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Research paper

Re-analysis of the association of temperature or sunshine with hyperthymic temperament using lithium levels of drinking water

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ABSTRACT

Background: The Japanese archipelago stretches over 4000 km from north to south and has four large islands: Hokkaido, Honshu, Shikoku, and Kyushu. Previously, using the Temperament Evaluation of Memphis, Pisa, Paris and San Diego-auto questionnaire version (TEMPS-A), we compared the hyperthymic scores of residents in Sapporo, Obihiro, Takaoka, Koshigaya, and Oita cities (which are located at latitudes of 43°N, 42°N, 36°N, 36°N and 33°N with various combinations of ambient temperament and sunshine in Japan, respectively). We found that latitude predicted significant variance in hyperthymic temperament, and that ambient temperature, but not sunshine, significantly affected hyperthymic temperament scores. However, the analysis failed to consider the effects of naturally occurring low-dose lithium on temperament.
Methods: In addition to the TEMPS-A data previously collected, we measured lithium levels of the five cities. The effect of temperature, sunshine, and lithium levels on hyperthymic temperament was analyzed for the five cities.
Results: A stepwise multiple regression analysis revealed that lithium levels as well as latitude, but not temperature or sunshine, predicted significant variance in hyperthymic temperament scores. Hyperthymic temperament scores were significantly and positively associated with lithium levels whereas they were significantly and negatively associated with latitude.
Limitations: The light, temperature, lithium exposure that residents actually received was not measured. The number of regions studied was limited. The findings might not be generalized to residents across Japan or other countries.
Conclusions: The present findings suggest that lithium in drinking water may positively maintain hyperthymic temperament, and that latitude may negatively maintain it.

1. Introduction

Hyperthymic people display extroversion, a high energy level, emotional intensity and little need for sleep and this temperament is an adaptive and desirable condition outside of the boundaries of mood disorders (Rovai et al., 2013). Within the series of our studies, Kohno et al. (2012) reported that latitude has a significant effect on hyperthymic temperament among residents living in two regions, and that lower and higher latitudes are associated with higher and lower hyperthymic temperament scores, respectively. This interesting "latitude effect" on hyperthymic temperament was recently confirmed by our subsequent extension study of three regions with different latitudes that indicated a dose–response relationship between hyperthymic temperament scores and sunshine and latitude (Kohno et al., 2014). These findings suggest that sunshine mediates the positive effect of latitude on hyperthymic temperament.

On the other hand, considering another possibility that temperature might mediate the effect of latitude on hyperthymic temperament, we investigated the association of hyperthymic temperament scores of residents in Sapporo, Obihiro, Takaoka, Koshigaya, and Oita cities (which are located at latitudes of 43°N, 42°N, 36°N, 36°N and 33°N with various combinations of ambient temperament and sunshine in Japan,

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respectively) with sunshine, temperature, and latitude (Inoue et al., 2015). As a result, we found that latitude predicted significant variance in hyperthymic temperament, and that ambient temperature, but not sunshine, significantly affected hyperthymic temperament scores (Inoue et al., 2015).

However, the analysis failed to consider the effects of naturally occurring low-dose lithium on temperament. Lithium is widely used in clinical settings for psychiatric treatment such as in pharmacotherapy for bipolar disorder. This naturally occurring element is taken up by all plants, although it appears not to be required for their growth and development. At high levels in the soil, lithium is toxic to plants, causing a chlorosis-like condition (Schrauzer, 2002). Uptake and sensitivity to lithium are species dependent. Consequently, grains and vegetables have 0.5–3.4 mg/kg of lithium, dairy products have 0.5 mg/kg of lithium and meat has 0.012 mg/kg (Schrauzer, 2002). Several studies have shown that a micro-dose of lithium could possess anti-suicidal, anti-aging, and anti-dementia effects, suggesting the possibility that lithium is a trace element, although presently this is yet to be determined (Terao, 2015).

At the moment, several epidemiological studies have showed the inverse association of lithium levels in drinking water and suicide rate (Schrauzer and Shrestha, 1990; Ohgami et al., 2009; Kapusta et al., 2011; Ishii et al., 2015; Shiotsuki et al., 2016), although a few studies failed to find such association (Kabacs et al., 2011). If lithium has anti-suicidal effect, impulsivity and aggression may be decreased by lithium and thereby suicidality may be reduced (Sher, 2015; Terao, 2008; Terao et al., 2009). Both impulsivity and aggression and hyperthymic temperament share a high energy level, although impulsivity and aggression appear suddenly whereas hyperthymic temperament appears persistently. Therefore, it can be hypothesized that very low levels of lithium suppress not only impulsivity and aggression, but also hyperthymic temperament.

In the present study, the effect of temperature, sunshine, latitude and lithium levels on hyperthymic temperament was analyzed for the five cities. The goal of this study is to determine which factor of climatic factors and/or lithium in drinking water are associated with hyperthymic temperament.

2. Subjects and methods

2.1. Subjects

The previous data were used of the 609 residents in Sapporo, Obihiro, Takaoka, Koshigaya, and Oita cities (Inoue et al., 2015, Table 1). 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. Written informed consent was obtained from all participants, and the 3 universities and 2 hospital ethical committees approved the 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. Lithium levels in drinking water

Tap water samples (chiefly from the main rail station, the city office, or water purification plant) of each city were taken and their lithium levels were measured by using mass spectroscopy analyzed by a third party. This method can measure very small amounts of lithium; the minimal amount of lithium that can be measured is 0.1 ppb (0.1 μg/l). If lithium levels of drinking water were measured at multiple points in the same city, the mean value was calculated. We previously confirmed only a very small fluctuation in levels over time because the correlation coefficient between the lithium levels and those re-measured after 1 year in the same places was 0.998 (Ohgami et al., 2009).

2.5. Data analysis

Including lithium levels in drinking water, we performed the following re-analyses. Firstly, Pearson's correlation coefficients were used to examine the relationships between hyperthymic temperament scores and age, gender (female = 1, male = 2), the other 4 temperament scores, temperature, sunshine, latitude, and lithium levels. Secondly, a multiple regression analysis using stepwise method was used to identify the variables associated with hyperthymic temperament scores. Data was analyzed with SPSS version 24 for Windows.

Table 1
Participant demographics, TEMPS-A scores, latitude, sunshine, temperature, and lithium levels of drinking water in Sapporo, Obihiro, Koshigaya, Takaoka, and Oita.

Variables	Sapporo	Obihiro	Koshigaya	Takaoka	Oita
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
Gender (M/F)	66/28	48/58	42/83	47/142	67/28
TEMPS-A scores					
Depressive	5.8 ± 3.4	7.3 ± 3.2	7.3 ± 3.1	7.9 ± 3.8	6.8 ± 3.2
Cyclothymic	3.3 ± 3.8	3.9 ± 3.6	3.8 ± 3.1	5.0 ± 3.9	4.4 ± 3.5
Hyperthymic	3.8 ± 3.2	3.5 ± 2.8	3.8 ± 2.9	4.3 ± 3.5	5.0 ± 3.9
Irritable	2.7 ± 3.7	2.7 ± 2.9	2.3 ± 2.4	3.1 ± 3.3	3.0 ± 3.0
Anxious	3.9 ± 4.2	4.7 ± 4.4	4.8 ± 3.8	5.2 ± 4.6	4.5 ± 3.7
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
Temperature (°C)	9.1 ± 0.4	7.0 ± 0.5	15.3 ± 0.5	14.1 ± 0.5	16.7 ± 0.5
Lithium (μg/L)	29.0 ± 17.3	0.1 ± 0.1	2.6	1.5	43.0 ± 5.0

Mean ± SD.

3. Results

3.1. Age, gender, latitude, sunshine, temperature and lithium levels in drinking water

Table 1 shows demographics of 609 participant, the mean and SD of their TEMPS-A scores, latitude, sunshine, temperature, and lithium levels of drinking water in their residential cities. Particularly, we measured lithium levels at 4 points (Shirakawa water purification plant, 10.0 µg/L; Sapporo station, 50.0 µg/L; Kita ward office, 21.0 µg/L; Teine ward office, 35.0 µg/L) in Sapporo city from 2013 to 2014, at 3 points (Inada water purification plant, 0.0 µg/L; Taisho branch, 0.2 µg/L; Kawanishi branch, 0.1 µg/L) in Obihiro city from 2013 to 2014, at 3 points (Oita city hall, 48.0 µg/L; Oita prefectural office, 43.0 µg/L; Oita station, 38.0 µg/L) in Oita city from 2010 to 2011, at 1 point (Tatenochinai, 1.5 µg/L) in Takaoka city in 2013, and at 1 point (Koshigaya-Matsubushi waterworks bureau, 2.6 µg/L) in Koshigaya city in 2015. Oita and Sapporo cities had relatively large amount of lithium in drinking water than Obihiro, Takaoka, and Koshigaya cities.

3.2. Correlations between hyperthymic temperament scores and age, gender, the other 4 temperament scores, temperature, sunshine, latitude, and lithium levels

As shown in Table 2, hyperthymic temperament scores were significantly and positively associated with gender, cyclothymic temperament scores, irritable temperament scores, temperature and lithium levels. In contrast, hyperthymic temperament scores were significantly and negatively associated with latitude. No significant association was found between hyperthymic temperament scores and age, depressive temperament scores, anxious temperament scores, or sunshine.

Notably, lithium levels were significantly and negatively associated with depressive temperament scores.

3.3. Multiple regression analysis

Table 3 shows the results of the stepwise multiple regression analyses where hyperthymic temperament scores were the dependent variable and the other 4 temperament scores, age, gender, sunshine, temperature, latitude, and lithium levels were independent variables. Surprisingly, hyperthymic temperament scores were significantly and positively associated with lithium levels as well as age, cyclothymic and irritable temperament scores whereas the hyperthymic scores were significantly and negatively associated with latitude, depressive and anxious temperament scores. Neither sunshine nor temperature was associated with hyperthymic temperament scores.

Table 3
Stepwise multiple regression analysis of hyperthymic temperament scores for 609 participants.

Independent variable	Beta	p	VIF
Depressive temperament	− 0.208	< 0.0001	1.493
Cyclothymic temperament	0.289	< 0.0001	1.977
Irritable temperament	0.211	< 0.0001	1.887
Anxious temperament	− 0.139	0.008	1.922
Age	0.152	< 0.0001	1.247
Latitude	− 0.078	0.045	1.076
Lithium	0.100	0.019	1.277
ANOVA	F = 15.9	< 0.0001	
R2 (adjusted R2)	0.16 (0.15)		

This stepwise multiple regression analysis excluded gender, sunshine and temperament as non-significant variables. VIF values of individual factors were all less than 10, suggesting no multicollinearity.

4. Discussion

The major findings of the present study are that lithium levels in drinking water as well as latitude predicted significant variance in hyperthymic temperament scores via the stepwise multiple regression analysis. In advance, we hypothesized that very low levels of lithium suppress not only impulsivity and aggression, but also hyperthymic temperament. The present findings have shown a significantly positive association of lithium levels with hyperthymic temperament scores, which is in contrast to our hypothesis. Although the reason is unclear, despite very small doses, antidepressant effects of lithium (Worrall et al., 1979; Terao et al., 1994) may be involved in positively maintaining hyperthymic temperament. This possibility is supported by the present findings that lithium levels were significantly and negatively associated with depressive temperament scores. In any case, to our knowledge, this is the first report suggesting lithium effect on the positive maintenance of hyperthymic temperament. Moreover, it seems probable that lithium in trace dosages cannot bring about anti-manic effects, although lithium in therapeutic doses can improve mania.

Although "latitude effect" (Inoue et al., 2015) has been also demonstrated in the present study, neither sunshine nor temperature significantly predicted variance in hyperthymic temperament scores in the stepwise multiple regression analysis. The non-significant association of sunshine or temperature with hyperthymic temperament is a surprising finding for us, but it is unknown what of latitude contributes to hyperthymic temperament. Further studies are required to identify the factor (e.g., food, culture, economy, and so on) of latitude in association with hyperthymic temperament.

One of limitations is that the light, temperature, lithium exposure that residents actually received was not measured. Another limitation is the number of regions studied. Finally, the findings might not be generalized to residents across Japan or other countries.

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

	Age	Gender	Depressive	Cyclothymic	Hyperthymic	Irritable	Anxious	Sunshine	Temperature	Latitude	Lithium
Age	1	− 0.086*	0.090*	− 0.094*	0.060	− 0.036	0.027	− 0.222**	0.073	− 0.069	− 0.395**
Gender (Female = 1, Male = 2)		1	− 0.101*	− 0.084*	0.083*	0.010	− 0.036	0.162**	− 0.076	0.095*	0.338**
Depressive			1	0.425**	− 0.072	0.387**	0.536**	− 0.040	0.066	− 0.096*	− 0.147**
Cyclothymic				1	0.244**	0.630**	0.572**	− 0.055	0.081*	− 0.105**	− 0.038
Hyperthymic					1	0.233**	0.036	0.000	0.104*	− 0.113**	0.086*
Irritable						1	0.568**	− 0.032	0.016	− 0.031	0.024
Anxious							1	− 0.020	0.039	− 0.054	− 0.067
Sunshine								1	− 0.101*	− 0.035	0.255*
Temperature									1	− 0.957**	0.211*
Latitude										1	− 0.153**
Lithium											1

* $p < 0.05$.
** $p < 0.01$.

In conclusion, the present findings suggest that lithium in drinking water may positively maintain hyperthymic temperament, and that latitude may negatively maintain it.

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