structure Rather Than Intensity: Typologizing Stress and Functional Rearrangement Across Three Temporal Scales

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### Abstract

现代心理困扰的关键变化并非压力总量增加，而是慢性压力输入结构的持续重组及其对心理资源配置的长期塑形。整合进化生物学、发育神经科学与社会历史视角，提出应激结构的类型化框架，并构建三重时间尺度解释坐标：进化尺度提供相对稳定的机制库，历史尺度重塑压力输入结构，发展尺度决定其写入并固化为功能配置。该框架将应激结构理解为模块并存基础上的功能主导性重排，用以解释倦怠、快感缺乏、意义危机与现实感不稳等表型差异，并提出可检验命题，为人工智能时代心理问题的机制分型、分层干预与结构治理提供理论坐标。

### Full Text

## Structure Rather Than Intensity: Typologizing Stress and Functional Rearrangement Across Three Temporal Scales

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**Abstract** Modern psychological distress is changing in a crucial way: the problem is not an increase in the total amount of stress, but the continuous restructuring of chronic stress inputs and their long-term shaping of the allocation of psychological resources. Integrating perspectives from evolutionary biology, developmental neuroscience, and social history, this paper proposes a typological framework for stress structure and constructs an explanatory coordinate system across three temporal scales: the evolutionary scale provides a relatively stable repertoire of mechanisms; the historical scale reshapes the structure of stress inputs; and the developmental scale determines how these inputs are written in and consolidated as functional configurations. This framework understands stress structure as a functionally dominant rearrangement on the basis of the

coexistence of modules, and uses it to explain phenotypic differences such as burnout, anhedonia, crisis of meaning, and instability of the sense of reality. It further proposes testable propositions, providing theoretical coordinates for mechanistic subtyping, tiered intervention, and structural governance of psychological problems in the age of artificial intelligence.

**Keywords** stress structure; functionally dominant rearrangement; evolutionary mismatch; developmental plasticity; generative artificial intelligence

Mental health in human society in the twenty-first century presents a profound paradox: in industrialized societies, objective threats to survival—such as famine and violence—have markedly decreased, and material wealth has reached unprecedented levels; yet subjective psychological suffering has not abated accordingly, but instead has shown an almost epidemic-like increase. Problems such as burnout, crises of meaning, anhedonia, and “hollowing-out” have become increasingly common, and their complexity and diffuseness are often difficult to explain adequately using traditional stress models (Slavich, 2020). Simply attributing these difficulties to intensified competition, technological pressure, or economic inequality may explain some proximal causes, but it still fails to account for a more structural phenomenon: when external threats continue to decline, why does the psychological system instead become more prone to long-term depletion and imbalance of meaning? Classical stress research laid the foundation for understanding stress responses and formed a theoretical spectrum ranging from physiological mobilization to cognitive appraisal. From Cannon’s “fight-or-flight” response (Cannon, 1915), to Selye’s general adaptation syndrome (Selye, 1956), and then to Lazarus’ stress-appraisal-coping model (Lazarus & Folkman, 1984). This tradition is highly effective in explaining acute stress responses, but its implicit prototype is often “event-based stress—short-term response,” making it relatively difficult to explain the more prevalent chronic distress of the contemporary era and its marked phenotypic heterogeneity. Evolutionary psychology provides a key entry point: the human stress system is an alarm mechanism shaped by natural selection, used to detect danger, mobilize resources, and serve key goals such as reproduction and status maintenance (Maner & Kenrick, 2010). Since the Agricultural Revolution, environments have undergone accelerating transformation; the Industrial Revolution reshaped the structure of life; and in the age of digitalization and artificial intelligence, the speed of change itself has become part of everyday life. Genetic updating has difficulty keeping pace with external change, producing a typical “evolutionary mismatch”: detection thresholds and response patterns formed in the Paleolithic era, when facing contemporary stress inputs that are chronic, diffuse, and highly symbolic, often manifest as “hypervigilance,” “mis-mobilization,” or “sustained activation” (Li et al., 2018; Nesse, 2023). Therefore, contemporary anxiety, addiction, compulsions, burnout, and loss of meaning do not necessarily point to entirely new pathological mechanisms; they are more likely a form of “malfunction after over-adaptation,” that is, systems originally used to defend against threats and maintain motivation are kept chronically elevated and ultimately lose regulatory flexibility (Durisko et al., 2016; Nesse, 2023).

However, “mismatch” alone is still insufficient to explain reality. Modern psychological distress is both a macro-level trend and a phenomenon with marked individual differences: some people collapse rapidly in similar environments, whereas others remain relatively robust; some show a rupture of motivation during adolescence, whereas others only in adulthood fall into

crisis of meaning. Understanding this differentiation requires introducing the perspective of developmental plasticity. Developmental neuroscience shows that stress-regulation systems, reward systems, and self-related processing networks all have sensitive periods; when stress exposure occurs in different windows, neural adaptive pathways differentiate accordingly. Adolescence, for example, is a stage in which reward and social evaluation are highly plastic, and also a stage in which the “reward-control” relationship is recalibrated (Steinberg, 2008; Casey et al., 2011). Stress structures at the macro level do not remain merely in social narratives; through developmental processes, they enter the individual and shape more enduring modes of psychological functioning. On this basis, this article introduces the perspective of “stress structure,” specifically referring to the combinatory patterns of chronic stress inputs across such dimensions as type, rhythm, intensity, and predictability, and proposes a threefold temporal-scale framework of “evolution-history-development” to explain how chronic stress inputs are inscribed through developmental processes and stabilized into differentiated functional configurations and psychological phenotypes. The contribution of this article lies not in claiming that its conclusions have been “proven,” but in advancing the explanation from a “stress-intensity narrative” to a testable pathway of “input structure-functional configuration” : translating stress structure into operational mechanism hypotheses and testable propositions, thereby providing a clear entry point for subsequent empirical identification, mechanistic typology, stratified intervention, and structural governance. To achieve these aims, this article will first review the evolution and limitations of traditional stress models, then construct a threefold temporal-scale framework and define the core concepts; on this basis, it will typologically propose four typical stress structures and explicate their dominant mechanisms and phenotypic consequences.

## **1 Theoretical Framework: A Threefold Temporal Scale and an Analytical Coordinate System for Stress Structure**

### **1.1 Defining Core Concepts: Stress Structure and Functional-Dominance Bias**

Traditional stress research has often understood stress as a process of subjective appraisal within the individual-environment relationship, emphasizing the match between situational demands and individual resources, as well as the differences in coping that this match elicits (Lazarus & Folkman, 1984). However, in a highly complex and technologically intensive modern society, many psychological difficulties do not arise from a single or short-lived stressful event, but

are more likely shaped by long-standing, difficult-to-avoid, and systematized configurations of stress (Sapolsky, 2004; Nesse, 2023). Accordingly, this article introduces the analytical concept of “stress structure,” referring to the pattern of stress configurations that continuously and systematically enter individual life within a particular socio-technical environment, as well as the structural effects these configurations exert on the organization of psychological resources. This concept emphasizes that stress does not occur in isolation; rather, it is embedded in everyday life in relatively stable configurational forms, altering the operating logic and functional priorities of the individual psychological system through long-term exposure. To render “structure” into empirically discussable dimensions, this article operationalizes the key features of stress structure into at least three criteria. First is temporal distribution: whether stress inputs are discrete and brief, or high-frequency, chronic, and difficult to interrupt. Second is predictability and escapability: whether stress cues are stable, whether boundaries are clear, and whether the individual can form effective buffers or exit. Third is feedback structure: whether behavioral consequences are immediate and clear, or delayed, ambiguous, and difficult to close into a feedback loop. These criteria are not equivalent to “stress intensity” ; rather, they are used to characterize how the organizational form of stress inputs affects the long-term load and regulatory costs of the psychological system (Sapolsky, 2004; Nesse, 2023).

On this basis, this article further proposes “functional-dominance bias” as an operational concept to describe the functional reorganization within the psychological-neural system under different stress structures. Functional-dominance bias refers to a condition in which, under the long-term action of a particular stress structure, a certain stress-related function gains relative priority in triggering thresholds, resource allocation, and behavioral mobilization, thereby becoming more likely to dominate information processing and behavioral output in overall psychological functioning. It should be emphasized that this change occurs on the basis of the long-term coexistence of existing mechanisms, and is manifested more as a shift in relative priority at the functional level than as a mechanism “replacement” at the structural level. This understanding is consistent with the perspective of developmental mismatch: early experiences can

shape preparedness for coping in later stages; adult risk often stems from “early-later environmental mismatch,” rather than from the appearance of wholly new mechanisms out of nothing (Hoogland & Ploeger, 2022). From the perspective of the “smoke detector” principle in evolutionary medicine, under conditions of high cost and high uncertainty, it is an understandable adaptive strategy for the stress system to tolerate a relatively high false-positive rate in order to avoid fatal missed detections (Nesse, 2001). When this “threshold drift–compensatory activation” becomes prolonged within a chronic stress structure, a bias in functional dominance may thereby form, further explaining systematic differences among psychological phenotypes (Nesse, 2023).

## 1.2 Triple Time Scales and Four Types of Stress Structure: An Analytic Coordinate System and Its Typological Results

Within the analytic framework of “stress structure–bias in functional dominance,” this article further develops its argument across three time scales: evolution, history, and development. The evolutionary scale provides a relatively stable repertoire of mechanisms; the historical scale reshapes the structure of stress inputs; and the developmental scale determines the window in which these structural inputs are written in and stabilized as functional configurations. Thus, this study does not describe an inevitable sequence for individuals, but instead provides an analytic coordinate system for locating biases in functional dominance under “history  $\times$  development” conditions.

First, at the evolutionary scale, the basic architecture of human stress and motivational systems is, overall, relatively conserved. Emotion–motivation mechanisms such as danger detection, resource mobilization, and social adaptation can be understood as psychological adaptations shaped over the long term by natural selection; their existence is not a product of modern society (Tooby & Cosmides, 1992; Maner & Kenrick, 2010). Second, at the historical scale, the agricultural revolution, industrialization, and the expansion of digital media did not create new mechanisms. Rather, by altering the structural characteristics of stress inputs—such as frequency, predictability, feedback delay, and symbolic substitution—they caused existing mechanisms to be triggered more continuously and more intensively, thereby producing more pronounced effects at the levels of experience and behavior (Durisko et al., 2016; Li et al., 2018). Third, at the developmental scale, the kinds of stress structures individuals encounter within critical developmental windows profoundly influence the functional configuration of psychological systems in adulthood. The stage-specific plasticity of stress-regulation networks and reward–control systems indicates that the same environmental input does not have identical long-term consequences at different developmental stages (Lupien et al., 2009; Casey et al., 2011). Further, from an allostatic perspective, “writing in and solidifying” means not only that responses are repeatedly triggered, but also that chronic stress places brain–body regulation in a long-term, higher-cost state and reallocates the energy budget, crowding out maintenance and repair processes and driving regulation from adaptive allostasis toward load/overload; as a result, functional bias is more likely to stabilize into a persistent configuration (McEwen, 1998; Bobba-Alves et al., 2022). At the same time, the core of allostatic regulation can also be understood as brain–body coordination grounded in predictive interoceptive integration. When this system operates at high cost over the long term under chronic stress inputs, overload is more likely to accumulate along neural–endocrine–immune and epigenetic pathways, thereby increasing the probability that functional configurations become solidified (Santamaría-García et al., 2025). Accordingly, the three time scales together constitute an explanatory coordinate system for understanding “how the structure of stress inputs becomes

solidified into functional configurations through developmental processes.”

Within the above coordinate system, stress structures can further be typologized into several representative structural types. A structural type is not a simple collection of single stressors; rather, it refers to a set of stress-configuration patterns that exist over the long term under particular socio-technical conditions and repeatedly act upon individuals during development. Based on sociohistorical analysis and existing psychological-neural research, this article summarizes them into four typical forms: a threat-type structure centered on acute survival crises; a temptation-type structure centered on high-density reward stimuli and social comparison; a value-gap-type structure centered on internalized value discrepancies and the destabilization of meaning; and a hyperreal-type structure that is gradually emerging within generative artificial intelligence and hyperreal media environments. It should be noted that the above four types are intended to characterize typical forms of chronic stress input structures; in reality, they are more likely to coexist, overlap, and undergo shifts in dominance and subordination. Further, relevant allostatic theories and frameworks of nervous-system organization provide a mo-

provided verifiable biological support: Santamaría-García et al. (2025), starting from predictive interoceptive integration, characterized the cross-system mechanisms of allostatic overload; Bobba-Alves et al. (2022), through competition in energy budgeting, translated the “wear-and-tear solidification” of chronic load into testable predictions; and Katsumi et al. (2022) provided whole-brain organizational coordinates with hierarchical gradients for predictive coding, thereby endowing the “three temporal scales  $\times$  four types of stress structures” proposed in this paper with mechanistic coordinates that are localizable, translatable, and testable.

## 2 Four Types of Stress Structures and Their Dominant Mechanisms

The following analysis unfolds around the chain of “stress structure—dominant mechanism—psychological phenotype.” It discusses, in sequence, the social backgrounds and stress-input characteristics of threat-type, temptation-type, value-discrepancy-type, and hyperreal-type structures, and on this basis identifies the psychoneural mechanisms more likely to acquire priority and their typical phenotypic consequences, so as to delineate the formation pathways of functionally dominant biases and the spectrum of psychological risks across different stress ecologies.

### 2.1 Threat-Type Structure: Acute Survival Crisis and the Threat-Detection System

Threat-type stress structures are commonly found in ecological contexts dominated by survival risks. Their stress inputs are characterized by high uncertainty and high cost, including famine, disease, violent conflict, and environmental dis-

asters. Such stressors often erupt acutely, are triggered externally, and are difficult for the individual to control. Their core function is to heighten vigilance, promote resource mobilization, and strengthen immediate defensive responses. The corresponding psychological phenotypes are often manifested as hypervigilance, risk avoidance, persistent tension, and hypersensitivity to threat cues. Under this input structure, the systems more likely to gain priority are the threat-detection system represented by the amygdala and the stress-regulation system centered on the hypothalamic-pituitary-adrenocortical axis (HPA axis). Their role is to rapidly identify potential danger and trigger physiological and behavioral mobilization, thereby supporting immediate defense and resource allocation (Sapolsky, 2004; Lupien et al., 2009). Threat detection has a certain degree of automaticity and selectivity: humans may have a lower triggering threshold and faster processing channels for evolutionarily relevant threat cues, enabling defensive responses to be rapidly mobilized with less conscious involvement (Öhman & Mineka, 2001). From an adaptive perspective, this bias toward “better a false alarm than a missed alarm” accords with the smoke-detector principle: under high-cost threat conditions, the system tends to tolerate a certain level of false positives in order to avoid fatal misses (Nesse, 2001).

The influence of threat-type structures is not limited to immediate responses. Early life is an important window during which the stress-regulation system is affected by environmental inputs and undergoes functional calibration. Early stress exposure may alter the baseline level and reactivity of the stress system through developmental plasticity, and may form relatively stable, highly sensitive stress characteristics in adulthood (Lupien et al., 2009). Neuroimaging studies suggest that early adversity is associated with functional changes in amygdala-related circuits and differences in their coupling with prefrontal regulatory networks, thereby affecting subsequent emotional reactivity and tendencies in threat-cue processing (Tottenham & Sheridan, 2010; Gee et al., 2013). A large body of research also indicates that early adversity is associated with increased risks of anxiety, mood disorders, and trauma-related outcomes in adulthood. One possible mechanism is that the stress-regulation system undergoes changes in reactivity and a lowering of thresholds under long-term load (Sapolsky, 2004; Lupien et al., 2009). In extreme cases, this may manifest as the continued maintenance of hypervigilance and intrusive threat memories even in safe contexts, suggesting that the defensive system has difficulty “shutting down” in time after a crisis (Shin et al., 2006), and it may be accompanied by the accumulation of cardiovascular and immune burden (Brudey et al., 2015). From the perspective of developmental mismatch, this process is closer to the calibration of “coping preparedness” within a sensitive period: when the early environment persistently presents high-threat characteristics, individuals in later contexts are more inclined to prioritize threat cues in allocating attention, interpretation, and emotional responses, thereby crystallizing into a functional bias that prioritizes threat detection (Hoogland & Ploeger, 2022). Accordingly, it can be expected that individuals chronically exposed to high-threat inputs in early life are more likely in adulthood to exhibit an enhanced vigilance bias and

stress-resetting  
difficulties (Lupien et al., 2009; Nesse, 2001).

## 2.2 Temptation-Type Structure: High-Stimulation Environments and the Reward System

Temptation-type stress structures are most commonly found in the high-stimulation ecology of industrialized and consumer societies. Their stress input takes “high stimulation—high frequency—low-cost acquisition” as its basic form, and is further amplified by immediate feedback and social comparison. Under these conditions, behavior is more readily pulled by cues and “locked” into immediate returns. Typical phenotypic manifestations include strengthened preference for immediate gratification, cue-hijacked attention, difficulty with impulse control, and increased risk of behavioral addiction, indicating that the reward system is more likely to form a relatively dominant bias. It should be noted that “temptation” here is not pleasure itself, but rather the inertial motivational load and self-control costs produced by sustained, high-frequency cue mobilization. Its long-term effects may manifest as depletion, upward shifts in hedonic thresholds, and risk of behavioral loss of control. Under this input structure, the system more likely to gain priority is the reward system centered on the mesolimbic dopamine pathway, especially the motivational mobilization process supported by the ventral tegmental area-nucleus accumbens (VTA-NAc) pathway. Incentive-sensitization theory proposes that repeated exposure to reward cues enhances responses to “wanting,” whereas subjective pleasure (“liking”) does not necessarily increase in parallel, thereby leading to persistent pursuit and motivational imbalance (Robinson & Berridge, 1993; Berridge & Robinson, 1998). This may form a functional alienation of “sensitization—decoupling”: craving escalates while satisfaction does not increase accordingly. Long-term high motivation may also induce functional allostasis, causing sensitivity to ordinary stimuli to decline and reward thresholds to shift upward, laying the foundation for hedonic loss and motivational depletion (Koob & Le Moal, 2001). Correspondingly, various forms of substance and behavioral addiction often involve dysfunction of dopamine pathways (Volkow et al., 2012). At the experiential level, this manifests as “wanting but being unable to be satisfied,” that is, a further decoupling of “wanting” and “liking” (Berridge & Robinson, 2016). When desensitization and allostasis accumulate, individuals may also experience anhedonia, boredom and indifference, and weakened sense of goals, which can be summarized as reward-system fatigue (Yau & Potenza, 2015).

From a developmental perspective, the adolescent reward-drive system is highly sensitive to reward cues and social evaluation, whereas maturation of the prefrontal control network is relatively delayed, showing a typical developmental pattern in which the “accelerator precedes the brake” (Steinberg, 2008; Casey et al., 2011). In environments with high stimulation and immediate feedback, this temporal imbalance is further magnified, increasing cue sensitization and

risk preference, and may have long-term effects on motivational structure and self-control capacity in adulthood (Casey et al., 2011). It can therefore be predicted that, under continuous reward input characterized by “high stimulation—high frequency—low-cost acquisition,” the reward system is more likely to form a dominant bias of sensitization and decoupling, and to consolidate during the adolescent window into preferences for immediate gratification, impulse-control failure, and addictive pursuit tendencies (Steinberg, 2008; Berridge & Robinson, 2016).

### 2.3 Value-Discrepancy Structure: Meaning Instability and the Self-Reference System

Value-discrepancy stress structures are more commonly found in post-industrial contexts. Their stress input is not simply “greater in intensity,” but rather a chronic “expectation–pathway discrepancy”: idealized expectations continue to rise, while the paths for realization are relatively insufficient or opaque, causing individuals to expend psychological resources over the long term on meaning coordination and self-justification. On the one hand, success narratives and comparison systems drive the inflation of expectations; when aspiration levels continue to rise, subjective well-being does not necessarily increase steadily with objective improvements, and instead is more likely to show frustration and loss (Easterlin, 2001; Diener et al., 2006). On the other hand, the fluidization of value-reference systems and the weakening of identity anchors make self-identification more dependent on continuous reflexive construction rather than stable institutional support (Bauman, 2000; Giddens, 1991). It should be noted that the relevant social theories are used here mainly for depicting the input side, providing a background for the subsequent discussion of psychological mechanisms, rather than replacing empirical evidence from psychology. At the same time, in digitalized environments, external

The ubiquity of external evaluation intensifies quantified feedback and online comparison, making self-worth more susceptible to external cues and thereby increasing fluctuations in self-esteem and emotional risk (Kross et al., 2013; Vogel et al., 2014; Lee et al., 2020). Under this input structure, individuals are more likely to fall into a cycle of “evaluative involution—suspended meaning—destabilized self-narrative.” Its typical phenotypic manifestations include burnout, crises of meaning, and ruminative self-depletion, and it may be accompanied by experiential features such as low motivational reactivity and anhedonia.

At the mechanistic level, the value-discrepancy structure is more likely to shift dominant weighting toward the self-referential processing system supported by the Default Mode Network (DMN). The DMN includes regions such as the medial prefrontal cortex (mPFC) and posterior cingulate cortex (PCC), and participates in self-related evaluation, autobiographical memory, and the integration of internal narratives (Raichle et al., 2001; Qin & Northoff, 2011; Andrews-Hanna, 2012). When individuals must engage in self-evaluation and coordination of meaning in a more sustained and more costly manner, the self-referential system

is more likely to enter a high-load state; in the absence of stable value anchors, this load is more likely to become fixed as negative rumination that is difficult to shut down. Empirical research shows that depression-related states are closely associated with excessive DMN involvement in negative self-rumination, suggesting that “self-related processing overload” may constitute one important neural signature of meaning imbalance (Hamilton et al., 2015).

At the level of developmental tasks, adolescence through early adulthood is an important window for integrating self-concept and value systems. Individuals need to integrate social evaluations, identity roles, and internal goals into relatively stable self-narratives and frameworks of meaning (Qin & Northoff, 2011; Andrews-Hanna, 2012). When external comparison pressure persists over the long term while value supports are insufficient, individuals are more likely to mobilize executive-control and emotion-regulation resources at higher frequency in order to maintain “performance-based self-validation” and self-monitoring. This gives rise to chronic resource occupation and subjective depletion, accompanied by reduced self-regulatory efficacy (Baumeister et al., 1998; Ackerman et al., 2009). What is emphasized here is sustained resource occupation and regulatory cost, rather than a mechanical extrapolation from any single theoretical conclusion. It should be noted that the motivational damage caused by the value-discrepancy structure differs from the “sensitization” mechanism of the temptation-type structure: it does not originate in direct stimulation by reward cues, but rather in the high load of self-related processing, which indirectly weakens reward processing through depletion and top-down regulation. As a result, some individuals show low reactivity of the motivational system and anhedonia, echoing research on low reward sensitivity (Treadway & Zald, 2011; Husain & Roiser, 2018). In addition, chronic psychosocial stress may affect the functional integrity of reward circuits through immune-related pathways, providing a potential biological route for anhedonia and motivational depletion (Cathomas et al., 2024). Large-sample symptom network analyses also suggest that, in young adulthood, “sadness” often remains central, whereas “failure/worthlessness” is more prominent in specific age windows (e.g., ages 30–34), which can be understood as a manifestation of an intensified “expectation–reality discrepancy” (Huang et al., 2026). Accordingly, it can be predicted that, under the long-term influence of a value-discrepancy input structure, the self-referential system is more likely to become consolidated into a ruminative, high-load operating bias, and through resource occupation and top-down regulation to implicate low reactivity of the motivational system, thereby presenting a phenotypic combination of burnout, crisis of meaning, and anhedonia (Hamilton et al., 2015; Husain & Roiser, 2018).

## 2.4 Hyperreal-Type Structure: Authenticity Crisis and Reality-Testing Overload

The hyperreal-type stress structure is gradually becoming evident in generative artificial intelligence and hyperreal media environments. The key change in its

stress-input structure does not lie in information being “more abundant and faster,” but in the structural uncertainty caused by damaged authenticity cues, which continuously raises the burden of reality testing in an additive manner. Deepfakes and scalable content generation weaken the traceability of information sources and intentions, causing individuals to face authenticity-judgment tasks more frequently and to bear higher cognitive verification costs (Chesney & Citron, 2019; Ahmed et al., 2025; Hynek et al., 2025). At the same time, the advance of algorithmic decision-making and automated substitution in occupational and creative domains strengthens concerns about replaceability and role stability, thereby increasing loss of perceived control and existential insecurity (Alkhalifah et al., 2024; Granulo et al., 2026). Therefore, this

The structure can be summarized as “uncertainty of authenticity—rising reality-testing load—drift in meaning benchmarks.” Its phenotypic risks may manifest as cognitive fatigue, weakened sense of reality, persistent unease, and existential anxiety (Kim & Lee, 2024; Yang & Sundar, 2025). It should be emphasized that, compared with the preceding three types of structures, hyperreal stress remains at a stage of “structural emergence but not yet full typological consolidation.” Existing evidence is reflected more in convergent clues across research domains, and longitudinal tracking and tests of mechanistic pathways are still needed to more clearly identify the direction and process of its effects (Chuang et al., 2025).

Under this input structure, the psychological system is more likely to passively form a dominant bias centered on reality monitoring and metacognitive verification. Reality monitoring involves discriminating information sources, generation pathways, and authenticity, and is closely related to explicit retrieval and post-retrieval monitoring functions supported by prefrontal-related networks (Simons et al., 2017). When the information environment continuously provides highly realistic yet suspicious inputs with weak causal constraints, individuals find it more difficult to rely on low-cost implicit judgments, and are more likely to depend frequently on explicit retrieval and post-retrieval monitoring to maintain consistency with reality. Neuroimaging evidence also suggests that, when facing identity cues in deepfakes, the brain often needs to simultaneously mobilize artifact processing in sensory cortex and social-meaning/reward evaluation in the striatum, thereby forming an authenticity-verification load that depends more on cortico-striatal coordination (Roswadowitz et al., 2024). To improve the operationalizability of the mechanistic pathway, it can be understood within a predictive-coding framework: the brain can be viewed as maintaining the interpretability and controllability of the environment by minimizing prediction error (Friston, 2010). Katsumi et al. (2022) further pointed out that prediction and error correction unfold along the hierarchical gradient organization of cortical functional connectivity, and that the default network and frontoparietal control network are located at the higher-order end and are responsible for regulating prediction precision and abstract interpretation. Therefore, when damaged authenticity cues lead low-cost heuristic judgments to fail, the system is more likely to be forced to shift toward explicit verification dominated by the

prefrontal-control network. As a result, the elimination of prediction error is no longer a rapid automated process, but is more likely to be transformed into a high-cost, accumulative task of maintaining reality consistency, causing reality monitoring and metacognitive verification to passively acquire higher priority in resource competition.

In the long term, this passive high-cost operation can be regarded as an accumulative process of allostatic load, whose costs may manifest as chronic depletion, increased psychological vulnerability, and heightened risk of fluctuations in the sense of reality (McEwen, 1998; Sapolsky, 2004). Its core risk does not lie in the “overactivation” of a single emotional module, but in the long-term maintenance of high load by the reality-testing mechanism: when verification costs continue to rise while available cues are insufficient, individuals may shift toward more conservative judgment strategies, increasing tendencies toward suspicion and avoidance, and manifesting as cognitive weariness and reduced capacity for meaning anchoring (Bawden & Robinson, 2009). Although related research is still in a developmental stage, existing evidence suggests empirical associations among deepfakes, information distortion, and damage to basic trust, which may further affect public trust and risk judgment (Ahmed et al., 2025). At the experiential level, evidence also indicates that AI-technology stress and digital involvement are significantly associated with anxiety and depressive symptoms (Liñan, 2025a; Liñan, 2025b). Accordingly, it can be predicted that, in environments where authenticity cues are damaged and verification costs continue to rise, reality monitoring and metacognitive verification are more likely to be forced to maintain high-load operation, and to increase the risks of cognitive fatigue and weakened sense of reality through the accumulation of allostatic load. More importantly, this structure is more likely to reshape existing stress experiences in an additive manner rather than replacing existing types (McEwen, 1998; Simons et al., 2017). This expectation can also be further implemented as measurable indicators, such as increased source-monitoring error rates, increased false memories, and heightened experiences of persistent uncertainty (Simons et al., 2017).

In summary, the key differences among the four types of stress structures do not lie in the total amount of stress, but in the uncertainty-cost structure of stress inputs and in the ways psychological resources are mobilized: the threat type triggers rapid defense and high vigilance through high-cost danger; the temptation type produces motivational sensitization and self-control load through high-frequency cue mobilization; the value-discrepancy type drives up self-reference and ruminative depletion through long-term expectation-pathway mismatch; and the hyperreal type forces long-term overload of reality testing and metacognitive verification through damaged authenticity cues. Thus, the stress ecology changes “functional priority

“levels” rather than newly added mechanistic modules, shaping distinguishable phenotypic combinations and risk spectra.

### 3 Behavioral Phenotypes and Psychological Consequences: From Changes in Intensity to Structural Reorganization

Traditional stress research often understands psychological distress as an exacerbation of symptoms caused by “elevated stress levels,” such as increases in anxiety, depression scores, or subjective burden. However, when the socio-technical environment undergoes structural change and enters individuals’ lives in a long-term and systematic manner, the more critical change in psychological distress is not necessarily that “intensity is greater,” but that the same set of evolutionarily relatively stable stress-related systems is mobilized under different input conditions at different frequencies and with different costs. Long-term repeated mobilization can also be regarded as the accumulation of allostatic load, which settles into relatively stable functional biases (Sapolsky, 2004; Nesse, 2023). Such biases may manifest at the behavioral level as distinguishable phenotypic differentiation, and may shape different types of psychological consequences through key processes such as attentional allocation, emotional processing, motivational regulation, and self-evaluation. In other words, different “stress structures” do not merely make individuals “more tense” ; they change “how individuals operate.”

#### 3.1 Behavioral Phenotypic Differentiation Under Four Types of Stress Structures

In life ecologies dominated by different stress structures, the more important change in psychological distress is not that “stress is greater,” but that individuals gradually develop distinguishable behavioral operating styles, thereby leading to different risk outcomes. Threat-type structures are more likely to form a “defense-first” phenotype, manifested as heightened vigilance, increased attentional bias toward threat, and stronger avoidance tendencies; even after the threat has been removed, difficulties in resetting may still occur, thereby coupling with trauma-related symptoms and chronic psychophysiological load (Shin et al., 2006; Sapolsky, 2004). Temptation-type structures are more likely to form a “pursuit—immediate gratification” phenotype, manifested as strengthened cue-driven behavior, increased impulsivity, and reduced capacity for delayed gratification; over the long term, this may appear as addiction proneness, attentional fragmentation, anhedonia, and motivational depletion (Berridge & Robinson, 1998; Volkow et al., 2012; Yau & Potenza, 2015). Value-discrepancy structures are more likely to form a “rumination—self-verification” phenotype, manifested as high-frequency self-evaluation and social comparison occupying psychological resources, fixation in negative rumination, and the prominent emergence of burnout, anhedonia, and a crisis of meaning (Hamilton et al., 2015; Treadway & Zald, 2011). Hyperreal-type structures are more likely to form a “doubt—high-load judgment” phenotype; their risks are not mainly reflected in increased emotional intensity, but in cognitive fatigue, instability of the sense of reality, and existential unease induced by the long-term elevation of judgmental burden (Bawden & Robinson, 2009; Simons et al., 2017). Overall, the four types of

structures are not linear increases or decreases in the intensity of the same symptoms, but rather phenotypic differentiations such as defensive, pursuit-oriented, ruminative, and verification-load types. Their common feature is that psychological resources are occupied and rearranged in different ways within long-term stress ecologies.

### **3.2 The Hidden Main Line: Alienation in the Organization of Attentional Resources**

Although the four types of stress structures present different psychological consequences on the surface, at a deeper level they can be connected by a hidden main line: how the organization of attentional resources is reshaped within long-term stress ecologies. It should be emphasized that this is not to reduce all psychological problems to “attentional deficits,” but to regard attention as an observable facet of changes in the allocation of psychological resources. Here, “attention” is not a single psychological function, but an observable projection of changes in the way resources are allocated, used to mark shifts in processing priority under different structures. In threat-type structures, attention shows compulsory capture by threat cues and narrowed focus, with clear directionality and short-term adaptiveness (Öhman & Mineka, 2001). In temptation-type structures, attention is continuously hijacked and fragmented by high-frequency reward cues, making it difficult to maintain deep processing; the cost of task switching rises and self-control is weakened (Volkow et al., 2012). In value-discrepancy structures, attention enters

further shifts from external stimuli to inward rumination, and DMN-related self-referential processing gains abnormal priority, making psychological energy more prone to becoming trapped in “inwardly spiraling depletion” (Hamilton et al., 2015). In the hyperreal-type structure, meanwhile, the cost of maintaining reality consistency rises markedly: the external world becomes difficult to distinguish as true or false, standards of meaning drift, and attention switches at high cost among verification, doubt, and avoidance, ultimately leading to cognitive exhaustion and a weakened sense of reality (Bawden & Robinson, 2009; Simons et al., 2017). Thus, the four types of structures can be traversed by the same “attention load-resource allocation” axis, but their differences are reflected in shifts in the mode of occupation: threat capture in the threat type, cue hijacking and fragmentation in the temptation type, inward rumination occupation in the value-discrepancy type, and high-cost reality verification in the hyperreal type.

### **3.3 Core mechanisms: rearrangement from “stress intensity” to “stress organizational structure”**

Understanding psychological distress as a structural reorganization of the way psychological resources are organized means that the theoretical focus shifts from “how much pressure there is” to “how the system is organized.” Under the four-type structural framework, this organizational rearrangement contains

at least three layers of mechanisms. First, the priority of functional modules is biased. Different types of stress structures, through long-term, structured inputs, allow certain modules (such as threat detection, reward drive, self-value evaluation, or reality verification) to acquire relatively dominant positions in the allocation of psychological resources and to be recruited more frequently in daily life (Sapolsky, 2004; Nesse, 2023). Second, processing modes shift from low-cost automation to high-cost explicitization. For example, in hyperreal environments, judgments of trust and source that could originally be completed through low-cost heuristics more frequently enter explicit verification, producing sustained cognitive depletion (Simons et al., 2017). Third, the temporal structure shifts from “peak-recovery” to “chronic load-difficult recovery.” Premodern threats were more often acute events, whereas later phases increasingly manifest as continuous exposure and psychological tasks that are difficult to close (comparison, optimization, self-justification, verification), making them more likely to accumulate long-term depletion and solidify into stable phenotypes (Sapolsky, 2004). Accordingly, psychological consequences are no longer merely a linear increase in symptom intensity; rather, psychological systems form different “operating styles” within long-term stress ecologies: defensive, reward-based, ruminative, and verification-based phenotypes correspond respectively to different risk profiles and intervention priorities. It should be noted that in real life the above phenotypes are more likely to overlap and intertwine, rather than replace one another in strictly mutually exclusive stages.

### **3.4 Testable inferences: from description to typology and operationalization**

On the basis of the above logic of mechanism rearrangement, the four-type stress-structure framework can be further translated into testable inferences, providing a pathway for mechanism-based typology and diagnostic operationalization. First, the inference of phenotypic typology: under equivalent levels of subjective stress, individuals may exhibit different dominant phenotypes (hypervigilance/impulsive pursuit/ruminative fixation/verification overload), and these may show differentiated associations with different symptom clusters (Shin et al., 2006; Volkow et al., 2012; Hamilton et al., 2015; Simons et al., 2017). Second, the inference of mechanism specificity: the same symptom (such as anxiety or depression) may be supported by different dominant mechanisms within different stress ecologies; for example, the threat type is more inclined toward threat detection and overload of the defensive system, the value-discrepancy type toward self-referential processing and instability of the meaning system, and the hyperreal type toward reality monitoring and explicit verification load (Sapolsky, 2004; Hamilton et al., 2015; Simons et al., 2017). Third, the inference of intervention matching: if intervention only reduces “stress intensity,” its improvement of structural phenotypes may be limited; a more feasible pathway is to target and reconstruct the key links of the dominant phenotype. For example, the threat phenotype prioritizes safety and fear extinction; the temptation phenotype prioritizes impulse control and reward desensitization; the

value-discrepancy phenotype prioritizes meaning anchoring and reducing rumination; and the hyperreal phenotype prioritizes information-source strategies, training of the sense of reality, and reduction of explicit verification load (Öhman & Mineka, 2001; Volkow et al., 2012; Hamilton et al., 2015; Simons et al., 2017; Nesse, 2023).

Overall, different stress structures affect mental health not merely by “increasing stress intensity,” but by changing the mind through long-term shaping

the way resources are organized, forming distinguishable behavioral phenotypes and spectra of consequences. The four types of stress structures do not constitute a linear sequence of stages in individual development; rather, they should be understood as “coexistence of a repertoire of mechanisms—context-driven dominant bias.” The same adult may exhibit different dominant phenotypes across different social contexts and stress ecologies, thereby manifesting dynamic switches of different mechanisms for the same symptoms or different mechanisms within the same person, with predictable differences (Herzberg & Gunnar, 2020; Hanson et al., 2016; Burani et al., 2022; Nesse, 2023).

#### **4 Developmental Neuroscientific Evidence: Rearrangement of Stress-System Dominance from the Perspective of Individual Development**

The four-structure framework proposed in this article holds that changes in the human stress system are not a linear replacement of one psychological mechanism by another. Rather, on the basis of the long-term coexistence of functional modules such as threat detection and stress regulation, reward mobilization, self-reference and value monitoring, and reality testing and metacognitive verification, their relative dominance undergoes systematic adjustment in response to inputs from the stress structure. At the biological level, this change does not depend on the emergence of new neural structures, but is realized primarily through developmental neural plasticity and key sensitive periods: the environment not only triggers stress responses in the moment, but may also produce a “calibration effect” on the reactivity and regulatory patterns of relevant systems within specific developmental windows, and, along the developmental trajectory, consolidate these into relatively stable features of stress responding (Lupien et al., 2009). From the perspective of allostatic integration, this “calibration—consolidation” can further be described as a long-term setting of interoceptive regulation: chronic stress accumulates allostatic load across pathways such as the HPA axis, the autonomic nervous system, and immunity, causing the organism to form persistent biases in internal-signal prediction and reset efficiency (Santamaría-García et al., 2025). Especially in adolescence, existing research indicates that social-brain networks still show continued development and functional reorganization at both structural and functional levels; sensitivity to peer evaluation, social rewards, and social-contextual signals may be more pronounced, thereby providing an important developmental basis for the

long-term embedding of “stress structure–neural mechanism bias” (Blakemore & Mills, 2014).

It should be emphasized that this study does not assume that, within the life cycle of a single individual, one can directly observe a linear replacement of different stress mechanisms or the disappearance of modules. On the contrary, inferences about changes in the dominance of the stress system are based mainly on the following three types of evidence from developmental neuroscience and cross-age research. First, different stress-related neural systems—such as the HPA axis, dopaminergic reward pathways, and prefrontal control networks—have differentiated developmental timing and sensitive windows of neural plasticity during individual development; that is, the same environmental stress input may trigger long-term effects of different magnitudes and in different directions at different ages (Tottenham & Sheridan, 2010). Second, long-term, structured exposure to environmental stress can, after neural structures are relatively mature, form relatively stable functional biases through sustained functional load and plasticity regulation, manifested as continuous adjustments in reactive set points, regulatory costs, and the distribution of weights among networks (McEwen, 1998). Third, behavioral and neuroimaging studies across ages, cohorts, and even historical conditions of stress-structure input suggest that groups situated within different stress structures may exhibit distinguishable dominant psychological phenotypes, reflected in heterogeneous differences in the dominant mechanisms underlying similar symptoms. What these bodies of evidence jointly support is not merely that “the relevant systems exist,” but that relevant stress circuits can be calibrated by environmental input during sensitive periods and, over long-term development, form functional biases with continuity, thereby constituting the developmental-mechanistic basis for this article’s hypothesis of “dominance rearrangement.” In this sense, evolutionary mismatch exists not only at the macro level of species evolution, but also runs through the process of individual development. When the stress-response pattern shaped by the early environment diverges systematically from later environmental conditions, developmental mismatch may arise, thereby affecting the adaptiveness and cost structure of stress coping in subsequent stages (Hoogland & Ploeger, 2022). Based on the above framework, this section proceeds from the perspective of individual development and, in sequence, reviews the developmental neuroscientific evidence corresponding to the four types of stress-structure frameworks at different developmental stages, in order to explain how stress-system dominance undergoes structural rearrangement on the basis of coexistence.

#### **4.1 Early Development and HPA-Axis Calibration: Biological Embedding of Threat-Type Structures**

Early life is the primary sensitive period for the shaping of the stress system. The HPA axis and circuits related to rapid threat detection begin to become functional as early as infancy and early childhood, and show high plasticity in re-

sponse to caregiving quality and environmental cues (Lupien et al., 2009; Essex et al., 2011). Stable and sensitive caregiving helps maintain stress responses at a moderate level, whereas sustained toxic stress—such as neglect, abuse, or domestic violence—may, through processes of “developmental programming/biological embedding,” calibrate the stress system toward adaptive response patterns characterized by heightened vigilance or lower thresholds (Koss & Gunnar, 2018). Neuroimaging studies and systematic reviews suggest that severe early adversity is closely associated with enhanced reactivity of threat-processing systems and with developmental differences in prefrontal–limbic networks. Among these findings, the evidence for elevated amygdala reactivity is relatively more consistent, whereas changes in hippocampal and prefrontal indicators show a certain degree of contextual variation and developmental-stage dependence (Lupien et al., 2009; McLaughlin et al., 2019). Because glucocorticoid receptors are highly expressed in the hippocampus and prefrontal cortex, long-term glucocorticoid load may induce impaired neural plasticity and structural changes in these regions, thereby weakening emotion regulation and cognitive control functions (Lupien et al., 2009). At the behavioral level, longitudinal studies show that early family stress can predict abnormalities in basal cortisol levels and circadian rhythms from childhood to adolescence, and is associated with subsequent risk of internalizing symptoms and their developmental trajectories (Essex et al., 2011; Koss & Gunnar, 2018).

From the perspective of the four stress structures, early “threat-type structures” may become biologically embedded through the developmental shaping of the HPA axis and amygdala-related systems, establishing for the individual a response baseline that is more readily mobilized by threat cues. From the perspective of developmental–evolutionary mismatch, this configuration may, in modern low-threat environments, be transformed into structural risks such as chronic anxiety (Hoogland & Ploeger, 2022). This stress configuration formed in early life is not entirely closed. Developmental research proposes that when the subsequent growth environment changes markedly, adolescence may serve as a second window of plasticity for the stress system, under certain conditions exerting a corrective effect on risks associated with early adversity (Jiang Ying et al., 2025).

#### **4.2 Development of the Dopamine System in Adolescence: The Neural Basis of Temptation-Type Structures**

Against the backdrop that the stress system may undergo functional recalibration during adolescence, this developmental stage also constitutes an important window of high plasticity for the reward system. Its core feature lies in the imbalance in the developmental timing of the reward system and the cognitive control system: midbrain–limbic dopaminergic pathways are highly sensitive to reward and social evaluation, whereas maturation of the prefrontal control network is relatively delayed (Casey et al., 2011; Steinberg, 2008). The adolescent social-brain network continues to undergo structural and functional reorganiza-

tion; adolescents are more sensitive to peer evaluation and social reward cues, and social contexts may exert a more prominent modulatory effect on their reward-driven behaviors and risky choices (Blakemore & Mills, 2014). At the same time, research on the enhancement of reward seeking during adolescence commonly regards dopamine-rich regions such as the striatum as a key neural basis, and suggests that adolescents' reactivity to reward cues is more likely to show a relatively heightened trend (Galván, 2010). This pattern of the “accelerator preceding the brakes” makes adolescence a stage in which risk preference and preference for immediate rewards are significantly enhanced. Longitudinal neuroimaging studies have further found that the sensitivity of the dorsal and ventral striatum to reward feedback is relatively elevated in late adolescence, providing important neural evidence for the view of an adolescent “peak in reward responsiveness” (Peters & Crone, 2017). In high-intensity, dense environments of immediate reward, the dopamine system is prone to incentive sensitization, manifested as the continual amplification of “wanting” for reward cues while subjective pleasurable experience gradually becomes blunted (Berridge & Robinson, 2016). Animal experiments show that, within the developmental window corresponding to human adolescence, repeated interventions such as drugs or stress can produce long-term alterations in dopamine-related circuits, leading to changes in impulsivity and addiction vulnerability that persist even after entry into the stage corresponding to human adulthood (Andersen & Teicher, 2008; Spear & Silveri, 2016). Human studies also generally hold that elevated reward sensitivity during adolescence is associated with the risk of substance use and other addictive behaviors

has been linked to increases, and is significantly modulated by factors such as social reward and peer contexts (Galván, 2010). From the perspective of developmental-evolutionary mismatch, the high-density reward cues supplied by industrialized and consumer societies may, through the highly plastic reward and stress systems of adolescence, systematically elevate the relative weight of the reward module within the overall adaptive structure, thereby providing an evolutionary-developmental mechanistic framework for the “temptation-type structure” proposed in this paper (Hoogland & Ploeger, 2022).

### **4.3 PFC-DMN Maturation: The Internalization Mechanism of Value-Discrepancy Structures**

Late adolescence to early adulthood is an important developmental stage in which self-concept and value systems continue to be integrated. Its neural basis is reflected in the gradual structural and functional maturation of the prefrontal cortex and the DMN (Davey et al., 2019; Fair et al., 2008). During this period, the prefrontal cortex is still undergoing myelination and synaptic pruning (Spear, 2013), while the functional connectivity of the DMN, in developmental comparisons from childhood to adulthood, gradually shifts from being relatively local to more stable long-range integration and maturation (Fair et al., 2008), supporting “internal mentation” such as self-reflection, internal narrative, and

meaning construction (Raichle et al., 2001; Andrews-Hanna, 2012). The longitudinal study by van Buuren et al. (2022) further revealed that, as development proceeds, functional connectivity among core DMN nodes such as the medial prefrontal cortex (mPFC) and posterior cingulate cortex (PCC) continues to strengthen, indicating that the self-referential processing network is undergoing a critical integration and reorganization. Chronic psychosocial stress and depressive states are closely associated with structural changes in the prefrontal cortex and hippocampus, as well as with excessive activation of the DMN during negative self-rumination (Zhang et al., 2018; Lois & Wessa, 2016). Developmental studies further show that self-concept clarity and a sense of meaning in life are significantly positively correlated in youth, whereas self-concept confusion is closely associated with an elevated risk of internalizing problems such as depression and anxiety (Xiang et al., 2023; Yuliawati et al., 2024; Yang et al., 2025). Building on prior findings regarding the abnormal functional load of DMN and prefrontal circuits in rumination and depression (Berman et al., 2011; Hamilton et al., 2015), and viewed from the perspective of the four types of stress structures, in postindustrial society the superposition of inflated external expectations and real-world uncertainty causes the prefrontal-DMN system to bear a sustained and high-cost functional load within the stress structure. When value integration within this developmental window is obstructed, individuals are more likely to form a chronic internalizing stress state characterized by ruminative self-negation, which manifests at the psychological-phenotypic level as a spectrum of value-discrepancy predicaments, including burnout, anhedonia, and a weakened sense of meaning.

#### **4.4 Functional Load and Developmental Mismatch on Mature Brain Architecture: Hyperreal-Type Structures and Longitudinal Mechanisms**

Unlike the first three types of stress structures, which more readily correspond to relatively well-defined developmental sensitive periods, the fourth type, the “hyperreal-type structure,” primarily occurs after neural structures have become relatively stable. Its key feature is not the addition of an independent brain module, but rather the sustained functional load imposed by generative artificial intelligence and hyperreal media environments on existing neural networks. Highly simulated information environments, deepfake content, and algorithm-driven information flows keep systems related to reality testing, attentional control, and authenticity evaluation in a state of prolonged high load. Existing studies suggest that long-term exposure to such environments may be associated with mechanistic changes such as increased reality-monitoring load and altered patterns of functional connectivity, and may further be linked to psychological phenomena such as derealization experiences and AI-related anxiety. However, the relevant evidence remains primarily cross-sectional and based on short-term experiments, and is not yet sufficient to define a clear developmental sensitive period (Simons et al., 2017; Zielasko et al., 2025; Liñan, 2025a; Liñan,

2025b). Therefore, this paper cautiously defines the “hyperreal-type structure” as a functional reorganization and long-term load effect occurring upon mature brain architecture.

This process needs to be understood by integrating developmental mismatch with mechanisms of life-course adjustment. Developmental mismatch theory holds that, in early stages, individuals

stress configurations formed during developmental stages on the basis of environmental cues may, in the rapidly changing sociotechnical environment of adulthood, shift from adaptations into burdens (Hoogland & Ploeger, 2022). At the same time, the allostatic framework indicates that the stress system does not respond to sustained environmental challenges by maintaining a fixed homeostatic state, but by continuously adjusting the level of its functional activity; when such adaptive regulation is repeatedly or chronically activated, its cost may appear as the gradual accumulation of allostatic load (McEwen, 1998; Logan & Barksdale, 2008). In artificial-intelligence and hyperreal media environments, this adjustment can be understood as the sustained mobilization of reality-testing and metacognitive monitoring systems, rather than necessarily as the direct activation of threat or reward modules. From the perspective of energy allostasis, the continuous mobilization of reality testing in hyperreal environments not only increases cognitive cost, but also means that long-term energy budgets are occupied by regulatory systems and encroach on maintenance and repair processes, thereby promoting the accumulation of allostatic load and making high-load operation more likely to become consolidated (Bobba-Alves et al., 2022). Recent research on human exploratory behavior offers a motivational-level supplementary explanation for the above-mentioned “sustained functional load” : over evolution, humans have developed an intrinsic exploratory preference for “novelty” and “environmental randomness,” and even in the absence of actual rewards, they can remain continuously attracted to highly random information sources (Modirshanechi et al., 2025). In the high-randomness and high-density information environments produced by generative artificial intelligence, this exploratory tendency, which originally served adaptive learning, may be over-recruited, causing attention and cognitive resources to remain continuously occupied in contexts lacking stable goals and effective feedback, and increasing the long-term cumulative risk of cognitive depletion and reality-testing load.

#### **4.5 Longitudinal Evidence for Transformations in Adult Stress Structure: Mechanistic Possibilities of Cross-Structural Switching**

Although the four-structure framework emphasizes the importance of calibration during sensitive periods, adulthood is not a fully closed stable state: individuals may still undergo structural transformations of the stress ecology as a result of life events, occupational trajectories, or abrupt changes in the media environment, and under long-term functional load may show reweighting of the dominant system. Developmental research provides operational evidence

for the mechanistic feasibility of such “cross-structural switching.” First, an accelerated longitudinal study directly quantified within-person trajectories of the difference between “reward sensitivity–executive control” in a sample aged 9–29 years. It found that in early adolescence there is a window of imbalance in which reward is relatively dominant, followed by increasing integration as the control system matures. This suggests that reward–control weighting can undergo measurable rebalancing along the developmental trajectory, and extends this reweighting process into early adulthood (Lozano Wun et al., 2025). Second, longitudinal evidence indicates that experiences of structural stress can continuously shape trajectories of reward processing: in a sample of 8–14-year-olds followed for two years, higher lifetime stress exposure predicted subsequent blunting of the reward-related ERP index (RewP), suggesting that stress inputs can alter the functional orientation of the reward system and providing empirical support for the formation of biases under different stress ecologies (Burani et al., 2022). Third, research on neurophysiological indicators further shows that dopamine-related processes continue to change from adolescence into adulthood, providing a biological substrate for stabilized biases to emerge in mature brain architecture under long-term functional load (Petrie et al., 2025). It should be emphasized that the above evidence supports “plasticity and reweighting,” rather than stage-based replacement of modules. Accordingly, the four types of stress structure are better understood within a model framework of “coexisting mechanism libraries–context-dominant biases”: individuals do not undergo replacement of mechanisms, but instead form switchable dominant-system biases and differences in behavioral phenotypes under inputs from different stress structures.

Taken together, the foregoing evidence shows that the basic neural architecture of the stress system remains relatively stable on an evolutionary timescale, but that different functional modules undergo dominant rearrangement under the joint influence of individual development and social history. More importantly, different developmental windows show differentiated mappings of susceptibility to different types of stress inputs: plasticity in early life makes threat-related cues more likely to be rapidly calibrated and embedded into response thresholds; neural sensitivity during adolescence more readily amplifies the traction exerted by reward–social-evaluative inputs; the self-integration tasks of young adulthood more

making value–meaning discrepancies a source of sustained load; in maturity, if individuals remain for long periods within a highly AI-mediated and platformized information ecology, networks related to reality testing and authenticity evaluation are more likely to accumulate chronic load and become a new center of stress.

## 5 Discussion: Theoretical Contributions, Applied Significance, and Testable Pathways

Starting from the modern mental-health paradox, this article points out that, while objective threats to survival have markedly declined in industrialized societies, psychological difficulties such as burnout, anhedonia, crises of meaning, and instability in the sense of reality have nevertheless continued to spread, and are closely related to the cumulative load of chronic stress input (Slavich, 2020). Traditional stress models emphasize subjective appraisal and coping processes within the person-environment relationship (Lazarus & Folkman, 1984), whereas evolutionary mismatch theory emphasizes the mismatch between evolved psychological mechanisms and rapidly changing modern environments (Durisko et al., 2016; Li et al., 2018; Nesse, 2023). However, relying solely on the macro-level explanation of “increased stress intensity” or “mismatch” still cannot fully account for two key phenomena: first, the organizational form of stress input is undergoing structural transformation under different historical-technological conditions; second, within the same stress environment, individuals display highly heterogeneous yet relatively stable differences in psychological phenotypes. To address this gap, this article proposes a “stress structure-functional dominance bias” framework and, within the nested relation of evolutionary, historical, and developmental time scales, constructs a typological framework that uses structural types to characterize the organizational modes of stress input. The “structural types” referred to in this article do not presuppose a linear replacement of stress mechanisms at the biological level or the emergence of new modules; rather, they emphasize that an evolutionarily relatively conserved repertoire of mechanisms may undergo stage-specific functional dominance biases under different historical stress structures, and that these biases may be written in during critical windows through developmental plasticity and stabilized as adult functional configurations. Therefore, what this study focuses on is the relative reordering of priorities among different systems—on the basis of mechanistic coexistence—in terms of trigger thresholds, frequency of recruitment, and regulatory costs, rather than “changes in strength” that can be directly captured by a single indicator within a short time scale (Tooby & Cosmides, 1992; Lupien et al., 2009; Hoogland & Ploeger, 2022).

In reviewing existing theories, this article does not replace the classical stress model’s characterization of the “appraisal-coping” process, nor does it reduce contemporary predicaments to a single proposition of “evolutionary mismatch.” The incremental contribution of this article lies in understanding stress in modern society as a typologizable “structural input”—that is, the frequency, cost, and feedback forms through which stressors enter everyday life, and how they reorder the relative priorities of the mechanism repertoire under long-term exposure. Thus, information overload, social-media pressure, or digital-technology stress do not merely increase the “intensity” of stress; they are more likely to alter the organizational form of stress input and the operating configuration of

the psychological system. In what follows, this article specifies this incremental contribution in three respects: first, using “stress structure” rather than “event accumulation” as the explanatory unit; second, using “functional dominance reordering” rather than “mechanism replacement” as the mechanistic narrative; and third, using the threefold temporal scale to provide a cross-level pathway through which structural transformation sediments into phenotypic differences.

### 5.1 Theoretical Contributions

The theoretical contributions of this article are mainly reflected in three points. First, it proposes the concept of “stress structure,” elevating stress from the traditional “event-response” framework to a structured explanatory unit of “long-term input patterns–resource-organization effects.” Existing studies have mostly understood stress as a relation between external demands and individual resources, emphasizing appraisal, coping, and context-specific response processes (Lazarus & Folkman, 1984). Yet in a highly technologized and institutionalized modern society, stress often persists in long-term, repeated, and difficult-to-avoid ways, and through sustained expos–

exposure alters the operating logic and resource-allocation patterns of psychological systems (Sapolsky, 2004; Nesse, 2023). Therefore, the stress structures proposed in this article emphasize that stress is not the linear accumulation of isolated events, but rather has relatively stable input forms and organized consequences. Over long periods, it can drive systems such as threat detection and stress regulation, reward mobilization, self-reference and value monitoring, reality testing, and metacognitive verification to form different functional biases, thereby providing a theoretical tool with greater structural explanatory power for explaining chronic psychological difficulties such as burnout, instability of meaning, and weakened sense of reality. Second, this article replaces the narrative of “mechanism replacement” with that of “functional-dominance reorganization,” and, across the three temporal scales of evolution, history, and development, specifies pathways through which such reorganization can occur and become sedimented. This framework avoids explaining contemporary psychological difficulties as the emergence of new mechanisms or the disappearance of old ones. Instead, it emphasizes that the same set of evolutionarily relatively stable stress components are recruited with different frequencies, thresholds, and costs in different stress ecologies, thereby forming relatively stable biases in resource allocation (Tooby & Cosmides, 1992; Maner & Kenrick, 2010; Sapolsky, 2004). Third, this article incorporates the evolutionarily conserved repertoire of mechanisms, the historical transformation of stress inputs, and developmental sensitive-period calibration into a unified coordinate system, thereby explaining how changes in the macro-environment are transformed, through developmental windows and long-term load, into observable differences in psychological phenotypes and mechanistic subtypes (Lupien et al., 2009; Casey et al., 2011; Hoogland & Ploeger, 2022). In this sense, the contribution of this article lies not in claiming that its conclusions have been “proven,” but in proposing structured

mechanistic propositions that can gradually be made “provable,” providing theoretical coordinates for subsequent empirical testing and stratified intervention.

## 5.2 Implications for Understanding, Diagnosing, and Responding to Psychological Problems

Overall, from understanding to diagnosis to intervention, the three-timescale framework provides a cross-level explanatory pathway for contemporary psychological problems. It encourages psychological distress to be understood as a functional bias formed by evolutionarily conserved mechanisms under the joint influence of historical stress structures and developmental plasticity, rather than simply as individual pathology. At the level of understanding, it promotes the depathologization of perspective; at the level of diagnosis, it supports a form of “configurational diagnosis” based on spatiotemporal coordinates; and at the level of intervention, it points toward a coordinated pathway of “stratified intervention + environmental governance.”

### 5.2.1 Understanding: From “Personal Vulnerability” to “Structural Stress Configuration”

The three-timescale framework understands psychological distress as a functional bias formed by evolutionarily conserved mechanisms under the joint influence of historical stress structures and developmental plasticity, thereby shifting the explanatory focus from individual deficits to system configuration. The four-type framework of stress structures suggests that contemporary psychological difficulties do not necessarily mean weak individual will or failed adaptation; rather, they may more likely reflect functional biases that the stress system has been forced to form under structural stress configurations. For example, heightened vigilance under a threat-type structure is not simply “suspiciousness”; a preference for immediate gratification under a temptation-type structure is not simply “poor self-control”; rumination under a value-discrepancy-type structure is not simply “overthinking”; and doubt and exhaustion under a hyperreal-type structure are also not simply being “overly fragile.” Instead, they are systemic consequences of the long-term action of specific stress inputs (Sapolsky, 2004; Nesse, 2023). This understanding has important depathologizing significance: it repositions psychological distress as an “adaptive cost under structural stress,” and further implies that mental-health policy cannot merely attribute psychological problems to individual vulnerability. Instead, structural inputs such as “high-frequency comparison—high-stimulation reward—high-cost verification” should be regarded as governable objects, so as to reduce chronic load at its source.

### 5.2.2 Diagnosis: The Necessity of Distinguishing Different Causes and Mechanistic Subtypes Behind the Same Symptoms

The so-called “same symptom, different mechanisms” means that beneath the surface of similar symptoms, there may be support from different dominant

stress structures and differently organized mechanistic networks;

The so-called “same person, different mechanisms” means that, in the same individual, across different life stages and under changes in the stress ecology, the superimposition of dominant structures and shifts between dominant and subordinate structures may occur. The triple-timescale framework provides a structured basis for a configurational diagnosis of “the same symptom with different causes” : similar symptoms may correspond to different stress structures and inscription windows, and their differences are more likely to manifest as systematic differentiation in the organization of mechanistic networks rather than as simple differences in symptom severity. In clinical and public mental-health service practice, the same symptom—such as anxiety, depression, or attentional problems—may correspond to different dominant mechanisms and stress structures. The framework of four stress structures supports a line of thinking in terms of “configurational diagnosis” : even similar clinical symptoms may originate from different configurations of historical-developmental coordinates. For example, with the same presentation of depressive symptoms, an individual may be dominated by a threat-type structure accompanied by hypervigilance and panic-like reactions, or may instead more strongly manifest meaning depletion and instability of the self-worth system under a value-discrepancy-type structure; the two may appear similar at the scale-score level, but they differ in stress-exposure history, developmental windows, and dominant mechanisms (Shin et al., 2006; Hamilton et al., 2015; Sapolsky, 2004). Therefore, the focus of assessment should shift from a mere list of symptoms to mechanistic subtyping: only by identifying the dominant stress structure in which the individual is situated (the historical dimension) and its developmental-stage specificity (the developmental dimension) can we avoid conflating different mechanisms in treatment. Anxiety may arise primarily from a hypersensitive bias in the threat-detection system, but under uncertainty and a high load of reality monitoring it may also manifest more as sustained high-cost verification and resource depletion (Shin et al., 2006; Simons et al., 2017). Such mechanism-based subtyping is a prerequisite for improving the specificity and efficiency of intervention. It should be emphasized that the four stress structures are not a linear sequence of stages in the sense of historical determinism; rather, they are more likely to appear through coexistence, superimposition, and shifts between dominance and subordination: the same individual may form a defensive-priority bias during early threat exposure, subsequently further strengthen reward sensitization in a high-stimulation ecology during adolescence, shift toward ruminative self-verification amid the accumulation of “expectation-path discrepancy” in adulthood, and develop overload in reality testing within media environments marked by uncertainty about authenticity (Lupien et al., 2009; Casey et al., 2011; McEwen, 1998). Thus, “changes in disease course/stage fluctuations” need not be understood as random ups and downs, but can be restated as a process of dominant reweighting triggered by changes in the stress ecology.

### 5.2.3 Coping: A Synergistic Pathway of Layered Intervention and Environmental Governance

The triple-timescale framework points to a hierarchically matched approach to coping: at the individual level, the emphasis is on recalibrating and reducing the burden of response thresholds and resource allocation; at the environmental level, the emphasis is on reducing the density of structural stress inputs and the cost of regulation, thereby preventing functional biases from being continuously maintained under long-term exposure. In terms of coping pathways, the framework of four stress structures suggests that relying solely on individual-level emotion regulation or stress management may be insufficient to reverse the long-term biases produced by structural stress configurations. A more feasible strategy is to adopt a synergistic approach of “layered intervention + environmental governance.” At the individual level, interventions should target the key links of the dominant phenotype: for example, for the threat-type phenotype, priority should be given to restoring a sense of safety and reducing sustained vigilance (Öhman & Mineka, 2001); for the temptation-type phenotype, priority should be given to rebuilding delayed gratification and reducing the density of reward cues (Volkow et al., 2012); for the value-discrepancy-type phenotype, priority should be given to stabilizing anchors of meaning and reducing the burden of rumination (Hamilton et al., 2015); and for the hyperreal-type phenotype, priority may be given to reducing the cost of authenticity verification and improving the traceability of information-source cues and the credibility of decision-making (Simons et al., 2017). At the environmental level, institutional and media governance is needed to reduce the load intensity of long-term structural inputs, so as to avoid continuously placing individuals within a stress ecology characterized by high-frequency comparison, highly stimulating rewards, and high-cost verification.

In addition, although the four stress structures differ in their stress sources and dominant systems, a more operationally actionable common axis can still be extracted.

axis: the organizational mode of attentional resources differentiates under different structures of stress input. In threat-type structures, attention manifests as compulsory capture by threat cues and narrowed focus; in temptation-type structures, attention is more readily and continuously hijacked by high-frequency reward cues and becomes fragmented, making it difficult to sustain deep processing; in value-discrepancy structures, attention shifts from external stimuli toward inward self-verification and becomes fixated on ruminative processing; in hyperreal-type structures, attention is forced to maintain high-cost reality testing and source verification over the long term, thereby inducing risks of depletion of judgmental resources and “ontological disorientation” (weakened sense of reality, uncertainty of authenticity, and destabilization of coordinates of meaning). This axis suggests that intervention and governance need not be fragmented into mutually unrelated technical checklists, but can form a unified lever around “attentional load–resource allocation–recovery mechanisms,” thereby establishing

an operable closed loop of coordination between reducing individual burden and lowering environmental pressure. For example, in hyperreal-type structures, the reduction of reality-monitoring load can be achieved not only through strategy training, but also supported through plasticity modulation of key prefrontal nodes; mPFC neurofeedback studies have provided direct evidence for the “intervenability of reality monitoring” (Garrison et al., 2021). When the dominant structure differs, the priority and pathway of action of the same intervention elements should also differ: threat dominance places greater emphasis on restoring a sense of safety, fear extinction, and downregulating sustained vigilance; temptation dominance places greater emphasis on impulse-inhibition training, desensitization to reward cues, and the reconstruction of delayed gratification; value-discrepancy dominance places greater emphasis on anchoring meaning, reconstructing self-narratives, and reducing ruminative load; hyperreal dominance places greater emphasis on information-source strategies and reality-monitoring training, in order to reduce the long-term burden of high-cost explicit verification. It should be noted that the “typing” referred to here is not a separate symptom-classification system, but rather an additional dimension for identifying the “dominant stress structure/mechanism configuration” on the basis of existing symptom assessment. Therefore, diagnostically moving from a “symptom checklist” toward “stress-structure typing” is a key step in achieving better intervention matching and improved efficiency.

### 5.3 Research Prospects and Testable Propositions

To transform “stress structure” from a theoretical concept into a testable object, the key lies in simultaneously measuring structural exposure, dominant phenotype, and network-level mechanistic indicators, and establishing reproducible mappings among the three. Structural exposure can be characterized through ecological exposure measurement and contextualized questionnaires—for example, frequency and uncontrollability of threat exposure, density of reward cues and immediate feedback, expectation–pathway discrepancy and the pervasiveness of external evaluation, and traceability of authenticity cues and load of verification tasks. Dominant phenotypes can be captured through behavioral indicators such as attentional bias, delayed gratification, rumination tendency, and reality-monitoring tasks. At the mechanistic level, one can further test their correspondence with indicators such as threat detection and regulation, reward mobilization, self-referential processing, and reality-monitoring networks. On this basis, a “structural typing index” can be constructed and used for longitudinal tracking and intervention-matching evaluation, thereby embedding the framework’s core propositions within operable measurement and testing procedures (Lupien et al., 2009; Casey et al., 2011; Hamilton et al., 2015; Simons et al., 2017). To enhance the testability of the theoretical framework, this article proposes several directional propositions to illustrate how the four-category framework of stress structures can generate operable empirical slices. It should be emphasized that the following propositions are intended to provide testable mechanistic pathways for subsequent research, and do not constitute an exhaus-

tive list of hypotheses covering all dimensions of the model.

First is the structural-difference proposition: network organization rather than intensity differences. After controlling for general stress levels and socioeconomic factors, exposure to different stress structures (threat/temptation/value discrepancy/hyperreality) should show systematic correspondence with the organizational modes of specific neural networks, and this correspondence is more likely to manifest as differences in network organization (such as connection efficiency, modular structure, and regulatory cost) rather than merely as changes in activation intensity. This line of thinking is more consistent with the “abnormal network-coupling patterns” revealed by existing studies in phenotypes such as depressive rumination, and does not necessarily equate to increased local activation intensity (Hamilton et al., 2015); at the same time, evidence for the long-term shaping of brain function and developmental trajectories by stress

also provides foundational background for this network-level proposition (Lupien et al., 2009; Casey et al., 2011; Katsumi et al., 2022).

Second, the sensitive-period interaction proposition: the predictive effect of developmental windows. Structural stress inputs during developmental sensitive periods should have prospective predictive value for dominant phenotypes in adulthood: early threat exposure may predict a higher priority for threat detection; high-stimulation exposure during adolescence may predict a stronger bias toward immediate gratification; and exposure to value imbalance in young adulthood may predict greater risks of rumination and instability of meaning. These effects should be moderated by subsequent environmental match or mismatch (Lupien et al., 2009; Casey et al., 2011; Hoogland & Ploeger, 2022).

Third, the threshold-effect proposition: the critical point of cognitive load in hyperreal environments. Under conditions of uncertain authenticity and insufficient source cues, the cognitive load imposed by reality testing and explicit verification may show threshold-like effects: when the frequency and complexity of verification tasks exceed a certain level, individuals may exhibit compensatory failure, manifested as intensified cognitive fatigue, avoidance of judgment, and an increased risk of a weakened sense of reality. This proposition can draw on the logic in the frameworks of allostasis and allostatic load—namely, that “the long-term accumulation of regulatory costs leads to functional dysregulation” (McEwen, 1998)—and is consistent with the cognitive depletion and avoidance tendencies revealed in research on information overload (Bawden & Robinson, 2009). At the mechanistic level, this process may take the form of a shift in authenticity judgment from relatively low-cost implicit evaluation to high-cost explicit verification dominated by prefrontal reality-monitoring networks. When high-cost verification accumulates over the long term and approaches the upper limit of regulation, it is more likely to induce cynicism, declining trust, and a destabilized sense of reality (Bawden & Robinson, 2009; Simons et al., 2017).

Fourth, the life-course transition proposition: dynamic prediction of cross-structural switching. When individuals encounter structural shifts in the

stress ecology during adulthood—such as transitions in occupational contexts, major life events, or abrupt changes in media/information environments—the dominant biases of their stress systems should exhibit predictable trajectories of network reweighting: the organizational modes and regulatory costs of key networks, such as reward-control and self-reference-reality monitoring, will undergo systematic reorganization, and may display a nonlinear inflection around transition points characterized by “compensatory enhancement → declining regulatory efficiency/exhaustion.” The magnitude of this dynamic reorganization should increase with higher levels of cumulative stress exposure, and can be tested through joint longitudinal tracking of neural indicators and behavioral phenotypes (Hanson et al., 2016; Burani et al., 2022).

#### 5.4 Limitations and Boundaries

It should be noted that, as a cross-scale theoretical framework, this article still has several important limitations. First, the four-category framework of stress structures involves transformations of stress structures across long historical time scales, which are difficult for a single longitudinal cohort to cover on the same temporal scale. It is more appropriate to conduct slice-based tests through cross-cohort comparisons, natural experiments, manipulations of task load, and the integration of multimethod evidence, so as to gradually accumulate evidence chains across different levels and time scales (McEwen, 1998; Hoogland & Ploeger, 2022). Second, the “dominance reorganization” emphasized by the model is mainly manifested as long-term biases in functional priorities and resource allocation. Such changes often appear as differences in network organization, alterations in regulatory costs, and systematic shifts in behavioral strategies, and are difficult to characterize with a single indicator. Future research should combine behavioral phenotypes, ecological exposure measurements, and neural-network indicators in multilevel modeling in order to improve the operability of proposition testing and its robustness across contexts. It is especially important to emphasize that the fourth type, the “hyperreal structure,” remains in a state of structural emergence but has not yet been fully typified: current evidence regarding reality monitoring and source discrimination still comes mainly from cross-sectional associations, task paradigms, and short-term experiments, and more often provides convergent mechanistic indi[[unclear: text continues off page after “提” ]]

indications, rather than strong causal identification capable of defining long-term trajectories, reversibility, and potential sensitive periods (Simons et al., 2017). At the same time, research related to immersive media exposure and digital-technology stress is also generally constrained by short-term effect measurement and cross-sectional designs; its conclusions are more appropriately regarded as indications of the “existence of load” rather than as definitive claims about “developmental windows” (Zielasko et al., 2025; Liñan, 2025a; Liñan, 2025b). Therefore, the goal of this article is not to conduct a one-time “overall validation” of the four-category stress-structure framework, but to provide

an explanatory framework and testing roadmap through which evidence can be accumulated step by step across cohorts and methods. In particular, for the “hyperreal-type structure,” which is still in a period of rapid formation, this article adopts a cautious mechanistic definition and places it among empirical questions that can be progressively clarified by future longitudinal studies and quasi-experiments. If future research can combine ecological exposure measurement, intensive longitudinal tracking, and network-level indicators, it will be possible to further identify the triggering conditions of dominant reorganization, nonlinear inflection points, and boundaries of reversibility, thereby transforming theoretical propositions into a cumulative, comparable, and falsifiable chain of empirical evidence.

## 6 Conclusion

The essence of the modern mental-health paradox does not lie in humanity’s bearing a greater total amount of stress, but in the fact that stress is reorganizing the operating mode of everyday life in a new form: it has evolved from discrete, identifiable event shocks into a structural input that is continuous, diffuse, and difficult to exit. The triple-timescale and four-category stress-structure framework proposed in this article is intended to reveal this crucial shift. What determines the forms of contemporary psychological distress is not the linear increase or decrease of stress intensity, but the structural features of stress configuration. Through developmental plasticity and long-term allostatic load, these features cause modules such as threat detection, reward mobilization, self-reference, and reality testing to undergo functionally dominant biases in thresholds and priorities, ultimately solidifying into distinguishable styles of psychological functioning and spectra of risk.

The primary implication of this perspective is a fundamental revision of the empirical assumption of “same symptoms, same causes.” Contemporary common experiences such as burnout, anhedonia, or instability in the sense of reality can certainly be subsumed under a single diagnostic category, yet they often correspond to markedly different dominant mechanisms and stress structures. Therefore, the assessment and intervention of mental health must complete a paradigm shift from “symptom intensity” to “mechanistic organization.” In other words, psychological distress is first a problem of bias in functional configuration, and only secondarily a problem of the severity of emotional experience. Only by identifying the dominant phenotype in which an individual is situated, as well as the stress “structure” behind it, can intervention break through the limitations of short-term relief and move toward systematic long-term resetting—otherwise, the more refined symptom classification becomes, the more homogeneous the resulting intervention pathways may be.

Ultimately, this article attempts to reposition mental health from a privatized task of adaptation into a structural public risk. In an era that continually overdraws systems of attention and meaning through comparison, stimulation, and verification, one-sidedly emphasizing the individual’s improvement of re-

silience is tantamount to converting the structural deficits of the socio-technical system into the individual's moral responsibility. The mission of future psychology should not be confined to seeking more refined stress-resistance techniques within existing frameworks; rather, it should be devoted to developing theories and methods capable of identifying and governing stress structures. For what truly determines the boundaries of mental health has never been how much stress an individual can endure, but whether society preserves for the mind the possibility of recovery and reconstruction. The "triple-timescale—four-category stress-structure" framework proposed in this article is precisely intended to translate this structural risk into identifiable mechanistic typologies, to explain same-symptom/different-mechanism and same-person/different-mechanism phenomena, and to provide operable theoretical coordinates for development-oriented, typological precision intervention.

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## Structure, Not Intensity: Stress Typology and Functional Rearrangement Across Three Timescales

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### Abstract

Mental health problems such as burnout, anhedonia, loss of meaning, and so-called “hollow disease” have become increasingly prevalent in industrialized societies. This trend presents a persistent paradox: while objective survival threats such as famine, infectious disease, and physical violence have markedly declined, subjective psychological distress continues to rise. Existing stress models and evolutionary mismatch accounts explain parts of this phenomenon but remain insufficient to capture the structural transformation of dominant stress inputs across major sociohistorical transitions, particularly under conditions of rapid technological acceleration and artificial intelligence.

From an evolutionary perspective, stress systems are adaptive mechanisms shaped by natural selection to detect and respond to threats to survival, reproduction, and social status. These conserved systems, however, are not expressed uniformly across the lifespan. Instead, they are developmentally calibrated through sensitive periods and long-term functional load, allowing historically specific stress environments to shape enduring patterns of stress responsivity. On this basis, a transdisciplinary framework is developed that integrates evolutionary biology, developmental and systems neuroscience, psychology, and social history to explain how dominant stress structures shift across historical epochs and become embedded in individual psychological functioning.

To avoid conflating macro-level historical change with individual developmental trajectories, the framework further specifies a three-timescale explanatory coordinate system: evolutionary timescales provide a relatively stable repertoire of conserved mechanisms, sociohistorical timescales reorganize the structure of chronic stress inputs, and developmental timescales determine when and how such inputs are written into functional configurations through plasticity and recalibration. Within this coordinate space, four dominant stress structures are identified. The Threat Structure is organized around acute survival risks and

dominated by threat detection and hypothalamic-pituitary-adrenal (HPA) axis activity, with early-life

exposure calibrating baseline stress sensitivity. The Temptation Structure, characteristic of industrial and consumer societies, reflects chronic exposure to reward-dense environments interacting with heightened dopaminergic plasticity during adolescence, increasing vulnerability to impulsivity and addictive behaviors. The Value Gap Structure emerges in post-industrial contexts marked by internalized evaluation and unstable meaning systems, involving dysregulation within self-referential and prefrontal networks that continue to mature into early adulthood. A fourth structure, the Hyper-real Structure, is proposed for the era of generative artificial intelligence and hyper-real media environments, characterized by authenticity uncertainty, role displacement, and information overload, operating primarily through sustained functional load on mature cognitive and reality-monitoring systems rather than new developmental programming.

Rather than depicting stress change as a linear replacement of mechanisms, the proposed stress-structure framework conceptualizes shifts in dominant stress patterns as coexistence-based reweighting of conserved systems, shaped by evolutionary constraints, historical input structures, and developmental calibration. By linking macro-level sociohistorical change with developmental plasticity and micro-level neuropsychological mechanisms, the framework offers a unified account of contemporary psychological distress and generates testable entry points for future empirical research, including network-level differences in functional organization, sensitive-period interactions, and non-linear threshold effects under AI-saturated environments.

**Keywords** stress structure; functional dominance rearrangement; evolutionary mismatch; developmental plasticity; generative artificial intelligence

*Note: Figure translations are in progress. See original paper for figures.*

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