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Abstract

Heat has an impact on several aspects of human cognition but the effects of the tropical climate (i.e., hot and wet) have rarely been explored. The purpose of this study was to determine whether selective attention and affect are negatively impacted by the tropical climate. The study followed a within-participants design: participants responded to an affective scale (PANAS) and performed an attention task (d2 Test) in two experimental climate conditions (tropical vs. neutral) with a one-week interval between sessions. The results indicated that they had lower positive affect and selective attention in the tropical climate than in the neutral climate. However, there was no significant difference in the effect on negative affect between conditions. The impact of tropical climate on affects and selective attention is discussed.

Keywords: environment, concentration, inattention, impulsivity, affective states, PANAS

The tropical climate (TC), where temperatures can exceed 31℃ and relative humidity (rH) exceeds 70%, can be considered an environmental stressor (Robin, Coudevylle, Hue, & Sinnapah, 2017). Thus far, research has been consistent regarding the negative impact of TC on aerobic exercise (Hue, 2011), and generally all individuals undergo a period of adjustment to very hot and humid conditions (Salati, Lovejoy, & Vose, 1983). Accordingly, Kosonen and Tan (2004) suggested that the thermal environment (including heat and humidity) is one of the most important environmental factors affecting human performance. However, research has not clearly determined whether performance decline is due to the direct impact of the climate (the physical and psychological aspects being affected independently) or whether this negative impact is mediated by a decrease in aspects of an individual's cognition (e.g., selective attention) and/or affect. The aim of the current study focused only on the direct impact of the climate on the psychological aspects and explored specifically whether affect and attention are impacted by exposure to TC.

Impact of Tropical Climate on Selective Attention

Although the literature shows that the separate effects of heat and humidity have been investigated, little is known about the combined impact of these two variables on cognitive performance. Pepler (1958) observed changes in the performance of a tracking task conducted in high and low rH (respectively, 80 and 20%), with each humidity condition crossed with four temperatures (i.e., 22, 26, 29, and 34℃). The author observed a significant performance decline between 22 and 26℃ for the 80% rH condition, whereas a significant decline was observed between the higher temperatures of 26 and 29℃ for the 20% rH condition, demonstrating that a high level of rH can be particularly deleterious to mental task performance.

In general, the literature has focused more on the effects of heat than on the influence of TC. In addition, the effects of heat exposure on cognitive function are a relatively recent research topic. Thus, although the physiological reactions to heat stress are well understood, the psychological reactions to heat have not been fully explored (see Robin, Coudevylle, Hue, & Toussaint, 2018). Chase, Karwowski, Benedict, Queseda, and Irwin-Chase (2003) reported poor dual-task performance at 30 and 35℃ and observed that participants were unable to successfully allocate their attention to the tasks, although they managed to maintain accurate performances. Gaoua, Racinais, Grantham, and El Massioui (2011) tested the effect of

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passive heat exposure on working memory and attention. They showed that memory was impaired but not the attentional processes. These two studies addressed the impact of heat on attention and need to be confirmed in other environmentally stressful conditions such as TC. Although the results in such tasks have been inconsistent across studies, it can be expected that the combination of heat and humidity would induce even higher levels of stress that might negatively impact performance in TC. Indeed, Gaoua (2010) suggested that humans have limited cognitive capacities to ensure successful outcomes due to the continuous external stimulations constantly competing for limited conscious access to the vast global workspace (see Baars, 1993).

Impact of Tropical Climate on Positive and Negative Affects

Given the characteristics of TC (i.e., high heat and humidity), it is likely that it has an impact on affective states. Watson, Clark, and Tellegen (1988) developed and validated the Positive and Negative Affect Schedule (PANAS), a scale that measures positive affect (PA) and negative affect (NA). The PA scale assesses the extent to which a person feels enthusiastic, active, and alert and the NA scale measures such feelings as anger, disgust, guilt, fear, and nervousness. However, there is no evidence in the literature regarding TC effects on affective state. According to Gaoua, Grantham, Racinais, and Massoui (2012), affective state is modified by exposure to heat alone. They showed that participants reported higher NA in a hot environment (50℃–30% rH) than in neutral conditions (24℃–30% rH) but PA did not vary as a function of the temperature condition. If the heat stress in hot conditions influences the affective state, one could argue that heat and humidity would have a similar impact on affect. Recently, Robin, Sinnapah, Hue, and Coudevylle (under review) examined how a hot (30℃) and humid (70% rH) environment (i.e., TC) influences PA and NA. In their study, TC reduced PA scores relative to the neutral climate (NC) condition. However, this result needs to be confirmed and more evidence is required before conclusions can be drawn about the impact of TC on affective states.

Research has been scant on whether TC has an impact on attention and affect according to sex. Wyon, Andersen, and Lundqvist (1972) reported that men were less able than women to withstand the negative effects of heat stress. Likewise, Karjalainen (2007) noted that men preferred cool environments and were more sensitive than women to heat. Lan, Lian, Liu, and Liu (2008) found similar results, observing that men preferred cooler room temperatures than women. Indeed, Robin et al. (2017) recently showed that men had lower cognitive performance (e.g., Vandenberg mental rotation test) in TC than in NC. Thus, it can be expected that the impact of TC on attention and affect will be greater for men than for women.

Overview

Little is currently known about the impact of TC on attention and affect. The purpose of this study was therefore to determine whether TC has an influence on selective attention and positive and negative affect. We hypothesized that the combination of heat and high humidity would be a stressful factor impacting these two psychological aspects of an individual's functioning. We expected that the selective attention score would be lower in TC than in NC and that positive affect would be lower and negative affect higher in TC compared with NC. Last, we expected that the negative impact of TC would be greater for men than for women.

Method

Participants

Thirty-two physical education students (27 men M_{age} = 19.8 years, SD = 1.44; and 5 women M_{age} = 21.2 years, SD = 1.48) volunteered for this study and gave written consent before participating. All were living in the West Indies, which has a TC (i.e., hot and wet) characterized by consistently high monthly temperatures, often exceeding 18℃ throughout the year, and rainfall that exceeds evapotranspiration for at least 270 days per year (Hue, 2011).

Experimental Conditions

The experiment was conducted during a regularly scheduled class. Each participant took part to two experimental conditions: Tropical and Neutral. They were randomly assigned by lottery to one of the experimental conditions first, and the two sessions were then conducted at a one-week interval. The tropical and neutral climates (respectively, TC and NC) were strictly monitored to standardize the experimental conditions. In the TC condition, the ambient temperature was 30.8℃$^{\pm 1.2}$ and the humidity was 70.1%$^{\pm 2.1}$; this environment was maintained by electric heating and kettle systems. In the NC condition, the ambient temperature was 22.5℃$^{\pm 2.8}$ and the humidity was 47.6%$^{\pm 2.1}$; this environment was obtained using an air conditioning system. The ambient light was artificial and strictly the same (fluorescent light 4000 K) in both conditions. Participants rested in a seated position for 30 min before starting the cognitive assessments.

Measures

Selective Attention: d2 Test

Attention capacity was assessed using the d2 Test of Attention (d2T), which was developed to measure sustained attention and concentration under the stress imposed by a time limit for completion (Brickenkamp & Zillmer, 1998).

The d2T is a paper-and-pencil letter-cancellation test comprising 14 lines, each containing 47 randomly mixed letters ("p" and "d"), for a total of 658 letters. The letters "p" and "d" appear with one or two dashes above or below each letter. The test participant has to carefully check whether each letter "d" has two dashes either above or below it, at a rate of 20 s per line. The complete duration of the test is 4 min 40 s.

The test allows the calculation of several different attention parameters. In the present study, we used four d2T-based measures of attention as dependent variables. First, we measured processing speed, which was calculated as the sum of the number of characters processed before the final cancellation on each trial (i.e., the total number of items processed). Then, we measured inattention, which was operationalized as the sum of the number of target symbols not canceled (i.e., errors of omission). Next, we measured impulsivity, which corresponded to the sum of the number of non-target symbols canceled (i.e., errors of commission). Last, we measured concentration performance, which was the difference between the total number of correctly canceled items and the number of errors of omission and commission (for a similar procedure, see Vanhelst et al., 2016).

Affect Scales

Affect was assessed using the French version of the PANAS (Lapierre, Gaudreau, & Blondin, 1999). This scale is a 20-item self-report psychometric scale developed to measure the two largely independent constructs (Watson et al., 1988). The ten PA items (i.e., active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, and strong) are grouped into two sub-dimensions (i.e., attentive and excited) and the ten NA items (i.e., guilty afraid, ashamed, distressed, guilty, hostile, irritated, jittery, nervous, scared, and upset) are grouped into three sub-dimensions (i.e., scared, nervous, and shameful). Participants rated the PANAS items on a 5-point scale (from 1 "very slightly" to 5 "very much").

Procedure

At the beginning of each session, the goal was presented: *"The purpose of this experiment is to test your cognitive capacities. Before performing this test of response time, you are going to respond to the items of various questionnaires. All the questionnaires are confidential and anonymous. Your test results will remain anonymous and confidential. For the needs of the study, the room conditions where you will do the tests are standardized."*

Before each session, the participants completed a control self-report questionnaire evaluating their use of medications, other drugs, and alcoholic and non-alcoholic drinks in the last 24 hours. None of them indicated having been thirsty before the sessions. After answering these questions, the participants successively completed subjective measures of environmental perceptions (comfort and thermal sensations), the PANAS, and the d2T.

Analyses

To determine whether the climate condition influenced attention and affect, the dependent variables (i.e., the four d2T-based measures of attention and the PA and NA scores) were submitted to mixed ANOVAs (with repeated measures on the second factor) using sex (female vs. male) as the between-participant factor and climate condition (TC vs. NC) as the within-participant factor. We checked that all variables were normally distributed with the Kolmogorov–Smirnoff test. Alpha was set at 0.05 for all analyses.

Results

Selective Attention: d2T Results

The ANOVAs for processing speed, inattention, and concentration performance revealed the main effect of climate condition [$F(1, 30) = 4.326$, $p < 0.05$; $F(1, 30) = 4.487$, $p < 0.05$; and $F(1, 30) = 4.751$, $p < 0.05$, respectively]. Participants had a lower score in TC than in NC (Table 1). Analysis of the impulsivity scores did not show any main effect of climate ($p > 0.05$). The ANOVAs for all the variables revealed no significant main effect of sex and no interaction between sex and climate condition ($p > 0.05$).

PANAS Results

Positive Affect

The ANOVA for PA revealed the main effect of climate condition [$F(1, 30) = 7.391$, $p < 0.05$], and the ANOVA for the attentive score also revealed the main effect of climate condition [$F(1, 30) = 9.157$, $p < 0.01$]. The ANOVA for the excited score revealed a tendency toward significance for the climate condition [$F(1, 30) = 3.651$, $p = 0.066$]. Participants thus had lower overall PA and attentive scores and showed a tendency toward lower excited scores in TC than in NC (Table 2). The ANOVAs of all the variables revealed no significant main effect of sex and no interaction between sex and climate condition ($p > 0.05$).

Table 1
Means and standard deviations for selective attention scores as a function of the climate condition ($N = 32$).

Task	Climate condition	
	Tropical *M* (*SD*)	Neutral *M* (*SD*)
Processing speed	187.63 (42.87)*	200.84 (46.15)*
Inattention	112.78 (44.91)*	98.47 (47.12)*
Impulsivity	2.81 (6.59)	1.91 (2.37)
Concentration performance	72.03 (89.05)*	100.47 (93.82)*

*Main effect for climate, $p < .05$.

Table 2
Means and standard deviations for affect scores as a function of climate condition ($N = 32$).

Task[a]	Climate condition	
	Tropical M (SD)	Neutral M (SD)
PA	21.59 (7.97)*	28.06 (7.66)*
Attentive	13.50 (4.92)**	17.47 (4.49)**
Excited	8.09 (3.45)	10.59 (3.57)
NA	13.97 (4.63)	12.28 (2.54)
Scared	3.97 (1.37)	3.44 (1.13)
Nervous	7.94 (3.47)	6.81 (1.73)
Shameful	2.06 (0.43)	2.03 (0.30)

[a]PA = positive affect; NA = negative affect.
*Main effect for climate, $p < 0.05$; **main effect for climate, $p < 0.01$.

Negative Affect

The analysis of the NA scores showed no main effect of climate or sex and no interaction between these two factors ($p > 0.05$). The analysis of the three NA sub-dimensions separately (i.e., scared, nervous, shameful) showed no main effect of climate or sex and no interaction between these two factors ($p > 0.05$).

Discussion

Tropical Climate Impacts Selective Attention

The primary purpose of this study was to explore the impact of the TC on selective attention and positive and negative affect. In line with our predictions, the results showed that the participants had lower selective attention scores in TC than in NC (except for impulsivity). Our results contrast with those reported by Gaoua et al. (2011), who did not find that attention was impaired by the hot climate. We may therefore assume that the combination of high humidity and high temperature played an important role. The results of our study are in line with those obtained by Chase et al. (2003), who tested dual-task performance (i.e., shared attention as opposed to selective attention). Those authors suggested that the discomfort induced by the hot climate provoked a cognitive cost and that the participants therefore used more cognitive resources to remain focused on the attention task (Chase et al., 2003; Sanders, 1983). This suggests that the individual must cope with competition for cognitive resources between the TC-induced stress and the attention task (Delignières, 1994). These results are important because no study to our knowledge has yet shown the deleterious effects of TC on selective attention. Indeed, cognitive psychologists have indicated that humans have limited cognitive capacities to cope with the multiple external stimuli constantly competing for the limited conscious access (Gaoua, 2010). It seems that the combination of heat and high rH imposes a cognitive load and therefore negatively impacts cognitive performance.

Tropical Climate Impacts Positive Affect

Consistent with our predictions, TC had a negative impact on PA (i.e., total score and the attentive and excited sub-dimensions). Participants had lower PA in TC than in NC. However, the effects of the two climate conditions on NA (i.e., total score and the sub-dimensions of scared, nervous, and shameful) showed no significant effects. Our results contrast with those of Gaoua et al. (2012), who reported no difference in PA between climates but higher NA in a hot environment (50℃) than in neutral condition, but they agree with those of Robin et al. (under review) (i.e., they found an impact of TC on PA but not on NA). It is fairly easy to understand that TC would have a negative influence on the scores for the attentive and excited sub-scales; it also seems reasonable that this climate would not have an effect on the scared, nervous, and shameful scores, particularly in these acclimatized participants. Indeed, in the study of Robin et al. (under review), participants were acclimatized to TC (i.e., born and or living in West Indies for more than 5 years). De Dear and Bragger (1998) have proposed that individuals adapt to the climatic conditions to which they are most exposed. It is therefore highly likely that people acclimatized to thermal and hygrometric stress will maintain a low level of negative affects, remaining calm and serene (Watson et al., 1988) in an environment in which they live daily (Robin, under review). Finally, it is possible that these sub-scales are not appropriate for detecting the possible negative influence of an environmental climate.

Contrary to our predictions, no sex difference was observed. Although men may be more sensitive than women to the TC while performing certain cognitive tasks (e.g., mental rotation test), they did not differ with regard to attention or affect. The results contrast with previous studies showing that men prefer cool environments and are more sensitive to heat (Karjalainen, 2007; Lan et al., 2008; Robin et al., 2017; Wyon et al. 1972). However, it should be kept in mind that our women's group was smaller than the men's group, and more research is needed to better understand the influences of TC according to sex.

Conclusion

In sum, the present research showed that in a regularly scheduled class (a) participants had lower selective attention scores (i.e., concentration performance) in TC compared with NC, (b) participants had lower positive affect (i.e., attentive and excited) in TC compared with NC, and (c) no sex difference was observed. These results advance our understanding of the psychological impact of TC. It should be underlined that these results were obtained in a sample of acclimatized participants and that the deleterious effects of the climate condition on attention and affect might well be worse in non-acclimatized participants.

Further research should explore this hypothesis with the acclimatization characteristic as a factor for comparison between participants. Despite these contributions, some limitations should be mentioned. The main limitation is that in TC, it is not possible to dissociate the impact of heat stress from that of high rH. Additional research could assess the rH effects on selective attention and affect using, for example, climatic chambers.

References

Baars, B. (1993). How does a serial, integrated and very limited stream of consciousness emerge from a nervous system that is mostly unconscious, distributed, parallel and of enormous capacity? *Ciba Found Symposium*, *174*, 282–290.

Brickenkamp, R., & Zillmer, E. (1998). *The d2 Test of Attention*. Seattle, WA: Hogrefe and Huber.

Chase, B., Karwowski, W., Benedict, M., Quesada, P., & Irwin-Chase, H. (2003). A study of computer-based task performance under thermal stress. *International Journal of Occupational Safety and Ergonomics*, *9*, 5–15. http://doi.org/10.1080/10803548.2003.11076550

de Dear, R. J., & Brager, G. S. (1998). Developing an adaptive model of thermal comfort and preference. *ASHRAE Transactions*, *104*, 145–167. http://escholarship.org/uc/item/4qq2p9c6

Delignières, D. (1994). Influence de la chaleur humide sur le traitement de l'information et la performance. *Etude technique de l'INSEP, 1–26*.

Gaoua, N. (2010). Cognitive function in hot environments: A question of methodology. *Scandinavian Journal of Medicine & Science in Sports*, *20*(3), 60–70. http://doi.org/10.1111/j.1600-0838.2010.01210.x

Gaoua, N., Grantham, J., Racinais, S., & El Massioui, F. (2012). Sensory displeasure reduces complex cognitive performance in the heat. *Journal of Environmental Psychology*, *32*(2), 158–163. http://doi.org/10.1016/j.jenvp.2012.01.002

Gaoua, N., Racinais, S., Grantham, J., & El Massioui, F. (2011). Alterations in cognitive performance during passive hyperthermia are task dependent. *International Journal of Hyperthermia*, *27*(1), 1–9. http://doi.org/10.3109/02656736.2010.516305.

Hue, O. (2011). The challenge of performing aerobic exercise in tropical environments: Applied knowledge and perspectives. *International Journal Sports and Physiology Performance*, *6*, 443–454.

Karjalainen, S. (2007). Gender differences in thermal comfort and use of thermostats in everyday thermal environments. *Build Environment*, *42*, 1594–1603.

Kosonen, R., & Tan, F. (2004) Assessment of productivity loss in air-conditioned buildings using PMV index. *Energy and Buildings*, *36*, 987–993.

Lan, L., Lian, Z., Liu, W., & Liu, Y. (2008). Investigation of gender difference in thermal comfort for Chinese people. *European Journal of Applied Physiology*, *102*, 471–480. http://doi.org/10.1007/s00421-007-0609-2

Lapierre, A. M., Gaudreau, P., & Blondin, J. P. (1999). Évaluation de l'affectivité positive et négative en contexte sportif : Traduction francophone du PANAS. *Evaluation of positive and negative affectivity in a sports context:* French translation of the PANAS. Paper presented at the 23rd Annual Conference of the Société Québécoise de Recherche en Psychologie, Quebec, QC, Canada.

Pepler, R. D. (1958). Warmth and performance: An investigation in the tropics. *Ergonomics*, *22*, 63–88. http://doi.org/10.1080/00140135808930403

Robin, N. (under review). Fonctionnement cognitif en climat tropical: Revue et perspectives de recherches. [Cognitive function in tropical climate: A review and research perspectives]. *Psychologie Française*.

Robin, N., Coudevylle, G. R., Hue, O., & Sinnapah, S. (2017). Effects of tropical climate on mental rotation: The role of imagery ability. *American Journal of Psychology*, *4*, 455–465.

Robin, N., Coudevylle, G. R., Hue, O., & Toussaint, L. (2018). The influences of tropical climate on imagined walking time. *Journal of Cognitive Psychology*, *30*, 98–107. http://dx.doi.org/10.1080/20445911.2017.1384382

Robin, G. R., Sinnapah, S., Hue, O., & Coudevylle, G. R. (under review). The influence of tropical climate on affect, fatigue and environmental perceptions. *Pratiques Psychologiques*.

Salati, E., Lovejoy, T. E., & Vose, P. B. (1983). Precipitation and water recycling in tropical rain forests with special reference to the Amazon basin. *Environmentalist*, *3*, 67–72. http://doi.org/10.1007/BF02240058

Sanders, A. F. (1983). Towards a model of stress and human performance. *Acta Psychologica*, *53*, 61–97. https://doi.org/10.1016/0001-6918(83)90016-1

Vanhelst, J., Beghin, L., Duhamel, A., Manios, Y., Molnar, D., De Henauw, D., … Gottrand, F. (2016). Physical activity is associated with attention capacity in adolescents. *Journal of Pediatrics*, *168*, 126–131. http://dx.doi.org/10.1016/j.jpeds.2015.09.029

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070. http://dx.doi.org/10.1037/0022-3514.54.6.1063

Wyon, D. P., Andersen, I., & Lundqvist, G. R. (1972). Spontaneous magnitude estimation of thermal discomfort during changes in the ambient temperature. *Journal of Hygiene*, *70*, 203–221.