



Relationship between Personality and Biological Reactivity to Stress: A Review

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Objective Personality traits can be the basis for individual differences in the biological response of stress. To date, many psychobiological studies have been conducted to clarify the relationship between personality and biological reactivity to stress. This review summarizes the most important findings in this area of research.

Results Key findings related to the relationship between personality factors and stress-sensitive biological systems in four research models have been summarized; model of psychosocial characteristics, model based on Rumination and Emotional Inhibition, Eysenck's biopsychological model, and Five-Factor Approach of Personality.

Conclusion According to the results of this review, it can be concluded that personality typology of individuals influenced their biological reactivity to stressful events. Understanding the biological basis of personality can help to better understand vulnerability to stress. Future research can be continuing based on framework of the four models. **Psychiatry Investig 2018;15(12):1100-1114**

Key Words Personality, Psychological stress, Biological markers, Cortisol, Alpha-amylase, Immunoglobulin A.

INTRODUCTION

The term of stress was used for the first time since the seventeenth century to describe the sadness, suppression, inconvenience and disaster. However, this term was reformed in the nineteenth century, and had meaning a strong effect exerted on a person or on a physical object.¹ At present, stress is a universal phenomenon and it is the result of positive and negative experiences of life.²

It is a common observation that people are clearly diverse in their psychological and physiological responses to stressors and challenging environments.^{3,4} Personality may be an important factor explaining this diversity, as it can have an effect on a person's assessment and perception of a potentially stressful situation and a subsequent potentially diverse biological reaction.^{5,6} Personality provides an important biological

trait, because of its hereditary bases, as well as linkage with intraindividual compatibility.⁷ Thus, identifying and targeting sources of individual differences, such as personality traits, which may lead to exhibiting excessive biological responses, can have important health implications. In this review, we tried to summarize evidence that the difference in biological reactivity of individuals to stress can be explained in terms of personality.

The concept of stress

The concept of stress undoubtedly owes to the works of Hans Selye, who is the father of stress research.⁸ In the biological field, he has defined the stress as a nonspecific and predictable response of the body to any demand.⁹ Actually, stress experience includes psychological and physical components, and it depends on the person perception of its controllability and predictability.¹⁰ Stress is a normal reaction and sometimes it can be useful, because of that, it provides the vital motivation and power to help person to overcome conditions such as work deadlines or exams. However, stress can become problematic when environmental demands go beyond the individual's ability to cope.¹¹

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Theoretical models of stress

Several models or theories within the literature have developed different scientific definitions of stress that include the basis for understanding stress. These models focus on the specific relationship between external demands, bodily processes and psychological components. Furthermore, these theoretical models help in identifying the stressful factors in a special situation as well as predicting the probability of a person's adaptation to a stressful condition. The most important of the theoretical approaches of stress include; Response-based, Stimulus-based, and Transaction-Based.^{1,12} The following briefly are discussed each of these models.

Response-based model emphasize a reaction or a physiological response pattern. The formulation of stress as a response has been described by Hans Selye.¹³ He presented these reactions in "General Adaptation Syndrome (GAS) model."¹⁴ According to GAS model, a stressful event leads to a three-stage bodily response: the alert reaction stage (or physiological and psychological changes to protect against the threats), the resistance stage (or a period of optimal adaptation) and exhaustion stage which comes up with prolonged exposure to stress, and often has negative consequences such as illness, fatigue, and burnout.^{12,15}

In the stimulus approach, stress arises from the individual's environment, and the reaction to external stressors is called "stress." Therefore, the advocates of this approach have tried to identify the stressful situations or events of life and determine ways to cope with it.^{16,17} This theory states that both positive and negative situations of life are considered as a stressful factor.¹⁶

Based on the transactional model, stress is considered as a process and the interpretation of stressful events is more important than the events.^{18,19} In the transactional models, the stimulus or stressor, the person's response (signs and symptoms of stress) and interfering factors such as personality traits have been considered. In essence, person is seen as an active element in stressful conditions, so that the cognitive, behavioral, and emotional self-regulations affect the strategies of coping with stressors.²⁰

Aspects and measurement of stress

According to the cognitive activation theory of stress (CATS), the term of stress is defined by four aspects that including stimuli, stress experience, response and feedback, which may be individually measured.²¹ The stress stimuli or stressors are threats and demands in the face of any given situation.¹³ Stress experience is conceptualized as individual appraisal (Perception) of the stressor or situation, so that it determines that the situation may be a threatening or pleasant stimulus.²² The stress response is a general and non-specific alarm that pro-

ducing a general increase in brain arousal (neurophysiological activation) and wakefulness, and specific responses to deal the stressor events. Finally, the feedback from the stress response involves all changes resulting from wakefulness and increases arousal after a stressful situation, and plays an important role in how stress experience.^{21,22}

Each of these four aspects of stress actually provides four ways to measurement of stress.²¹ The first aspect or "stressor" is an easy way to measuring stress, and is often considered as the most objective way of measurement. Although, this method is easy to quantify external factors, but it is emotional and social factors that may determine survival in severe environments.²³ The second aspect or the experience (feeling) of stress is possibly related more to research on work-related stress.²¹ Generally in this method, stress assessment is performed by means of questionnaires such as perceived stress scale,²⁴ job stress,²⁵ academic stress,^{26,27} etc. So that, by formulating the questions in this way, asking whether a certain situation or relationship is a source of stress. The final result of the evaluation is based on the expectancies of individual for this or similar conditions.

The stress responses (or third aspect) are the easiest way to measure the stress. Arousal affects almost all physiological systems. During the stressors, stress-sensitive physiological systems including the hypothalamic-pituitary-adrenal axis, the autonomic nervous system, and the immune system, are undergone biochemical and pathological changes. These changes are commonly shown by stress biomarkers (cortisol, alpha-amylase, pro-inflammatory cytokines, IgA),²⁸ so that alterations in basal activity and stress-dependent reactivity can be measured in these systems.²⁹ On this way, there are different measurement methods such as psycho-endocrinology, psycho-immunology, psychophysiology, and brain biochemistry. Finally, Fourth aspect of stress or the feedback is used in many of the questionnaires in research on humans.²¹ This aspect is an important component of questionnaires in case of health complaints,³⁰ and many anxiety scales.³¹

Stress-sensitive biological systems and their biomarkers

In the field of the physiology of stress, when the body is excited, two primary systems are activated in stress-related conditions which are hypothalamus-pituitary-adrenocortical axis (HPA) and the sympathetic-adrenal-medullary (SAM) system.⁵ These two systems closely interact with the immune system.²⁸ Actually, stress can also suppress the production of immunoglobulin by reducing the function of the immune system.²⁹ These three systems are recognized as stress-sensitive biological systems²⁸ and they are implicated in the physiological response to stress.³² One of the methods for evaluating the activity of these three systems is using of the secretion pattern of

specific stress-related biomarkers.³³ Stress biomarkers provide an accurate, reliable and objective assessment of stress, while psychometric evaluation using stress questionnaires is highly the results of subjective responses.^{34,35}

Biomarkers are biological indicators (as a biological characteristic) which can be objectively measured and evaluated in tissues, cells or various fluids of the body such as blood, urine and saliva. Also they represent underlying and various physiological processes, including normal biological processes, pathogenic status and/ or response to therapy.^{36,37} Cortisol and catecholamines (norepinephrine and epinephrine) are known as reliable stress markers for the reactivity of HPA axis and SAM systems.³⁵ In general, serum, urine and saliva cortisol are classical biomarkers to measure of biological stress response.⁵ So far, the evaluation of the SAM system has been limited to electrophysiological measurements such as skin conduction, heart rate, or plasma measurements of epinephrine and norepinephrine.³⁸ However, a rapidly growing collection of research emphasize the usefulness of salivary alpha-amylase protein as an indicator of the increased activation of the SAM system.^{28,32,33,39} In summary, increased cortisol secretion is due to the activation of HPA, while activation of SAM leads to an increase in sAA.^{40,41}

Immune system accompanied by the HPA axis and SAM as an evolutionary physiological reaction, are necessary for biological response to stressful situations.^{32,42} Stress-related immune changes have been investigated by various immune parameters including cytokines, C-reactive protein (CRP),²⁸ serum immunoglobulins, complement proteins as well as immune cells.^{42,43} However, the salivary immunoglobulin A (sIgA) has been used as a sensitive and non-invasive biomarker for evaluating stress-induced immune system changes. The IgA is the major antibody in mucosal membrane which protects against infectious agents, allergy, and external proteins. The immune factor has a concentration that can be affected by stressful stimuli.^{29,44} So that the animal studies have also shown that long-term stress and acute stress reduce IgA levels.⁴⁵

Evidences also suggest that biological stress response is tracked by levels of sex hormones specifically stress-related testosterone which may be a stress-sensitive biomarker.⁴⁶ For example, lower levels of blood testosterone⁴⁷ and suppressing steroidogenesis in testicles⁴⁸ have been observed under chronic stress. Moreover, the increased levels of salivary testosterone in male students under exam stress⁵ and psychosocial stressors,^{49,50} as well as low levels of serum testosterone during anticipatory stress,⁵¹ immobilization stress (in adult male rats),⁵² physical stress, psychological stress, and actual stress⁵³ have been reported. Testosterone can be a useful and sensitive biomarker for the activity of the Hypothalamic-Pituitary-Gonad axis under stress.⁵⁴ Studies also showed that the HPG axis in-

teracts with the HPA axis as well as the immune system in response to stress.^{47,54-56}

Personality: definition, measurement

Personality is defined by tendencies and sustainability characteristics that determines the similarities and differences in psychological behaviors (such as thoughts, emotions, and actions) of individuals and shapes a complex pattern of learning and biological preparation.⁵⁷ So far, various perspectives have been presented in the field of personality psychology. From among these perspectives, traits theory is commonly considered as an important approach to the study of human personality, which it has provided group evaluation methods in personality assessment.⁵⁸ Trait-based perspectives such as the 16-factor theory of Cattell, the three-factor model of the Eysencks, and, finally, the five-factor approach of personality have made remarkable progress in theories and methods of personality assessment.⁵⁹ The two personality theories are including one the five-factor model of personality that uses the NEO-Personality Inventory (NEO-PI) as a measurement instrument,⁶⁰ and the other psychobiological theory of personality, which uses the Eysenck Personality Questionnaire and Temperament and Character Inventory as measurement instruments.^{61,62} Among objective personality tests, the dimensions of the big five personality (for example, neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness) have received more attention than other personality constructs.⁶³ This may be due to the fact that during the 50 years of personality research there was a common agreement that the personality could be summarized in five dimensions, which became known as the "Big Five personality."⁶⁴

Personality traits and coping with stress

In health psychology, there is a growing interest about the personality traits that may be important as sources of stress.⁶⁵ Personality factors play an important role in identifying, responding, and approaching stressful events.⁶⁶ In fact, vulnerability to stress is based on person's appraisal and response to stressful situations.⁶⁷ Types of personality can have powerful traits, which over time show resilience to stress and psychological support against the toughest of life events.⁶⁶ Personality traits can predispose individuals to some mental disorders.^{68,69} Even animal studies also showed that personality dimensions can make them vulnerable to environmental stress.^{70,71} In previous studies, a number of constructs, such as hardiness,⁷² self-efficacy,⁷³ optimism,⁷⁴ learned Resourcefulness,⁷⁵ hope,⁷⁶ and Sense of Coherence⁷⁷ have been designed to act as personality aspects that predict positive appraisal, resilience, effective coping, or even growth in the stress process. Available evidences support the hypothesis that personality factors rather than

the environment play a causal role in the coping and generation of a reaction to stress.^{78,79} So far, numerous studies have been conducted to identify the personality characteristics that influence the relationship between stimuli and stress responses.⁸⁰ Several studies have shown that some personality traits can predict the level of stress as shown in the literature. For example, based on the Five-Factor Model of Personality, there was a positive correlation between the trait of neuroticism with level of psychological stress.⁸¹⁻⁸³ Also, neuroticism and extraversion influenced post-traumatic stress disorder.⁸⁴ type of personality combining low levels of neuroticism and high conscientiousness, have shown a favorable personality profile to the coping with stress.⁸³ Similarly, In the case of children, neuroticism also was positively related to the level of stress.⁸⁵ Furthermore, personality domains of the Temperament and Character Inventory (TCI) such as harm avoidance were positively correlated with perceived stress, but the persistence and self-directedness had a negative relationship.⁶ Dimensions of harm avoidance, reward dependence, and self-directedness significantly predicted by Ways of Coping scales.⁸⁶ Other traits such as irritability detachment, psychasthenia and somatic anxiety, extraversion and lie scale were significant explanatory variables of reactivity to stress.^{67,87,88} Therefore, personality traits can be predicting the level of psychological stress in individuals, as noted. What emerges from these studies is that neuroticism is a prominent factor of personality in the reactivity to stress. However, some studies have shown that the level of psychological stress is not influenced by personality.⁸⁰

Personality and biological stress reactivity

Individual differences in biological and cognitive responses to stress indicate that physiological mechanisms are influenced by moderator variables. Personality has been proposed as one of these moderators.⁸⁹ So far, the impact of personality on biological stress reactivity by the biomarkers of stress-sensitive biological systems such as the hypothalamus-pituitary-adrenal (HPA), as indexed by cortisol,^{41,90} the sympathetic-adrenal-medulla system (SAM), as indexed by cardiovascular activity,³ immune system, as indexed by IgA,²⁹ sympathetic nervous system (SNS), as indexed by salivary A-amylase,^{39,40} sex hormones, as indexed by testosterone levels⁵ has been investigated. In this line of researches, several studies tried to uncover the possible associations between biological stress responses and personality. In the following, briefly, the results of these studies are presented in four models; Model of psychosocial characteristics, Model based on Rumination and Emotional Inhibition, Eysenck's biopsychological model, and five personality factors.

Psychosocial characteristics and biological responses to stress

In this field, earlier studies have attempted to discover the possible relationship between biological responses to stress, specifically cortisol and cardiovascular reactions, with psychosocial characteristics. For example, in response to stressful situation, self-esteem negatively were associated with cortisol and adrenocorticotrophic hormone responses,⁹¹ instead, in other study, it has been reported that higher basal plasma cortisol levels predicted by high self-esteem, hardiness and affective stability.⁹² In addition, low levels of hardiness predict cardiovascular disease.⁹³ Also, self-concept, social resonance, and trustfulness negatively predicted cortisol responses.⁹⁴ In a study, morning cortisol levels related to less depressive and neurotic tendencies in men,⁹⁵ and in people with lower perceived sense of control (mastery) have shown lower level of basal and/or provoked adrenocortical activity, while the high level of basal and/or lower adrenocortical reactivity predicted by monotony avoidance.⁹⁶ Furthermore, available evidences showed that hostility and locus of control were associated with more cortisol and cardiovascular reactions to stress.^{90,97} It has been reported that individuals with lower cortisol response had higher Achievement Motivation and social acceptance.⁹⁸ On the other hand, cortisol reactivity was predicted by Purpose in Life and Self-Perception in a negative direction.⁹⁹ Hopelessness also was associated with a higher cortisol-awakening response.¹⁰⁰ Recently, studies reported a negative correlation between aggression control and salivary cortisol,¹⁰¹ and a positive correlation with salivary testosterone under psychological stress.⁵

Model based on rumination and emotional inhibition of the biological reactivity

Some researchers by examining previous findings have argued that these personality constructs used in early studies, have made a little progress in the field of stress studies. They proposed another model based on rumination and emotional inhibition.^{89,102} In general, in response to emotional stress, emotional inhibition is related to dysfunctional bodily reactions such as physiological, endocrinological, and immunological changes.¹⁰³ Previous studies have shown that emotional inhibition was associated with prolonging the physiological activity,^{89,104} lower cardiovascular recovery,¹⁰⁵ higher cardiovascular reactivity,¹⁰⁶ increased levels of arousal, norepinephrine, and salivary cortisol,¹⁰³ as well as it can positively predict levels of salivary immunoglobulin A (IgA)²⁹ and salivary testosterone⁵ under psychological stress. However, in a study, only the Benign Control (scale of the ECQ) and rumination were linked to heart-rate recovery.¹⁰⁷ Rumination can lead to persistent activation of the HPA axis.¹⁰⁸ Specifically, rumina-

tion is correlated with high cortisol stress response.⁸⁹ More recent researches also show that greater rumination on stressful situations predict the levels of salivary alpha-amylase,³⁹ higher cortisol reactivity,^{41,108-110} and prolonged cardiovascular activity.¹¹¹ Although, some studies have reported that there was no difference between high and low ruminators in neuroendocrine response to stress.¹¹² Nevertheless, these disparate results may be due to the different measurements of rumination (state and trait measures). So that, the state measures of rumination may be more related to the of HPA axis activation.^{108,113} It is also observed co-rumination in young women's friendships (as psychological stressor) can predict increased cortisol and sAA.¹¹⁴

Eysenck's biopsychological theory of personality

Based on Hans Eysenck's theory, there is a biological basis to personality, and Personality differences arise from genetic heritage.^{62,115} The Eysenck's model has three super-factors that are independent constructs: extraversion, neuroticism and Psychoticism. Eysenck believed that distinct physiological substrates may form the basis of the personality traits, so that characterized by differential biological responses.¹¹⁶ It is assumed that neuroticism is based on low activation thresholds in the sympathetic nervous system, or visceral brain. Therefore, higher score in neuroticism strongly linked with physiological responses to stress. In contrast, extraverts have high thresholds in the ascending reticular activating systems (ARAS), and other arousal systems such as the pituitary-adrenocortical system. Also, by observing the fact that the criminals were mainly male, Eysenck suggested that biological basis of psychoticism may be related to androgen (e.g., the increased testosterone levels).¹¹⁶⁻¹¹⁸ Several psychophysiological studies provided support for this model. Extraverts had higher arousal thresholds in react to the varying stimulations,¹¹⁷⁻¹²² Whereas, high neuroticism had lowest thresholds¹²³ and it was correlated with functioning of several emotion processing networks in the brain (cortical regions that involved in emotion regulation, anxiety and depression, in addition to many sub-cortical/limbic regions), particularly during exposure to negative stimuli.¹²⁴ The biological basis of psychoticism has not been fully identified. Primary research showed that there is the kind of central nervous organization underlying psychoticism, which has been observed in two-flash threshold and electrodermal level.^{125,126} It is reported that psychoticism was linked with several testosterone-related genes, which explained the high level of testosterone in these individuals.^{127,128}

Eysenck's model and biological stress responses

As indicated in Table 1, some studies have not found any association between Eysenck's model and urinary cortisol re-

sponse to psychological stress.^{129,130} Nevertheless, an earlier study has shown that neuroticism and extraversion are strong predictors stress-induced neuroendocrine reactions.¹³¹ The next investigation using Eysenck's model showed that in response to psychological stress, neuroticism positively related to the cortisol secretion⁸⁹ and diastolic blood pressure responses.¹³² Contrary, it was reported that there was no association between neuroticism of Eysenck's model and the daytime cortisol secretion.¹³³ High levels of neuroticism was associated with the blunted cortisol reactivity, and poorer A/Panama antibody response to acute laboratory mental stress.¹³⁴ Whereas in response to the combined dexamethasone-CRH test, low-neuroticism individuals showed a greater cortisol response than high-neuroticism individuals.¹³⁵ Research also reported extraversion negatively associated with the cortisol stress responses.^{94,99} Instead, in response to change in work-related circadian behavior pattern, individuals with high extraversion secreted more cortisol during the day shift, while high introverts produced more cortisol during the night shift.¹³⁶ Despite this, it has been observed that higher introversion of Eysenck's model was associated with a lower cortisol awakening response, and in interaction with gender, higher levels of introversion among males were also associated with the increased cortisol levels at the time of wakeup (Table 1).⁴

Biological stress reactivity based on the five-factor approach of personality

The "big five or five-factor" model (FFM) is known as a broadly accepted construct that describes the diversity of personality in five dimensions: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness. Numerous researchers have stated that the structure of the big five model is a genetically based human personality universal, such that goes beyond language and other cultural differences.¹³⁷⁻¹⁴⁰ Although, some studies suggested extraversion and agreeableness may be more dependent to cultural context,¹⁴¹ but lately, based on the FFM, researchers presented the evolutionary approach about personality structure that has stated personality diversity may not be constant among human communities.^{142,143}

The FFM provide a psychobiological typology of resistant to stress or stress reactivity.¹⁴⁴ Previous studies suggested that five big dimensions not only have a moderate heritability, but also because important physiological correlations with biological systems such as cardiovascular and endocrine responses to stress, indicating causal link of psychometrics with biology.¹⁴⁵ In previous psychophysiological research, the relationship between FFM and stress-sensitive biological systems has been investigated, as shown in Table 2. Although it must be acknowledged that some studies reported no association between neuroticism of the FFM and cortisol levels,^{100,146} but, in

Table 1. Summary of findings related to Eysenck's model and biological responses to stress

Studies	Biological measures	Personality assessment	Type of stress position	Results
Arnetz et al. ¹³¹	Diastolic and systolic blood pressure reactions, heart rate, urinary and serum cortisol, urinary adrenaline and noradrenaline, growth hormone, prolactin, progesterone, glucose, triglycerides	Two dimensions of Eysenck's short questionnaire: extrovertness and neuroticism	Psychological stress (The colour-word conflict test and Mental arithmetic problems)	- Diastolic blood pressure reactions to Psychological stress predicted by extrovertness - 25 percent of adrenaline response explained by extrovertness - High scores in neuroticism were associated with the lowest progesterone response to stress. - 36 percent of A-prolactin response explained by neuroticism.
Kirschbaum et al. ¹²⁹	Salivary cortisol	The German version of the Eysenck Personality Questionnaire-Revised (EPQ-R)	Psychological stress (public speaking and mental arithmetic)	No significant correlation was observed between Salivary cortisol and any of the EPQ measures
Kirschbaum et al. ⁹⁴	Salivary cortisol	Eysenck Personality Inventory (EPI; German version): extroversion (EPI-E) and neuroticism (EPI-N)	Psychological stress (public speaking and mental arithmetic in front of an audience)	- Extraversion negatively associated with the salivary cortisol responses to psychological stress
Roger et al. ⁸⁹	Urinary free cortisol test (UFC)	Eysenck Personality Inventory (EPI); extroversion (EPI-E) and neuroticism (EPI-N)	Psychological stress (written examination)	Neuroticism positively was related to the cortisol secretion
Senior et al. ¹³⁶	Salivary cortisol	Extraversion-introversion scale of the Eysenck Personality Inventory	Physical stressor (change in work-related circadian behavior pattern)	- Individuals with high extraversion secreted more cortisol during the day shift, - high introverts produced more cortisol during the night shift
Schommer et al. ¹³⁰	Salivary cortisol	The Eysenck Personality Questionnaire-Revised (EPQ-R)	Psychosocial stress (a free speech and a mental arithmetic task)	No significant correlation was observed between basal /or stimulated concentrations of cortisol and stressful exposure.
McCleery et al. ¹³⁵	Plasma cortisol	Neuroticism dimension of the Eysenck Personality Questionnaire (EPQ)	The Combined dexamethasone-CRH test	Individuals with low-neuroticism showed a greater cortisol response than high-neuroticism individuals
Kennedy et al. ¹³²	Cardiovascular measures: systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) activity	Neuroticism dimension of the Eysenck Personality Questionnaire (EPQ-R)	Psychological stress (a mental arithmetic task)	Neuroticism was related to diastolic blood pressure responses
Phillips et al. ¹³⁴	Salivary cortisol	Neuroticism dimension of the Eysenck Personality Questionnaire (EPQ)	Psychological stress (a mental arithmetic task)	A high level of neuroticism was associated with the blunted cortisol reactivity, and poorer A/Panama antibody response.
Ferguson ¹³³	The daily salivary cortisol	Neuroticism dimension of the Eysenck Personality Questionnaire (EPQ)	Health anxiety (HA)	There was no association between neuroticism of and the daytime cortisol secretion

Table 1. Summary of findings related to Eysenck's model and biological responses to stress (continued)

Studies	Biological measures	Personality assessment	Type of stress position	Results
Taylor et al. ⁹⁹	Salivary cortisol	the Extraversion subscale of the Eysenck Personality Inventory	Psychological stress (a speech to audiences and mental arithmetic tasks)	Extraversion negatively was associated with the Salivary cortisol responses to stress
Hauner et al. ⁴	Diurnal salivary cortisol patterns	Four measures of neuroticism: (EPQ-R), international personality item pool NEO-PI (IPIP) and big five mini-markers). Introversion (low extraversion of big five mini-markers)	Life stress risk factors	- Higher introversion was associated with a lower cortisol awakening response - In interaction with gender, higher levels of introversion among males were associated with the increased cortisol levels at the time of wakeup - A flatter cortisol rhythm was observed across the waking day among male participants with higher Neuroticism

particular, high neuroticism was associated with more levels of cortisol^{141,147-149} and Salivary alpha amylase³⁹ under psychological stress, the diurnal cortisol secretion,¹⁵⁰ and the increased cortisol levels in response to Dex/CRH test,¹⁵¹ which reflecting a more activation of the HPA axis in the neurotic individuals. Also in highly neurotic individuals, blood pressure reactivity to laboratory stressors,¹⁵² and the lower levels of diastolic blood pressure response,¹⁵³ and higher pre-ejection period (PEP) reactivity¹⁵⁴ was reported. Neuroticism was also associated with low level of salivary IgA under psychological stress.²⁹ However, there were evidences that neuroticism of FFM has been associated with lower cortisol and cardiovascular reactions,^{3,155} as well as in another study, it was not associated with blood pressure, heart rate, urinary cortisol.¹⁵⁶ Some researchers have argued that the nature of stress-related task plays an important role in stress response. For example, higher neurotic during the cognitive task showed lower DBP and TPRI responses, whereas during the emotional task, lower neuroticism was related to high levels of TPRI reactivity.¹⁵³

On other dimensions of the FFM, extraversion, in interaction with various types of stressors (health, family, social, work) can negatively predict physiological stress response.¹⁵⁷ Higher extraversion may be associated with a low level of sAA,⁴⁰ lower levels of basal/or increased salivary testosterone,⁵ lower cortisol reactivity,¹⁵⁴ and lower cardiovascular reactivity¹⁵³ to psychological stress. Furthermore, low levels of extraversion were associated with higher blood pressure, epinephrine, norepinephrine, and natural killer cell cytotoxicity (NK cells).¹⁵⁶ There is also evidence that Lower extraversion predicts greater cortisol reactivity,^{146,149} and tended to show a low level of cortisol awakening response.¹⁰⁰ Other research was non-significant, but its findings showed that extraversion of FFM tends

to have a lower cortisol response.¹⁵¹

Although in a study, agreeableness of FFM in interaction with various types of stressors (health, family, social, work) negatively predicted physiological stress response,¹⁵⁷ but also, there are some dissimilar findings. For example, individuals with low levels on agreeableness tended to have higher levels of diastolic blood pressure, systolic blood pressure and urinary epinephrine,¹⁵⁶ and on the other hand, these people also have shown lower levels of cortisol and cardiac reactions to stress.³ In addition, another studies displayed that Agreeableness positively related to the levels of cortisol,^{149,158,159} and sAA³⁹ under psychological stress. However, some researchers reported a negative correlation between Agreeableness and sAA,⁴⁰ as well as it was related to lower cortisol levels at awakening.¹⁶⁰ In addition, a negative non-significant and remarkable relationship between Agreeableness and the decreased salivary testosterone response to stress have been reported.⁵

Researchers have found that because having positive affection, individuals with high levels of conscientiousness showed reduction in diurnal cortisol concentrations^{150,161} and lower cortisol reactivity to psychological stress.¹⁴⁹ In addition, it has been reported that conscientiousness was related to low level of basal/or lower cortisol reactivity,^{158,162} and lower hair cortisol concentration.¹⁶³ There is also a research that reported no correlation between conscientiousness and the cortisol awakening response (CAR), or the diurnal cortisol levels.¹⁶⁴

Openness to experience is one another of the domains of the FFM. So far, previous psychobiological studies showed a positive association between openness with basal/salivary testosterone,⁵ and IgA²⁹ under psychological stress, while it was negatively correlated with salivary cortisol.⁴¹ There were also inconsistency findings. for example, the increased corti-

Table 2. The five-factor model of personality and biological responses to stress

Studies	Biological measures	Personality assessment	Type of stress position	Results
Vickers et al. ¹⁵⁸	Blood cortisol levels	The 181-item NEO personality inventory (NEO-PI)	Physical stress (Military basic training)	- Agreeableness was associated to higher cortisol - Conscientiousness was related to lower cortisol
Miller et al. ¹⁵⁶	Blood pressure and heart rate, neuroendocrine parameters(urinary Epinephrine, norepinephrine, and cortisol) and immune parameters (T lymphocytes, helper T lymphocytes, cytotoxic/suppressor T lymphocytes, B cells, and natural killer cells)	Big five personality factors of goldberg's (1992)	Physical laboratory stress (viral exposure)	- Low agreeableness has showed higher levels of systolic blood pressure, diastolic blood pressure, and urinary epinephrine - Low extroversion was related to higher levels of epinephrine, blood pressure, norepinephrine, and natural killer cell cytotoxicity - Neuroticism was not associated with physiological outcomes
Schwebel et al. ¹⁵²	Cardiovascular reactivity (blood pressure and heart rate)	The NEO PI-R neuroticism scale	Psychological and physical stressor (laboratory reactivity tasks)	Blood pressure reactivity to laboratory stressors reported in highly neurotic individuals
Zobel et al. ¹⁵¹	Blood cortisol levels	NEO-five-factors Inventory (NEO-FFI)	Combined dex/CRH tests	Participants with high neuroticism revealed high levels of cortisol
Oswald et al. ¹⁵⁵	Plasma concentrations of cortisol	The revised NEO personality inventory (NEO PI-R)	Psychological stress (mental arithmetic challenge)	- In total sample, low levels of openness were associated with lower cortisol responses - In the interaction of gender, the low cortisol responses were associated with higher neuroticism in women and with lower extraversion in men
Tops et al. ¹⁵⁹	Salivary cortisol responses	Five factor personality inventory (FFPI)	Physical laboratory stress (the Eriksen Flanker Task while by EEG was recorded)	Agreeableness positively related to the levels of Salivary cortisol
Hauner et al. ⁴	Diurnal salivary cortisol patterns	Four measures of neuroticism: (EPQ-R), international personality item pool NEO-PI (IPIP) and big five mini-markers). Introversion (low extraversion of big five mini-markers)	Life stress risk factors	High neuroticism among males were associated with a flatter diurnal cortisol response
Jonassaint et al. ¹⁵³	Cardiovascular reactivity: heart rate, blood pressure, cardiac output index, total peripheral resistance index (TPRI)	Neuroticism and extraversion of the NEO PI-R	Psychological stress: a cognitive task as mental arithmetic (MA) and an emotional task as The anger recall (AR)	- High extraversion was related to lower cardiovascular reactivity on both tasks - High neuroticism was associated with low levels of DBP and TPRI reactivity during MA, Whereas during AR, lower N associated with high TPRI reactivity

Table 2. The five-factor model of personality and biological responses to stress (continued)

Studies	Biological measures	Personality assessment	Type of stress position	Results
Nater et al. ¹⁵⁰	Salivary diurnal cortisol levels	Neuroticism and conscientiousness of the NEO-FFI	-	- N was positively associated with cortisol levels during all periods of measurement - Because having positive affection, individuals with high levels of conscientiousness showed reductions in diurnal cortisol concentrations
Inukai et al. ⁴⁰	Baseline salivary alpha-amylase (sAA)	The 70-item Big Five Inventory (BFI)	-	- Between neuroticism and sAA were observed a positive correlation - Agreeableness was positively correlated with sAA. - Extraversion, agreeableness, openness were negatively related to sAA after controlling for age
van Santen et al. ¹⁰⁰	Salivary cortisol awakening responses	The 60-item NEO-FFI personality Inventory	-	- Individuals with higher levels of extraversion have tended to a lower cortisol awakening response - No significant associations were found for neuroticism, conscientiousness, openness, agreeableness,
Agrigoroaei et al. ¹⁴⁹	Salivary cortisol levels	The 240-item NEO-PI-R	Psychological stress : challenging driving scenario with simulator	- Individuals with higher levels of conscientiousness showed lower cortisol reactivity - Neuroticism, agreeableness and extraversion were positively related to greater cortisol reactivity
Gartland ¹⁶⁴	The diurnal salivary cortisol levels	Chernyshenko conscientiousness scales	Daily perceived stress	No correlation was found between conscientiousness and the diurnal cortisol levels
Bibbey et al. ³	Salivary cortisol and cardiovascular activity: Heart rate, blood pressure	The Big Five Inventory (BFI)	Three psychological stress tasks: stroop, mirror tracing, and speech	- Higher neuroticism was related to lower cortisol and cardiovascular stress reactions - Low agreeableness and low openness had shown lower cortisol and cardiac reactions to stress
Chu et al. ¹⁵⁷	Physiological stress response measured by Work Stress Scale	NEO-personality inventory	Types of stressors (health, family, social, work) of Work Stress Scale	- Interaction of stressors (health, family, social, work) and agreeableness negatively predict physiological stress response - Interaction of stressors (health, family, social, work) and Extraversion negatively predict physiological stress response
Afrisham et al. ³⁹	Salivary alpha amylase reactivity	The 60-item NEO-FFI personality Inventory	Psychological stress: exam stress	Neuroticism and agreeableness were positively correlated with SAA

Table 2. The five-factor model of personality and biological responses to stress (continued)

Studies	Biological measures	Personality assessment	Type of stress position	Results
Laceulle et al. ¹⁶²	Basal salivary cortisol and cortisol awakening responses	The revised NEO personality inventory (NEO PI-R)	Physical laboratory and psychosocial stress: orthostatic stress (from supine to standing), a spatial orienting task, a gambling task, a startle reflex task, and a social stress test	Neuroticism, extraversion and conscientiousness were related to low level of basal cortisol
Bogg et al. ¹⁶¹	The diurnal salivary cortisol levels	Neuroticism and conscientiousness of NEO-personality inventory	Daily stressors	High conscientiousness is associated with reductions in diurnal cortisol concentrations
Parent-Lamarche et al. ¹⁶⁰	The diurnal Salivary cortisol levels	The 20-item Mini International Personality Item Pool (Mini-IPIP)	Psychosocial stress: Stressful life events, Marital stress, Parental stress	Agreeableness was associated with lower cortisol levels at awakening
Afrisham et al. ²⁹	Levels of salivary immunoglobulin A	The 60-item NEO-FFI personality Inventory	Psychological stress: exam stress	- A negative correlation was found between neuroticism and salivary IgA - Openness was positively correlated with salivary IgA
Afrisham et al. ⁵	Salivary Testosterone Levels	The 60-item NEO-FFI personality Inventory	Psychological stress: exam stress	- Openness was positively correlated with salivary testosterone - A negative correlation was found between extroversion and salivary testosterone
Evans et al. ¹⁵⁴	Salivary cortisol and Heart rate reactivity, pre-ejection period (PEP)	Extraversion and neuroticism of Big Five personality markers	Psychosocial stress: the speech delivery and social evaluation	- Higher levels of extraversion showed lower cortisol reactivity - higher level of neuroticism showed higher PEP reactivity
Sadegh-Nejadi et al. ⁴¹	Salivary cortisol reactivity	The 60-item NEO-FFI personality Inventory	Psychological stress: exam stress	- A Positive correlation was found between neuroticism and salivary cortisol - Openness has a negative correlation with salivary cortisol response
Ouanes et al. ¹⁴⁶	Salivary Cortisol Awakening Response and Cortisol AUC (Area Under the Curve)	The 60-item Revised NEO Five Factor Inventory (NEO-FFI-R)	-	- High extraversion was negatively associated with Cortisol AUC. - High openness was associated with higher cortisol - No correlation was found between neuroticism and cortisol levels
Stephoe et al. ¹⁶³	Hair cortisol concentration	The Midlife Development Inventory (MIDI) Personality Scales	Socioeconomic position: Educational attainment and wealth	Conscientiousness was related to lower hair cortisol concentration
Russell ¹⁴⁸	Salivary Cortisol response	The 60-item Revised NEO Five Factor Inventory (NEO-FFI-R)	Psychosocial stress: the Trier Social Stress Test (TSST)	High neuroticism was associated with more levels of cortisol

sol,¹⁴⁶ and or the lower cortisol responses¹⁵⁵ were associated with low levels of openness.

On the reviewed studies, some researchers believed that cortisol reactivity may be corresponded to certain personality dimensions of FFM in a gender-specific manner. Thus, they evaluated gender effects on relationship between the FFM and HPA axis activation. Their results demonstrated that the low cortisol responses were associated with higher neuroticism in women and with lower extraversion in men.¹⁵⁵ Another study also reported that high neuroticism among males were associated with a flatter diurnal cortisol response.⁴

Other personality profiles and biological stress response

In addition to the researches based on the presented four models, a number of psycho-neuroendocrinological studies have used other personality profiles to find out the relationship between personality and biological stress response. For example, the individuals with type-A behavior have shown the high level of basal and/or lower adrenocortical reactivity,⁹⁶ while type-D behavior (or 'distressed' personality) was associated with higher cortisol reactivity to stress.¹⁶⁵ Also, a research using the dimensions of (TCI) showed that Masterful Subjects (highly self-directedness and mastery individuals) showed low alpha-amylase reactivity, and moderate level of cortisol reactivity, whereas trustful subjects (or highly cooperative and trustful individuals), had low cortisol reactivity. In addition, courageous Subjects (or individuals with higher harm Avoidance, lower Self-directedness, and partially lower Self-transcendence) has shown high sympathetic reactivity, while their cortisol activation was moderate.¹⁶⁶

Conclusion

According to the results of this review, it can be concluded that personality typology of individuals influences their biological reactivity to stressful events. Actually, differences in biological reactivity to stress may be caused by a different biological personality. Commonly, the biological stress responses have been investigated by current biomarkers of stress-sensitive biological systems such as HPA axis, the autonomic nervous system, the immune system, sympathetic-adrenal-medulla system, and sex hormones. In addition, of the presented four models, the models of psychosocial characteristics, rumination and emotional inhibition include dimensions of higher-order personality and groups of more specific traits. Whereas, Eysenck's model and specifically big five personality traits are not only reflected more extensive and organized personality structures, but also included most basic and higher-order dimensions of personality. Future research can be continuing based on the framework of the four models.

In general, from a biological perspective, Personality as a set of traits or characteristics can be determined based on biological bases, more precisely neural mechanisms and brain structures. In other words, the human may have a biological personality that influences the way of thinking, behavior and as well how to interact with themselves and environment. Whether the biological personality is derived from heredity (nature) or learning (nurture) and or interaction between them, requires more future research in this field. The anatomical features of the brain can be different, and this is the basis of personality differences, especially in people with mental disorders. For example, studies showed that the brain anatomy of individuals with cluster B personality disorders has features such as abnormalities in the amygdala, superior frontal cortex and enlarged striatal volumes.¹⁶⁷ Hence, understanding the biological basis of personality can be effective in improving diagnosis as well as decision making about clinical management and therapeutic options.

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