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BRAIN-BEHAVIORAL SYSTEMS AND SENSORY PROCESSING SENSITIVITY IN ASSOCIATION WITH HOSTILITY IN HYPERTENSIVE PATIENTS

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ABSTRACT

Psychological factors, such as personality and behavioral characteristics, are the effective factors in hypertension. This research investigates the relationship between brain-behavioral systems and sensory processing sensitivity with hostility in patients with hypertension. 150 male and female hypertensive patients (30 to 60 years old) referring to Tabriz Madani Hospital were selected by sampling at convenience. Data were collected by the questionnaires of Redford-Williams hostility, Highly Sensitive Person scale and Carver-White's approach/inhibition scale. Pearson's correlation test and multiple linear regression with SPSS software were used for data analysis. As the results showed, there is a significant inverse relationship between behavioral activation system and hostility in patients with hypertension ($P=0.001$). There is a significant positive relationship between behavioral inhibition system and high sensory processing sensitivity with hostility in patients with hypertension ($P=0.001$). The variables of the inhibitory system, the behavioral activating system and the high sensory processing sensitivity explain 44% of the variance of the hostility in patients with hypertension. The high sensory processing sensitivity has a greatest effect on the hostility in patients with hypertension.

Keywords: Brain-behavioral systems, Sensory processing sensitivity, Hostility, hypertension.

INTRODUCTION

Hypertension is a cardiovascular disease that has a high prevalence and is a most important health threatening factor in developing societies, including Iran (Moslehi and Barqi Shirazi, 2023). It is associated with lifestyle, mental health and the quality of life of patients like most chronic diseases, and the lack of timely and control can cause the various diseases, create significant disability, reduce productivity, and reduce the quality of life (Devo, 2005). High blood pressure is included pathologically in the cluster of psycho-somatic disorders, and psychological factors such as stress and hostility play a role in its occurrence (Wiener et al., 2020; Curtis and O'Keefe, 2002).

Hostility, as a personality trait with negative emotions and emotional dysregulation, is an aggressive behavior that is used as a synonym for anger and aggression in everyday speech. Hostility is also defined by mistrust, pessimism, and negative beliefs and attributions towards others (Cui et al., 2021). The potentially harmful effects of anger on health have long been



known. Therefore, anger, hostility and relevant constructs have attracted considerable attention as potential risk factors for heart diseases, such as hypertension. Although anger and hostility have unique structures, they are often used interchangeably and their interrelationship is not well defined. Anger is an emotional state or trait characterized by feelings ranging from mild irritation to extreme anger or rage toward others. Anger outburst is a relatively constant trigger for acute coronary events and, as a personality trait, is a less constant risk factor for heart disease, but hostility is a personality or cognitive trait with a negative attitude toward others. It is a dimension of personality type A. Early researches believed that this personality type is a risk factor for heart disease, a relation that was not supported by subsequent researches (Douglas and Zipes, 2019). However, hostility in interpersonal relationships, in comparison with all the behaviors of personality type A, is a better predictive factor for heart disease (Kelly et al., 2007).

We can say that different dimensions of personality (type, trait or any other term) are effective in cardiovascular reactions and probably in some cardiovascular diseases, such as hypertension (Janassaint et al., 2009). Personality type of psychology refers to the psychological classification of different types of individuals. Personality types are sometimes distinguished from personality traits, the latter comprising a smaller group of behavioral tendencies. Type is sometimes supposed to include qualitative differences between individuals, while personality traits may comprise quantitative differences. Introverts and extroverts are two different groups of individuals according to typological theories, while, introversion and extroversion are part of a continuous dimension, according to trait theories, so that many individuals are in the middle of this range (Donnellan & Robins, 2010). Therefore, each individual's personality can make him suffer physical-psychological problems and disorders because of incompatible traits and characteristics. Gray's theory has good implications for explaining the relationships between personality traits and psychosomatic disorders (Jani and Hajlo, 2019).

The reward sensitivity theory proposed by Gray is a most influential model on the personality (Pourakbaran et al., 2021). It has introduced three brain-behavioral systems: a behavioral approach system (BAS), which responds to conditioned stimuli of reward and lack of punishment. The activity and increased sensitivity of this system causes positive emotions and approaching behavior and avoidance. Behavioral inhibition system (BIS), which responds to conditioned stimuli of punishment and lack of reward, and to novel stimuli and innate fearful stimuli. The activity of this system causes the emotional state of anxiety and behavioral inhibition, passive avoidance, silence, increased attention and erection, and the fight flight system (FFS) which is sensitive to annoying stimuli. The behavioral components of this system, whose high activity is associated with the psychotic component (Gray and McNaughton, 2000; Gray, 1982).

Brain-behavioral systems, as the basis of behavioral and emotional tendencies, can make a person susceptible to psycho-physical disorders (like high blood pressure). Studies have shown that there is a relationship between negative emotions and the behavioral inhibition system. Individuals with high negative emotions are easily affected by stress and have a weak coping with it, which can lead to disorders such as high blood pressure (Taban Sadeghi et al., 2013). Investigations have proven the role of these systems in cardiovascular responses in patients with high blood pressure. For example, the characteristics of the behavioral inhibition system have



increased blood pressure and heart rate (Ruiz et al., 2007; Taban Sadeghi et al., 2013). Therefore, individuals, based on brain-behavioral systems, adopt one of two approach/avoidance strategies when facing a new stimulus in the responses to environmental changes. The choice of each of these strategies by a person is associated with the processing of sensory information in the brain, and these strategies are termed as sensory processing (Abaiian et al., 2022). Sadeghian et al. (2017) conducted a research titled investigating the activity of behavioral brain systems and defense mechanisms in individuals with high blood pressure and normal individuals. The average scores of the group of hypertensive patients in the defense mechanism component were significantly higher than the average of the group of normal individuals.

Sensory processing is a process that organizes one's sense in body and of the environment; it makes possible the effective use of the body in the environment and deals with how the brain processes multiple sensory inputs into usable functional outputs, such as proprioception, vision, auditory system, touch, olfactory, vestibular, interstitial, and gustatory systems (Stein et al., 2009). Previously, it was believed that inputs of different sensory organs are processed in different areas of the brain. The relation within and between these specialized brain regions, is known as functional integration (Macaluso & Driver, 2005). More recent researches have shown that these different brain regions may not be solely responsible for a sensory modality, but can use multiple inputs to understand what the body feels about its environment. Multi-sensory integration is essential for almost every activity, because the combination of multiple sensory inputs is necessary to understand the surrounding environment (Vanzetta and Grinvald, 2008). The sensory processing sensitivity explains risky decision-making, which is associated with the behavioral inhibition system and sensitivity to form and structure. Individuals with high processing sensitivity evaluate possible situations before taking action and have more ability to inhibit behavior (in the face of reward and postpone behavior to get more reward) (Khanjani et al., 2019). The characteristic of individuals with high inhibition is to avoid stimuli associated with punishment. Those who score low in sensory processing sensitivity are likely to pay less attention to surrounding stimuli and avoid situations that lead to the arousal of powerful emotions, what happens in behavioral inhibition (Carver and White, 1994).

Thus, since the psychological factors play a role in having high blood pressure and there are still research gaps regarding the relationship between the above variables and sensory processing sensitivity in our country, this research seeks to find a relationship between brain-behavioral systems and sensory processing sensitivity and hostility in hypertensive patients.

MATERIALS AND METHODS

The current applied research was cross-sectional and descriptive-correlational in its data collection.

The population of the current research is all men and women between the age range of 30 to 60 years who visited a private specialized clinic in Tabriz at an interval of two months in 2022. The size of the statistical population was equal to 245 people. The sample size was 150 people based on the Krejci and Morgan table. Sampling was done at convenience. Inclusion and exclusion criteria were observed during sampling. The inclusion criteria for entering the study include



blood pressure above 140 mm Hg (systolic) or above 90 mm Hg (diastolic), age between 30 and 60 years, having enough literacy to read and write, and the exclusion criteria for leaving the study include incomplete answers to the questionnaire, non-cooperation and defective questionnaires.

Data Collection tools

Redford-Williams Hostility Scale

Redford (1998) created this questionnaire that has 12 items. This tool evaluates the hostility and the relationship between the hostility and heart attacks. Answering this list is done on a 5-point Likert scale from never (0) to always (4). Its reported retest coefficient in a sample of 20 people was 0.82 and its internal consistency coefficient was 0.85. The content validity of this questionnaire has been confirmable by some of the psychologists and psychometric experts. The study by Shokohi Yekta et al. (2013) has confirmed the experimental validity of this test and its reliability according to Cronbach's alpha is above 0.90. The current research calculated the reliability of the questionnaire by 0.74 using Cronbach's alpha coefficient.

Aron's Highly Sensitive Person scale

Aron and Aron in 1997 created this scale to measure individuals who react more strongly to environmental stimuli. The scale has 25 questions and three dimensions: easily aroused (12 items), aesthetic sensitivity (7 items) and low sensory threshold (6 items). This test uses a 5-point Likert scale (1 (never) and 5 (always)). The confirmatory factor analysis of this scale compared to the exploratory analysis showed that the correlation coefficient of the scale *easily aroused* and *aesthetic sensitivity* is 40%, *low sensory threshold* and *aesthetic sensitivity* is 45%, and *low sensory threshold* and *easily aroused* is 73%. The reliability of this test using Cronbach's alpha for the entire scale is 89%. The validity of the entire scale and of the sub-scales of *easily aroused*, *aesthetic sensitivity* and *low sensory threshold* were reported in Iran by Cronbach's alpha coefficients as 0.85, 0.70, 0.79 and 0.75, respectively (Khanjani et al., 2019). The current research calculated the reliability of the questionnaire by 0.81 using Cronbach's alpha coefficient.

Carver-White inhibition/approach scale

Carver and White in 1994 prepared this scale that includes 24 self-report questions. The questionnaire has a design in the Likert scale with four options that receive points from 1 to 4. The BIS subscale in this questionnaire has seven items that measure the sensitivity of the behavioral inhibition system or response to threats and anxiety in confronting the signs of threats. The BAS scale includes 13 items and measures the sensitivity of the behavioral activation system. This subscale also comprises three other subscales: drive (4 items), response to reward (5 items) and seeking happiness and entertainment (4 items). The degree to which rewards lead to positive emotions is measured by response, while drive measures a person's tendency to actively pursue pleasant goals, and the pleasure-seeking subscale measures one's tendency to pursue pleasant goals, one's tendency to seek new rewards and turn to potentially rewarding events in immediate stimulation. Four additional items are proposed as cover items in the scale and do not play a role in BIS, BAS evaluation. As Carver and White (1994) report, the internal



consistency of the BIS subscale is 0.74, and the internal consistency of the three subscales of seeking entertainment, response to reward, and drive are 0.66, 0.73, and 0.76, respectively (Namdar et al., 2016). Seyed Mousavi et al. (2013) in Iran reported Cronbach's alpha for BAS by 0.87, for BIS by 0.76, and test-retest correlation of 0.91 and 0.89 for this scale. The current research calculated the reliability of the questionnaire using Cronbach's alpha coefficient by 0.78

The data, after collecting information, was entered SPSS version 24 software and analyzed.

RESULTS AND DISCUSSION

The results showed that 57.3% of the entire sample were women and 42.7% were men. 26.7% were single and 73.3% were married. As for education, 24.7% were under diploma, 0.40% diploma, 25.3% BSc and 10.0% MSc and above. The average age of the respondents was 43.44 years, the lowest value was 30 and the highest value was 60 years. The average systolic blood pressure of the respondents was 153.67, the lowest value was 144 and the highest value was 163. The average diastolic blood pressure of the respondents was 105.91, the lowest value was 92 and the highest value was 121.

Table 1. Descriptive indices of research variables

	Number	Mean	Standard deviation	Skewness	Kurtosis	Minimum	Maximum
Hostility	150	25.27	44.6	12.0	13.-0	12	45
Behavioral activation system	150	51.35	72.4	07.0	77.-0	25	45
Behavioral inhibition system	150	43.19	46.3	39.-0	71.-0	12	25
High sensory processing sensitivity	150	95.81	04.14	38.-0	13.0	35	111
Ease of stimulation	150	01.39	20.8	29.-0	24.-0	12	55
Aesthetic sensitivity	150	67.22	80.4	42.-0	12.0	9	33
Low sensory threshold	150	27.20	82.3	26.-0	62.-0	11	28

As the table (1) shows, the average hostility was 27.25, its lowest value was 12 and its highest value was 45. The average behavioral approach system was 35.51, its lowest value was 25 and its highest value was 45. The average behavioral inhibition system was 19.43, its lowest value



was 12 and its highest value was 25. The average high sensory processing sensitivity was 81.95, its lowest value was 35 and its highest value was 111. The skewness and kurtosis indices are less than 2; it shows that the variable distribution does not differ much from the normal distribution.

Table 2. Pearson's correlation test results to investigate the relationship between behavioral activation system and hostility

		Hostility
behavioral activation system	Correlation coefficient	342.-0
	Significance level	001.0
	Number	150

As the table (2) reveals, the Pearson correlation coefficient is -0.342 and the significance level of the test is 0.001. Since the significance level of Pearson's test is less than 0.05, the assumption of independence of the variables is refused. There is a significant inverse relationship between behavioral approach system and hostility in patients with hypertension.

Table 3. Results of Pearson's correlation test to investigate the relationship between behavioral inhibition system and hostility

		Hostility
behavioral inhibition system	Correlation coefficient	0.402
	Significance level	001.0
	Number	150

As the table (3) shows, the Pearson correlation coefficient is 0.402 and the significance level of the test is 0.001. Since the significance level of Pearson's test is less than 0.05, the assumption of independence of the variables is rejected. There is a significant positive relationship between behavioral inhibition system and hostility in patients with hypertension.

Table 4. Pearson's correlation test results to investigate the relationship between high sensory processing sensitivity and hostility

		High sensory processing sensitivity	Ease of stimulation	Aesthetic sensitivity	Low sensory threshold
Hostility	Correlation coefficient	564.0	657.0	468.0	074.0
	Significance level	001.0	001.0	001.0	367.0
	Number	150	150	150	150

As the table (4) shows, the Pearson correlation coefficient is 0.564 and the significance level of the test is 0.001. Since the significance level of Pearson's test is less than 0.05, the assumption of independence of the variables is rejected. There is a significant positive relationship between the



high sensory processing sensitivity and hostility in patients with hypertension. There is also a significant positive relationship between the dimensions of ease of stimulation and aesthetic sensitivity and hostility in patients with hypertension. This significant relationship does not exist between the dimension of low sensory threshold and hostility in patients with hypertension ($P < 0.05$).

Table 5. Correlation and Durbin-Watson test for the influence of inhibition system, behavioral activation system and high sensory processing sensitivity in hostility

Multiple correlation coefficient	Coefficient of determination	Adjusted coefficient of determination	Standard error of estimation	Durbin-Watson
0.664	0.44	0.429	4.867	2.174

As the table (5) shows, the multiple correlation coefficient is 0.664 and the determination coefficient is 0.44. The coefficient of determination shows the value of variance explained by the model. The numerical value of the coefficient of determination is between zero and 1. The closer this value is to one, the stronger the relationship of the model. The variables of inhibition system, behavioral approach system and high sensory processing sensitivity explain 44% of the variance of the hostility in patients with high blood pressure. Durbin-Watson value is equal to 2.17. Because this value is between 1.5 and 2.5, the criterion variable does not have autocorrelation and the errors are independent of each other.

Table 6. Significance test of the linear relationship for the effect of the inhibition system, the behavioral activation system and the high sensory processing sensitivity in hostility

	Total squares	Degree of freedom	Mean squares	F value	Sig.
Regression	238.2721	3	079.907		
Remaining	635.3458	146	689.23	291.38	0.001
Total	873.6179	149			

As the table (6) shows, the significance level of F test is equal to 0.001. Since the significance level of the F test is less than 0.05, there is a significant linear relationship between the criterion variable and the predictor variables.

Table 7. Regression coefficients for the influence of inhibition system, behavioral activation system and high sensory processing sensitivity in hostility

	Non-standardized coefficients		Standardized coefficients	T value	Sig.	Tolerance	VIF
	B	Standard error	Beta				
Constant	595.9	89.4		962.1	052.0		



Behavioral activation system	271.-0	087.0	199.-0	097.-3	002.0	933.0	072.1
Behavioral inhibition system	486.0	12.0	261.0	058.4	001.0	924.0	082.1
High sensory processing sensitivity	218.0	029.0	474.0	421.7	001.0	938.0	066.1

In conclusion, as the table (7) shows, the behavioral approach system has a significant inverse effect on the hostility of patients with hypertension ($p = 0.002$ and $\beta = -0.199$). Behavioral inhibition system ($p = 0.001$ and $\beta = 0.261$) and high sensory processing sensitivity ($p = 0.001$ and $\beta = 0.474$) have a significant positive effect on the hostility in patients with hypertension. The high sensory processing sensitivity with a standardized coefficient (β) of 0.47 has the greatest effect on the hostility in patients with hypertension. The behavioral inhibition system and the behavioral approach system get the second position, respectively.

The results showed a significant negative relationship between behavioral approach system and hostility in patients with hypertension. The result is in line with the researches of Amiri et al. (2018) and Ayoublou and Arvin (2022). This finding is explainable through Gray's theory of sensitivity to reinforcement. As this theory argues, the behavioral approach system serves positive motivational functions and causes active avoidance behaviors and approach behavior. This system responds to conditioned stimuli, reward and lack of punishment. The activity and increased sensitivity of this system causes positive emotions and active avoidance. When the approach system becomes active, a person does not experience negative emotional states in facing with events and people; rather, he will have a positive feeling and excitement towards them. A positive feeling and excitement will prevent the hostility and anger. In conclusion, we can say that there is a significant negative relationship between behavioral approach system and hostility in patients with hypertension. Jani and Hajlo (2019) showed in their research that there is a significant negative relationship between behavioral approach system and psychological symptoms. This finding explains that the behavioral approach system responds positively to pleasant unconditioned and conditioned stimuli with the behavioral approach. This pleasant motivational system responds to positive incentives by activating behavior. It also energizes and directs behavior. Putting it otherwise, it is both responsible for activating behavior for reward situations and fortunate events, and responsible for active avoidance situations where the organism must suitably respond to avoid punishment. This system makes the individual sensitive to potential rewards and motivated to seek these rewards. Therefore, the activation of this system gives to the individual a motivation to search for goals and pleasant events, and destroys the tendency and act of violence and hostility. Because these individuals have more motivations to achieve success and their goals, and they strive to surround their environment.



The result showed a significant positive relationship between behavioral inhibition system and hostility in patients with high blood pressure. It is in line with the researches of Amiri et al. (2016), Ayoublou and Arvin (2022). We can explain the result: the activity of the behavioral approach system and the inhibition of the behavioral inhibition system reflect the trait of early arousal, and sensitivity to reward that is directly associated with the behavioral approach is a sign of early arousal. As Gary believes, these brain-behavioral systems are the foundation of individual differences, and the activity of each of them leads to different emotional reactions; so there is sensitivity to conditioned stimuli of reward and lack of punishment in the behavioral approach system, and it causes positive emotions; but the behavioral inhibition system activates sensitivity to conditioned stimuli of punishment and lack of reward. Thus, the incidence of hostility is higher in individuals in whom the approach system is of lower activity and the behavioral inhibition system has more activity. Amiri et al. (2016) showed that there are significant differences between four personality groups in internalizing and externalizing problems. So the group of high inhibitory system sensitivity and low inhibitory system sensitivity had the highest anger and aggression.

Hostile individuals cannot avoid certain behaviors and give up pleasures (lack of behavioral inhibition). Gray (1987) believes that individuals with signs of antisocial behavior who also act impulsively are individuals with highly reactive inhibition systems. These individuals have a low level of behavioral inhibition. That's why they perform uninhibited behavioral reactions and react in a sensation-seeking manner. We can explain it otherwise: if the sensitivity of the behavioral brain systems is beyond the optimal and level, the person becomes hypersensitive to stimuli and symptoms that activate these systems. This sensitivity increases the arousal of emotions and starts behaviors related to those stimuli. Therefore, because the hypersensitivity of the behavioral inhibition system is associated with arousal, impulsivity and anxiety, and this system works broadly in three behavioral, nervous and cognitive levels, the ability of coping with emotions such as anger and hostility for individual is reduced or becomes impossible.

The result showed a positive and significant relationship between the sensory processing sensitivity and hostility in patients with high blood pressure. It is in line with the research of Shafii et al. (2017) and Atadokht and Majdi (2019). Individuals with high sensory processing sensitivity believe that they are easily stimulated by external stimuli, because they have a lower perceptual threshold than many others and low and deeper cognitive processing of stimuli. The sensory processing sensitivity, independent of specific sensory quality, is associated with the tendency to experience excessive arousal, high negative excitability and low emotional stability, mood, temperament and daily functions and can also be a factor for vulnerability to mental and behavioral disorders. Therefore, the sensory processing sensitivity is an important and unique part of the personality, which might be a hereditary susceptibility for all kinds of psychopathological conditions, especially its neurotic forms (Basharpour and Ghazani, 2019). The sensory processing sensitivity can stimulate the amygdala in creating or strengthening anger and hostility through sensory pathways in the brain's thalamus, and the frontal areas have an inhibitory effect on hostility at all levels. The amygdala in individuals with high anger and hostility may cut the connection between the gray matter of brain stem, where it prevents aggressive behavior; so sensory sensitivity in individuals with high blood pressure reaches a higher level, and these individuals experience high anger and hostility eruption.



CONCLUSION

The results showed a significant inverse relationship between behavioral approach system and hostility in patients with hypertension. There is a significant positive relationship between the behavioral inhibition system and high sensory processing sensitivity and hostility in patients with hypertension. The variables of the inhibitory system, the behavioral approach system and the high sensory processing sensitivity explain 44% of the variance of the hostility in patients with hypertension. The high sensory processing sensitivity has the greatest effect on the hostility in patients with hypertension.

A limitation of the research is to set aside the individuals' psychological and underlying diseases.

This research, relying on its results, suggests that paying attention to psychological components, including brain-behavioral systems and high sensory processing sensitivity in the treatment of patients with high blood pressure, can be a facilitator and be effective in the treatment process. It also suggests reducing the hostility of hypertensive patients by holding various training courses or seminars on the control of brain-behavioral systems and the high sensory processing sensitivity. So the stress and other side pressures of these patients are reducible.

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