Does temperature or sunshine mediate the effect of latitude on affective temperaments? A study of 5 regions in Japan

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Abstract

Background: Previously, we compared the hyperthymic scores of residents in Sapporo, Koshigaya, and Oita (which are located at latitudes of 43˚N, 36˚N, and 33˚N in Japan, respectively) using the Temperament Evaluation of Memphis, Pisa, Paris and San Diego-auto questionnaire version (TEMPS-A). We found that residents who lived at lower latitudes had higher hyperthymic temperament scores; however, the mechanism of the effect of latitude on hyperthymic temperament remained unclear. The current study examined the mediators of the latitude effect in additional regions with different annual temperatures and amounts of ambient sunshine.

Methods: The Japanese archipelago stretches over 4000 km from north to south and has four large islands: Hokkaido, Honshu, Shikoku, and Kyushu. In addition to the TEMPS-A previously reported data collected at Sapporo (latitude 43˚N), Koshigaya (36˚N), and Oita (33˚N), we collected the TEMPS-A data of 189 and 106 residents from Takaoka (36˚N) and Obihiro (42˚N), respectively. Taken together, these five regions have different patterns (i.e., highs and lows) of annual ambient total sunshine (hours) and mean temperature (˚C). The effect of latitude, sunshine, and temperature on affective temperaments was analyzed for five Japanese regions.

Results: Multiple regression analyses revealed that latitude predicted significant variance in hyperthymic temperament. Ambient temperature, but not sunshine, significantly affected hyperthymic temperament.

Limitations: The light exposure that residents actually received was not measured. The number of regions studied was limited. The findings might not generalize to residents across Japan or other countries.

Conclusions: The present findings suggest that latitude affects hyperthymic temperament, and ambient temperature might mediate this effect.

Key words: latitude, temperature, sunshine, hyperthymic temperament

1. Introduction

People with hyperthymic temperaments display extroversion, a high energy level, emotional intensity and little need for sleep; furthermore, this temperament is an adaptive and desirable condition outside of the boundaries of mood disorders (Rovai et al., 2013). Conversely, four additional affective temperaments, cyclothymic, depressive, irritable and anxious (Akiskal et al., 2005), are more closely related to mood, anxiety and substance use disorders. Moreover, they imply difficulties in adapting emotionally and behaviorally to somatic diseases and life stressors (Rovai et al., 2013). A gap between the hyperthymic temperament and other four is associated with stress vulnerability and experiences of childhood abuse (Nakai et al., 2014; Rovai et al., 2013; Sakai et al., 2005). However, other factors that explain this gap have not been well clarified.

Within the series of our studies, Kohno et al. reported that latitude has a significant effect on the hyperthymic temperament (but not other four) among residents living in two regions (Kohno et al., 2012). Lower and higher latitudes are associated with higher and lower hyperthymic temperament scores, respectively. This interesting “latitude effect” on affective temperaments was recently confirmed by our subsequent extension study of three regions with different latitudes that indicated a dose-response relationship between hyperthymic temperament and sunshine and latitude (Kohno et al., 2014) (our unpublished data). Hoaki et al. (2011) reported that more hyperthymic participants receive more light. In addition, more hyperthymic participants prefer brightness and dislike darkness compared with less hyperthymic participants, suggesting the presence of heliotropism (Harada et al., 2013). These findings suggest that the sunshine mediates the positive effect of latitude on the hyperthymic temperament. However, another possibility should be considered: Because latitude is generally correlated with ambient temperature in Japan (despite certain exceptions), temperature might mediate the effect of latitude on the hyperthymic temperament.

To determine which factor, sunshine or ambient temperature, mediates the effect of latitude

on the hyperthymic temperament, it is useful to examine the hyperthymic temperament scores of residents living in regions with various combinations of higher or lower temperatures and more or less sunshine. The present study used multiple regression analyses to investigate affective temperaments (including the hyperthymic temperament) across five regions with various combinations of ambient temperament and sunshine (see Fig. 1).

2. Subjects and methods

2.1. Subjects

Totals of 189 and 106 medical personnel from Kouseiren Takaoka Hospital in Takaoka and National Hospital Organization Obihiro Hospital in Obihiro, respectively, volunteered for the present study. Their data were combined with those of 94 medical students and personnel from Hokkaido University in Sapporo, 95 medical students and personnel from Oita University in Oita, and 125 medical students and personnel from Juntendo Koshigaya Hospital in Koshigaya (Kohno et al., 2014). The data of these 609 participants were collected, and their mean age was 33.4 years ± 9.1 (SD). There were 270 males and 339 females. All participants were screened for present and past psychiatric disorders, and no participants suffered from psychiatric disorders. Their demographic data are shown in Table 1. Written informed consent was obtained from all participants, and the 3 universities and 2 hospital ethical committees approved the study.

Japan has 4 large islands that extend north to south: Hokkaido, Honshu, Shikoku, and Kyushu. The northernmost island, Hokkaido, and its cities Sapporo and Obihiro are located at latitude of 43˚N and 42˚N respectively, whereas Oita of the southern island Kyushu is at 33˚N. Honshu, whose cities Koshigaya and Takaoka are located at 36˚N, is located between Hokkaido and Kyusyu. When three cities, Sapporo, Koshigaya, and Oita, were compared in our previous study (Kohno et al., 2014) (our unpublished data), lower latitudes were associated with higher

temperatures and more sunshine; however, it was impossible to analyze the effect of sunshine and temperature as the predictors of hyperthymic temperament scores because sunshine and temperature are strongly correlated with each other (r=0.95), thereby causing multicollinearity. To avoid this problem in the current study, 2 regions with different sunshine and temperature data (Obihiro and Takaoka) were added so that sunshine and temperature would be weakly correlated across the 5 regions of this study.

2.2. Temperament assessment

The participants completed the Japanese version of the Temperament Evaluation of Memphis, Pisa, Paris and San Diego-auto questionnaire (TEMPS-A). This 110-item true-false questionnaire measures the following temperament dimensions: depressive, cyclothymic, hyperthymic, irritable and anxious (Akiskal et al., 2005; Matsumoto et al., 2005). TEMPS-A was translated into Japanese, and the reliability and validity of the Japanese version have been established (Akiyama et al., 2005; Kawamura et al., 2010; Matsumoto et al., 2005).

2.3. Illuminance and temperature

The mean annual total sunshine (in hours) was used as the illuminance parameter for Sapporo, Obihiro, Koshigaya, Takaoka, and Oita. The mean annual ambient temperatures of the 5 regions from 1993 to 2012 were denoted "temperature".

2.4. Data analysis

First, participant age, sunshine, and TEMPS-A scores were compared across Sapporo, Obihiro, Koshigaya, Takaoka, and Oita using a one-way analysis of variance (ANOVA). Post-hoc analyses

were performed using Fisher's protected least significant difference (PLSD) test. The gender ratio was compared among the 5 cities using the Kruskal-Wallis test followed by the Steel-Dwaas test. Second, Pearson's correlation coefficients were used to examine the relationships among the 5 temperament scores, age, gender, temperature, sunshine, and latitude. Finally, a multiple regression analysis was used to identify the variables associated with hyperthymic scores based on TEMPS-A. Finally, multicollinearity was investigated.

3. Results

3.1. Age, gender, latitude, sunshine, and temperature

As Table 1 shows, significant differences were observed with regard to age and the gender ratio among the participants of the 5 regions. Obihiro and Oita had significantly more mean annual total sunshine than Sapporo, Koshigaya, and Takaoka, and Koshigaya had significantly more sunshine than Sapporo and Takaoka. Based on mean annual ambient temperature, the warmest to coldest cities were Oita, Koshigaya, Takaoka, Sapporo, and Obihiro. The relationship between mean annual total sunshine and mean ambient temperature is illustrated in Fig. 1. Obihiro had more sunshine than Sapporo even though Obihiro and Sapporo are located at almost the same latitude and had similar mean annual ambient temperatures. Takaoka had less sunshine than Koshigaya even though Takaoka and Koshigaya are located at the same latitude and had similar mean annual ambient temperatures.

3.2. Correlations among age, gender, the 5 temperaments, sunshine, temperature, and latitude

As Table 2 shows, several significant associations were observed among the affective temperaments. Moreover, depressive, cyclothymic and hyperthymic temperament scores were significantly and

negatively associated with latitude. Latitude was strongly and negatively associated with temperature but not with sunshine when comparing the 5 regions investigated in this study; however, temperature and sunshine were significantly and negatively associated with each other. Temperature, but not sunshine, was positively associated with cyclothymic and hyperthymic temperament scores.

3.3. Multiple regression analyses

Table 3 shows the results of the multiple regression analyses where individual temperament score was the dependent variable and the other 4 temperament scores, age, gender (female=1, male=2), and latitude were independent variables. Only the hyperthymic temperament scores among the 5 affective temperaments were significantly and negatively independently associated with latitude.

When both sunshine and temperature were included as the independent variables in place of latitude in a multiple regression analysis, hyperthymic temperament scores were significantly and positively associated with cyclothymic and irritable temperament scores, age, gender, and ambient temperature as well as significantly and negatively independently associated with depressive and anxious temperament scores (Table 4). According to these datasets, hyperthymic temperament scores were not significantly associated with sunshine.

Multicollinearity was not found in these multiple regression analyses.

4. Discussion

The major findings of the present study are that latitude predicted significant variance in hyperthymic temperament via multiple regression analyses. Participants who live in regions at lower latitudes showed higher hyperthymic temperament scores. This finding confirmed the results of our previous study that compared the hyperthymic temperament scores of residents from 2 regions in Japan suggesting that lower latitude induces a hyperthymic temperament (Kohno et al.,

2012). Of the two possible mediators of the effect of latitude on hyperthymic temperament scores (sunshine and temperature), temperature predicted significant variance in hyperthymic temperaments of the participants of this study. Thus, this study extends our previous findings and suggests a possible mechanism of the latitude effect on hyperthymic temperament.

To the best of our knowledge, no prior study has found an association between ambient temperature and hyperthymic temperament. Interestingly, Gonda et al. found significant differences among 6 cultural and national samples with regard to the hyperthymic temperament (Gonda et al., 2011): The frequencies of participants with dominant hyperthymic temperament from high to low lived in Portugal (3.3%), Hungary (3.0%), Korea (2.8%), Germany (2.1%), Argentina (0.2%), and Lebanon (0%). These international differences suggest that uncertainty avoidance is involved in the hyperthymic temperament. However, this study did not examine the associations of other geographical factors (Gonda et al., 2011). Although lower hyperthymic temperaments tended to be associated with lower latitudes in their study (unlike the current study), factors such as culture, gender and age might also affect this tendency. Comparisons of hyperthymic temperaments within the same ethnic group among regions with a wider range of latitudes will be necessary for future studies.

Although the current study found a negative relationship between sunshine and hyperthymic temperament, our previous study suggested the presence of a dose-dependent effect of light (ambient sunshine) and latitude on hyperthymic temperament among residents of 3 regions at different latitudes (Kohno et al., 2014) (our unpublished data). Different datasets might account for this discrepancy regarding the role of sunshine between our present and previous studies. On the other hand, the low ambient temperatures in Sapporo and Obihiro might preclude residents from going outside and receiving sunshine, especially during cold winters. Thus, the light exposure that residents actually receive (rather than ambient sunshine) should be measured in a study of the effect of light on hyperthymic temperament in future studies, representing a limitation of the current study. This study cannot deny the possibility that illuminance affects the hyperthymic temperament.

Ambient light exposure is most likely associated with mood, mood disorder, or both (reference citation in Kohno et al., 2014). More importantly, Hoaki et al. (2011) reported that the greater illuminance of daytime independently predicted higher hyperthymic temperament scores via a multiple regression analysis. That study measured the illuminance that each participant received using actigraphy.

Another limitation is the limited number of regions studied: Our findings might not generalize to participants across Japan or other countries.

In conclusion, the present findings suggest that latitude affects the hyperthymic temperament, and ambient temperature might mediate this effect.

Conflict of Interest

All authors declare that they have no conflicts of interest that are relevant to the subject of this article.

Contributors

Dr. Terao and Dr. Inoue designed the study, wrote the protocol and analyzed data. All other authors collected data, checked the protocol and discussion. All authors contributed to and have approved the final manuscript.

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Figure legend

Fig. 1. The relationship between the annual means of total sunshine and ambient temperature for the 5 regions

Figure 1

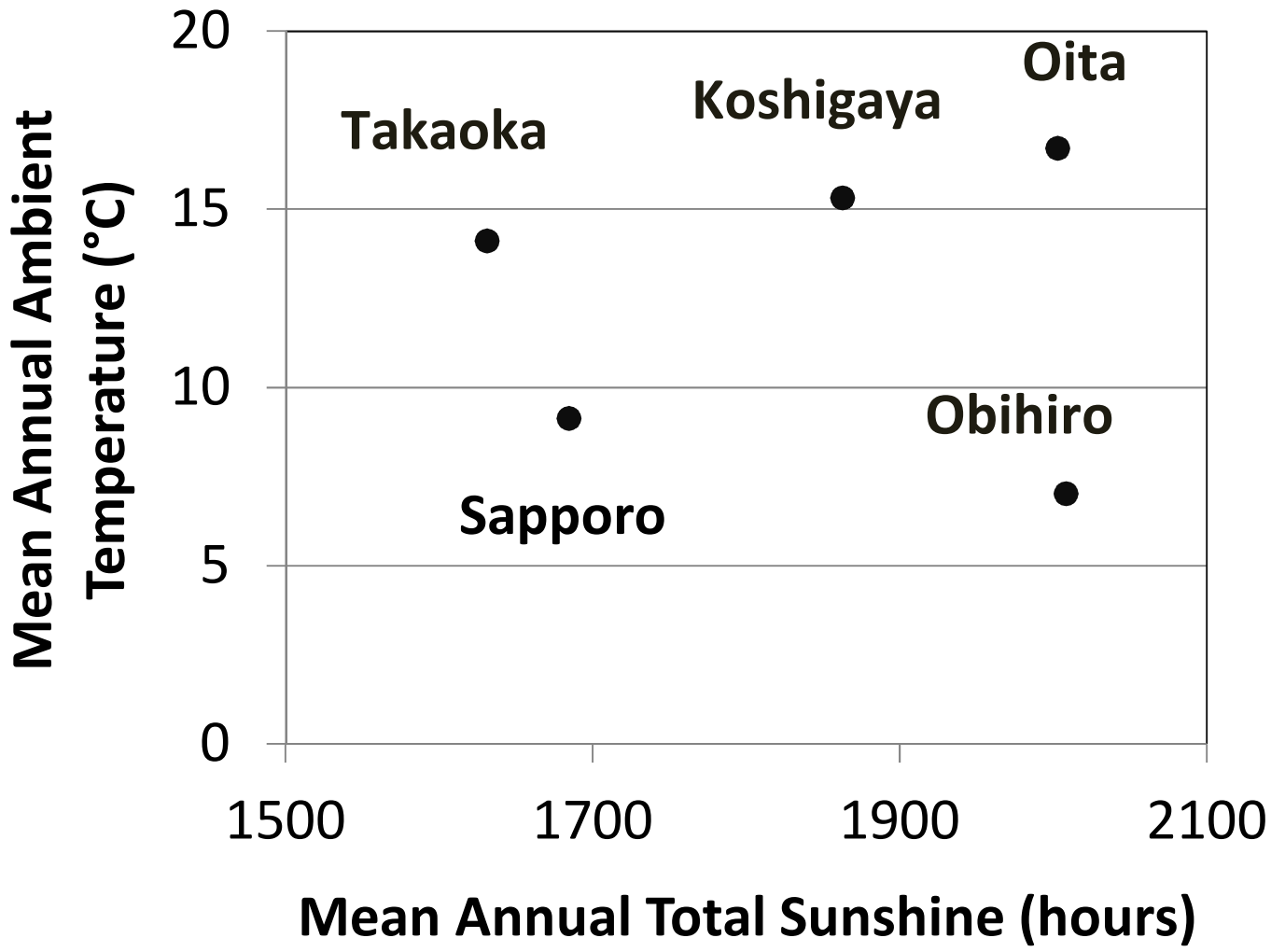
20
15
10
5
0
1500
1700
1900
2100
Mean Annual Ambient Temperature (°C)
Mean Annual Total Sunshine (hours)
Takaoka
Koshigaya
Oita
Sapporo
Obihiro

Table 1. Participant demographics and the annual means of climatic variables from 1993 to 2012 for Sapporo, Obihiro, Koshigaya, Takaoka, and Oita

Variables	Sapporo (a)	Obihiro (b)	Koshigaya (c)	Takaoka (d)	Oita (e)	F (ANOVA) or H (Kruskal-Wallis) value	# Post-hoc comparison
N	94	106	125	189	95		
Age	29.4 ± 4.9	32.6 ± 7.4	36.6 ± 9.4	37.1 ± 9.9	26.8 ± 5.8	35.9 (F)***	*a vs e **a vs b, c, d; b vs c, d, e; c vs e; d vs e
Gender (M/F)	66/28	48/58	42/83	47/142	67/28	86.7 (H)***	**a vs b, c, d; b vs d, e; c vs e; d vs e
TEMPS-A scores							
Depressive	5.8 ± 3.4	7.3 ± 3.2	7.3 ± 3.1	7.9 ± 3.8	6.8 ± 3.2	6.3 (F)***	**a vs b, c, d; d vs e
Cyclothymic	3.3 ± 3.8	3.9 ± 3.6	3.8 ± 3.1	5.0 ± 3.9	4.4 ± 3.5	4.0 (F)**	*a vs e; b vs d **a vs d; c vs d
Hyperthymic	3.8 ± 3.2	3.5 ± 2.8	3.8 ± 2.9	4.3 ± 3.5	5.0 ± 3.9	3.2 (F)*	*a vs e; **b vs e; c vs e
Irritable	2.7 ± 3.7	2.7 ± 2.9	2.3 ± 2.4	3.1 ± 3.3	3.0 ± 3.0	1.6 (F)	
Anxious	3.9 ± 4.2	4.7 ± 4.4	4.8 ± 3.8	5.2 ± 4.6	4.5 ± 3.7	1.5 (F)	
Latitude	43˚N	42˚N	36˚N	36˚N	33˚N		
Sunshine (h)	1684.6 ± 98.4	2008.4 ± 104.5	1862.9 ± 189.9	1631.3 ± 121.3	2002.9 ± 127.9	35.1 (F)***	**a vs b, c, e; b vs c, d; c vs d, e; d vs e
Temperature (ºC)	9.1 ± 0.4	7.0 ± 0.5	15.3 ± 0.5	14.1 ± 0.5	16.7 ± 0.5	1527 (F)***	**a vs b, c, d, e; b vs c, d, e; c vs d, e; d vs e

Mean ± SD

Fisher's PLSD test after ANOVA or Steel-Dwaas test after the Kruskal-Wallis test among Sapporo (a), Obihiro (b), Koshigaya (c), Takaoka (d), and Oita (e)

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Table 2. Pearson's correlations among age, gender, the 5 temperaments, sunshine, temperature, and latitude for 609 participants

	Age	Gender	Dep	Cyc	Hyp	Irr	Anx	Sunshine	Temperature	Latitude
Age	1	– 0.09	0.09*	– 0.09*	0.06	– 0.04	0.03	– 0.22***	0.07	– 0.07
Gender		1	– 0.10*	– 0.08*	0.08*	0.01	– 0.04	0.16***	– 0.08	0.10*
Dep			1	0.42***	– 0.07	0.39***	0.54***	– 0.04	0.07	– 0.10*
Cyc				1	0.24***	0.63***	0.57***	– 0.06	0.08*	– 0.10**
Hyp					1	0.23***	0.04	0.00	0.10*	– 0.11**
Irr						1	0.57***	– 0.03	0.02	– 0.03
Anx							1	– 0.02	0.04	– 0.05
Sunshine								1	– 0.10*	– 0.03
Temperature									1	– 0.97***
Latitude										1

Dep: depressive temperament, Cyc: cyclothymic temperament, Hyp: hyperthymic temperament, Irr: irritable temperament, Anx: anxious temperament, Gender: female=1, male=2

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Table 3. Multiple regression analysis using the 5 affective temperaments for 609 participants

	Dependent variable				
Independent variable	Dep	Cyc	Hyp	Irr	Anx
Dep	n.t.	0.14***	– 0.21***	0.08*	0.29***
Cyc	0.19***	n.t.	0.29***	0.13***	– 0.09**
Hyp	– 0.16***	0.17***	n.t.	0.40***	0.29***
Irr	0.10*	0.38***	0.21***	n.t.	0.29***
Anx	0.37***	0.27***	– 0.14**	0.30***	n.t.
Age	0.10**	– 0.12***	0.12**	– 0.01	0.05
Gender	– 0.04	– 0.08**	0.10**	0.05	0.03
Latitude	– 0.06	– 0.05	– 0.11**	0.04	0.005
ANOVA	F=45.9***	F=92.2***	F=16.1***	F=80.0***	F=81.3***
R^2 (adjusted R^2)	0.35 (0.34)	0.52 (0.51)	0.16 (0.15)	0.48 (0.48)	0.49 (0.48)

Beta values (standardized partial regression coefficients) are presented except in cases of F values and R^2 (adjusted R^2).

Dep: depressive temperament, Cyc: cyclothymic temperament, Hyp: hyperthymic temperament, Irr: irritable temperament, Anx: anxious temperament, Gender: female=1, male=2, n.t.: not tested

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Table 4. Multiple regression analysis of hyperthymic temperament scores for 609 participants

Independent variable	Beta	*p*
Depressive temperament	-0.21	<0.0001
Cyclothymic temperament	0.29	<0.0001
Irritable temperament	0.21	<0.0001
Anxious temperament	-0.15	0.005
Age	0.13	0.001
Gender (female=1, male=2)	0.09	0.018
Sunshine (h)	0.04	0.37
Temperature (ºC)	0.10	0.01
ANOVA	F=13.9	<0.0001
R^2 (adjusted R^2)	0.16 (0.15)	

Beta values (standardized partial regression coefficients) are presented except in cases of F values and R^2 (adjusted R^2).