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ORIGINAL ARTICLE

Big Five personality traits, BIS/BAS dimensions and meteoropathy: a mediation model

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BACKGROUND
The main goal of this cross-sectional study was to assess the relationship between Big Five personality traits and meteoropathy and the role of the behavioural activation system (BAS) and the behavioural inhibition system (BIS) as mediators in this relationship.

PARTICIPANTS AND PROCEDURE
The sample consisted of 1,336 women and men gathered via the online recruitment platform from the general population. The participants' ages ranged from 18 to 76 years (M = 29.52, SD = 11.67). The Polish version of the Ten Item Personality Inventory was used to assess Big Five personality traits. The BIS and BAS were diagnosed using the Polish version of the original BIS/BAS scales. Meteoropathy was assessed using the Polish adaptation of the METEO-Q questionnaire.

RESULTS
Meteoropathy correlated negatively with emotional stability and positively with the BIS level and BAS Reward Responsiveness. BIS negatively correlated with emotional stability. The correlations between meteoropathy and other personality variables were nonsignificant. The analysis indicated a significant indirect relationship between emotional stability and meteoropathy through BIS. We demonstrated the importance of neuroticism (low emotional stability) and the BIS dimension for the development of meteoropathy symptoms.

CONCLUSIONS
Neuroticism and the BIS dimension were important for the development of meteoropathy symptoms. The results may be helpful in assessing the risk of developing meteoropathy in a healthy population.

KEY WORDS
Big Five; healthy adults; BIS/BAS; meteoropathy

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BACKGROUND

Meteoropathy is a phenomenon relatively unknown in the psychology literature. Ćurić et al. (2022) used the term "meteoropathy" in relation to people whose chronic disease is exacerbated or whose health deteriorates due to sudden changes in the weather. Previously, Janiri et al. (2009) defined meteoropathy as "a group of symptoms and pathological reactions in response to gradual or sudden changes in meteorological factors in a specific area interacting, presumably, through natural electromagnetic influences covering a wide range of frequencies and amplitudes" (p. 46). In turn, Mazza et al. (2012) provided a list of common symptoms of meteoropathy, such as lability of mood, depression and anxiety, irritability, joint pains or headache, vertigo, insomnia or excessive sleepiness, alterations of cardiac rhythm, and loss of or excessive appetite, which can occur in people sensitive to weather changes.

The under-recognition of meteoropathy in psychology may be due to both the absence of a developed theoretical concept of this phenomenon and the lack of a theory on the mechanism of the impact of weather on human health. Nevertheless, there are some hypotheses concerning the relationship between weather changes and human health. For example, Freti et al. (2017) suggested that human sensitivity to weather changes, i.e., meteorosensitivity, results from the functioning of the brain's emotional regulatory mechanisms and the autonomic nervous system (ANS). According to these authors, meteorological factors, like other stressors, may contribute to the dysfunction of these mechanisms and lead to the development of disorders typical of meteoropathy. A similar hypothesis regarding the mechanism of meteoropathy was formulated by Žikić and Rabi-Žikić (2018), who suggested, as did Janiri et al. (2009), that electromagnetic waves associated with weather phenomena may affect the hypothalamus, indirectly increasing the secretion of adrenocorticotropic hormone and cortisol, and reduce the level of endorphins. Consequently, people who are psychophysically unstable and susceptible to weather changes may react with meteoropathic symptoms, such as increased anxiety or pain. The results of research based on animal models seem to confirm both hypotheses mentioned above. For example, Sato et al. (2019) found that stimulation resulting from falling atmospheric pressure induced activation of neurons in the upper vestibular nucleus (SuVe) in male and female mice. The same authors speculated that SuVe activation resulting from a drop in atmospheric pressure may be similar to meteoropathy in humans through activation of the fibres of the sympathetic nervous system or the hypothalamus. Consequently, the hypothalamic-pituitary-adrenal axis may be activated, thus leading to the development of certain meteoropathy symptoms. On the other hand, Panagopoulos et al. (2020) suggested that both animals and humans can sense the effects of electromagnetic fields, which disrupt the electrochemical balance of cells and may lead to behavioural changes. According to these authors, this mechanism may explain one meteoropathy symptom, which is the detection of incoming storms by sensitive individuals.

Benevolenza and DeRigne (2019) suggested that climate change plays a significant role in the mental health of specific populations, such as children and adolescents, those on low incomes, elderly individuals, disabled individuals, people with substance use disorders, and those who are incarcerated. According to Cianconi et al. (2020), climate change may directly affect the mental health of individuals and social groups through extreme weather phenomena such as tornadoes, storms, or floods, causing changes such as distress and clinical disorders. According to the authors, rapid changes in weather can lead to the development of anxiety and depression, sleep disturbances, substance abuse, increased violence, somatic disorders, as well as the development of symptoms of post-traumatic stress disorder and an increase in suicides.

Several studies have confirmed the relationship between weather changes and mental health in clinical groups that are predisposed to the development of meteoropathic symptoms. Di Nicola et al. (2020) found that patients with bipolar disorder (both BD-I and BD-II), including those with a history of suicide attempts, were characterized by a higher level of meteorosensitivity and meteoropathy when compared to a group of healthy control subjects. The number of suicide attempts in this clinical group was correlated with the mental and physical symptoms caused by weather changes. Brazienė et al. (2022) detected the influence of weather factors such as the daily air temperature, wind speed, atmospheric pressure, and relative humidity on depression levels in a sample from the general population. In yet another study, Vencloviene et al. (2023) observed that both increases and decreases in diurnal atmospheric pressure were associated with a higher level of depression in patients after coronary artery bypass grafting or valve surgery. Lickiewicz et al. (2020) reported that a drop in atmospheric pressure and a rise in wind speed increased aggressive behaviour in patients, while the positive correlation of aggressive behaviour with temperature and negative correlation with humidity were weak but statistically significant.

In pain research, Fagerlund et al. (2019) found that low atmospheric pressure was associated with increased pain in patients with fibromyalgia. Bando (2021) reported the association of low atmospheric pressure with migraine pain. In another study, Lee et al. (2018) detected associations of high temperature and humidity with joint pain, and high temperature

with headaches. It is worth noting that the results of studies pointing to the association of low atmospheric pressure with, for example, pain intensity, depression, and aggressive behaviour seem to confirm the hypothesis of Sato et al. (2019) concerning the role of reduced atmospheric pressure in a potential meteoropathy mechanism.

Considering the phenomenon of individual differences, there is compelling evidence to explain the meteoropathy symptoms by referring to personality differences. Unfortunately, few studies have addressed the relationship between personality and meteoropathy. For example, Rzeszutek et al. (2020), based on latent profile analysis, found that young adults with low emotional stability (i.e., high levels of neuroticism) and average levels of the remaining Big Five personality traits (extraversion, openness to experience, agreeableness, and conscientiousness) had significantly higher levels of meteoropathy compared to those with all average Big 5 trait levels. This result is consistent with the suggested relationship between high neuroticism level and seasonality of mood and affect (Ogińska & Ogińska-Bruchal, 2014; Winthorst et al., 2020). However, according to Denissen et al. (2008), the importance of neuroticism for weather sensitivity may not be so obvious because people may have different levels of sensitivity to weather regardless of their personality traits. Consequently, we can theorize that weather sensitivity may be a biological property of any human or animal organism, as suggested by the hypotheses about the biological foundations of meteoropathy. Against this background, neuroticism (i.e., low emotional stability) may highlight differences in biological sensitivity to weather as well as in meteoropathy. As Lionetti et al. (2019) reported, neuroticism is associated with a basic trait related to individual differences in sensitivity to internal and external stimuli, including physical, social, and emotional stimuli (the so-called Sensory Processing Sensitivity trait). So, we can assume that the low level of emotional stability associated with greater activation in the autonomic nervous system may be directly associated with meteoropathy development. We also posit that low levels of emotional stability can indirectly influence meteoropathy via the behavioural inhibition system/behavioural activation system (BIS/BAS) dimensions, wherein the BIS mechanism is of particular interest to us.

According to the original version of Gray's (1982) reinforcement sensitivity theory (RST), personality includes two basic, separate, brain-motivational systems detecting and responding to aversive signals: the behavioural inhibition system (BIS) and the behavioural activation system (BAS), which are activated by conditioned appetite stimuli (i.e., reward stimuli). According to Carver and White (1994), the BAS is associated with the search for anticipated rewards (BAS Reward Responsiveness), the achievement of goals (BAS Drive), and the desire for new stimuli (BAS Fun Seeking).

RST provides a good reference to the personality-psychopathology association (Bijttebier et al., 2009; Harnett et al., 2013). For example, Taban et al. (2013) reported that people with high BIS levels showed more negative emotions in stressful situations and responded to them with higher diastolic blood pressure and heart rate compared to people with high BAS levels. In another study, Turner et al. (2021) identified the relationship of BIS/BAS and especially the BIS dimension with pain. High BIS levels were also associated with anxiety and depression (Katz et al., 2020) and this relationship had a genetic basis (Takahashi et al., 2021). Previously, Heponiemi et al. (2003) observed the relationship of BIS sensitivity with a human predisposition to emotional stress along with its somatic consequences. According to Kennis et al. (2013), BIS activation was associated with neuroticism and anxiety traits, while BAS activation was associated with extraversion, novelty-seeking, reward addiction, and openness to experience. Caseras et al. (2003) also found a strong positive correlation between neuroticism and BIS level. The results suggested that the BIS dimension may be directly related to changes typical of meteoropathy and at the same time act as a mediator between emotional stability and meteoropathy. There is an open question about the role of the other Big Five features and the BAS mechanism in the formation of meteoropathy.

THE CURRENT STUDY

The main goal of our cross-sectional study was to determine the direct relationship between Big Five personality traits and meteoropathy. We also intended to explore whether the BIS/BAS dimensions could serve as mediators between Big Five personality traits and meteoropathy. Based on the available data, we expected that emotional stability as the inverse of neuroticism would negatively correlate with symptoms of meteoropathy. Neuroticism is a well-known personality dimension related to mental and physical health (Jeronimus et al., 2016; Widiger & Oltmanns, 2017; Zhang et al., 2021). Rzeszutek et al. (2020) documented the relationship between emotional stability and symptoms of meteoropathy in a group of young adults. We also expected that the BIS dimension would mediate the relationship between emotional stability and meteoropathy, negatively correlating with emotional stability and positively with meteoropathy. As Aubi et al. (2011) found, BIS positively correlated with depression anxiety, and stress. All these symptoms frequently accompany meteoropathy.

PARTICIPANTS AND PROCEDURE

PARTICIPANTS

The present study included 1,336 participants (25.2% males) aged 18 to 76 years (M = 29.52, SD = 11.67). All participants were recruited via an online social network platform from the general population. In terms of education levels, 664 participants had received higher education, 541 participants secondary education and 131 participants primary education. Seven hundred and fifty-three participants were single, 555 married or partnered and 28 divorced. Two hundred and sixty-three participants lived in the countryside, 348 in small or medium-sized towns and 725 in large cities.

PROCEDURE

Preliminary information about the study aims and conditions was available to potential participants online. The only inclusion criterion for the study was that participants be age 18 or older. Participation in the study was completely voluntary and anonymous, and any participant could opt out of the study at any time without giving a reason. Participants were in no way remunerated for participating in the study. Participants gave informed consent to participate in the study via an online questionnaire. The research procedure and questionnaires used in the study were fully compliant with ethical principles for human research and were approved by the Research Ethics Committee at the University of Warsaw (ref: 02-11-2022).

MEASURES

Big Five personality traits were diagnosed via the Polish adaptation of the Ten Item Personality Inventory (TIPI; Gosling et al., 2003; Sorokowska et al., 2014). The TIPI consists of 10 items and each item is assessed on a 7-point scale that ranges from 1 (*strongly disagree*) to 7 (*strongly agree*). Cronbach's α values for the current study are in parentheses: emotional stability (α = .72), extraversion (α = .68), openness to experience (α = .21), agreeableness (α = .50), and conscientiousness (α = .70).

The BIS and BAS were assessed using the Polish version of the original BIS/BAS scales (Carver & White, 1994; Müller & Wytykowska, 2005). We used the original BIS/BAS scales to diagnose the BAS subscales. The BIS/BAS scales consisted of a 20-item questionnaire with four subscales measured by a four-point response scale ranging from 1 (*very true for me*) to 4 (*very false for me*). Cronbach's α coefficients for the current sample are in parentheses: BIS (α = .84), BAS Drive (α = .70), BAS Fun Seeking (α = .59), and BAS Reward Responsiveness (α = .74). The three BAS subscales were combined to calculate the BAS Total Scale. In the current study internal reliability (Cronbach's α) of the BAS Total scale was .76.

Meteoropathy. To diagnose meteoropathy, the Polish adaptation of the METEO-Q questionnaire (Mazza et al., 2012; Polish adaptation Włodzimierz Oniszczenko) was used. METEO-Q consists of 11 items that measure meteorosensitivity (5 items) and meteoropathy (6 items) as well as a structured checklist to identify the 21 physical and psychological symptoms related to climate change. All items are rated on a 4-point Likert response scale ranging from 0 (*absent*) to 3 (*severe*). The Cronbach's α for the meteoropathy scale in the current sample was .81. Since we were interested in changes in health status accompanying weather changes, only the meteoropathy scale was analysed in our study.

STATISTICAL ANALYSIS

All statistical computations were performed using IBM's SPSS 27 Statistics software. Correlation analysis was performed using Pearson's product-moment correlation coefficients. Multivariate hierarchical regression analysis was used to estimate Big Five personality traits and BIS/BAS as predictors of meteoropathy level. The PROCESS macro for SPSS version 3.5 (Model 4) was applied for the mediation analysis (Hayes, 2018). The bootstrapping procedure (5,000 sample draws, 95% confidence intervals) was used to estimate the direct and indirect effects.

RESULTS

Table 1 presents Pearson's r correlation coefficients and descriptive statistics for the studied variables. Meteoropathy correlated negatively with emotional stability and positively with the BIS level and BAS Reward Responsiveness. BIS negatively correlated with emotional stability. The correlations between meteoropathy and other personality variables were nonsignificant.

The results of multivariate hierarchical regression analysis showed that both emotional stability and BIS were good predictors of meteoropathy. Together, emotional stability and BIS accounted for only 5% of the meteoropathy variance. The model was not burdened with the problem of collinearity (VIF, variance inflation factor values were between 1.0 and 1.3). The results are summarized in Table 2.

To test the indirect relationship between emotional stability and meteoropathy via the BIS dimension, a mediation analysis was performed. The analysis indicated a significant indirect relationship between emotional stability and meteoropathy through BIS

Table 1

Pearson's r correlations, means, and standard deviations for the study variables

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Emotional stability	–										
2. Extraversion	.42***	–									
3. Openness	.05*	.36***	–								
4. Agreeableness	.18***	.22***	.09***	–							
5. Conscientiousness	.13***	.23***	.03	.23***	–						
6. BIS	−.45***	−.19***	−.07**	.01	.03	–					
7. BAS Total Scale	.04	.21***	.20***	−.10***	.05*	.14***	–				
8. BAS Drive	.10***	.11***	.09***	−.14***	.09**	−.22***	.68***	–			
9. BAS Fun Seeking	.02	.19***	.27***	−.09***	−.13***	−.02	.75***	.34***	–		
10. BAS Reward Responsiveness	−.03	.16***	.09***	−.01	.14***	.47***	.75***	.21***	.35***	–	
11. Meteoropathy	−.21***	−.01	.03	−.02	.04	.16***	.04	−.03	.03	.07*	–
M	7.18	9.46	9.40	10.25	9.94	21.47	36.40	9.98	10.69	15.73	7.28
SD	3.49	3.26	2.43	2.59	3.15	4.67	5.84	2.51	2.46	3.02	3.92

Note. N = 1,336. BIS – behavioural inhibition system; BAS – behavioural activation system; $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 2

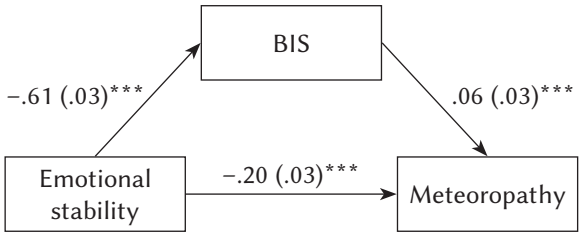
Multivariate hierarchical regression analysis of emotional stability and BIS as predictors of meteoropathy in the study sample with variance inflation factor (VIF) and tolerance

Variable	*B*	*SE*	β	R^2 adjusted	VIF	Tolerance
Step 1				.04		
Emotional stability	−.24	.03	−.21***		1.00	1.00
Step 2				.05		
Emotional stability	−.20	.03	−.18***		1.26	.79
BIS	.06	.02	.07*		1.26	.79
ΔR^2				.01		

Note. N = 1,336. BIS – behavioural inhibition system; $^{*}p < .05$, $^{***}p < .001$.

Figure 1

Mediating effect of BIS in relationship between emotional stability and meteoropathy in studied sample



Note. Unstandardised coefficients are reported, with standard errors in parentheses; BIS – behavioural inhibition system; $^{***}p < .001$.

(effect = −.04, *SE* = .02, 95% CI [−.07; −.01]). The individual pathways in the mediation analysis are displayed in Figure 1.

DISCUSSION

As expected, the results of our study confirmed the negative relationship of emotional stability with meteoropathy and the positive relationship of the BIS dimension with meteoropathy. Reward Responsiveness, as a component of BAS, also showed a significant relationship with meteoropathy. However, it should be noted that the absolute value of the Reward Responsiveness correlation coefficient with meteoropathy was less than .10, which suggests a minimal relationship, or no relationship at all. The other components of the BAS were not related to meteoropathy. These results seem logical because BAS traits, unlike those of BIS, tend to be associated with adaptive psychological functioning and therefore they are not conducive to the development of psychopathology symptoms (Taubitz et al., 2015).

The results of our study indicate that a low level of emotional stability (neuroticism) as a personality trait was associated with a high level of meteoropathy, understood as a set of symptoms of a new disease or exacerbation of symptoms of an existing disease in people sensitive to weather changes related to temperature, atmospheric pressure, humidity, or brightness of the environment (Mazza et al., 2012). Neuroticism may be a factor predisposing to the development of meteoropathy both in the healthy population and among people with mental health disorders or people suffering from somatic diseases. This feature is associated with sensitivity to internal and external stimulation as well as negative emotions (Lionetti et al., 2019). Widiger and Oltmanns (2017) emphasized that neuroticism is a disposition to experience anger, anxiety, irritability, emotional instability, and depression. A high level of neuroticism is related to the tendency to react negatively to environmental stressors, including weather or climate changes, and to evaluate ordinary situations as threatening or even overwhelmingSome authors have suggested that people with high levels of anxiety and depression are most susceptible to developing symptoms of meteoropathy (Janiri et al., 2009). Jeronimus et al. (2016) noted the significant and long-term importance of neuroticism as a risk factor for common mental disorders, including anxiety and depression. As several studies have shown, neuroticism is also associated with many other disorders that may manifest or worsen in response to changes in the weather such as arthritis (Goodwin et al., 2006), weakness/fatigue, gastrointestinal symptoms, cardiac symptoms, and musculoskeletal pain (Vassend et al., 2012) and insomnia (Zhang et al., 2021). The present results confirm the importance of neuroticism as a predictor of human mental and somatic health. Neuroticism may also contribute to both the development of sensitivity to weather stressors and pathological responses to these stressors, as demonstrated in our study.

Neuroticism may also be related to meteoropathy indirectly. Our study confirmed that the BIS dimension may serve as a mediator of the relationship

between neuroticism and meteoropathy. The BIS dimension is associated with some mental health disorders that manifest themselves in meteoropathy such as emotional stress along with its somatic consequences (Heponiemi et al., 2003), anxiety and depression (Katz et al., 2020), and pain Turner et al., 2021). Oniszczenko et al. (2018) found that BIS positively correlated with symptoms of mental health disorders, which included somatic symptoms, anxiety/insomnia, social dysfunction, and severe depression in patients with neurological diseases such as Parkinson's disease, multiple sclerosis, and stroke.

Our results suggest that neuroticism and the BIS dimension are related to meteoropathy, especially with some of its symptoms, such as anxiety, depression, and insomnia. Neuroticism is a personality trait associated with a tendency to worry and react with fear and create a negative mood. The BIS dimension, on the other hand, is a physiological mechanism for controlling behaviour in situations related to threatening events through negative emotions, such as anxiety or fear (Gray, 1982). Neuroticism and the BIS dimension are related through the hippocampus, suggesting a common influence of this brain structure on anxiety induced by both neuroticism and the BIS dimension (Levita et al., 2014; Servaas et al., 2013). We therefore inferred that both neuroticism and BIS may contribute to changes in the mental and somatic health of people with and without health problems in response to environmental stressors related to weather changes.

Our study had several limitations. The study was cross-sectional, and its design did not allow for the assessment of cause-and-effect relationships or the dynamics of change over time. We also did not measure the impact of real weather conditions on the well-being of study participants. We did not control for many important factors associated with meteoropathy, other than personality traits postulated in the Big 5 model and BIS/BAS dimensions. Finally, meteoropathy was diagnosed using a self-report inventory, the results of which may be subject to measurement error. It should also be noted that the lower confidence interval in the mediation analysis is close to zero, which may suggest a false positive effect. For this reason, our results should be verified in future studies.

CONCLUSIONS

Despite these limitations, our study demonstrated in a large, healthy sample the importance of neuroticism and the BIS dimension for the development of meteoropathy symptoms. These results expand the knowledge base about the functional significance of neuroticism and the BIS dimension. This relationship may be helpful in assessing the risk of meteoropathy developing in healthy people.

Disclosures

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The study was approved by the Research Ethics Committee of the University of Warsaw (Approval No. 02-11-2022).
The author declares no conflict of interest.

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