University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

No chill: Heat-related student stress in varied classroom occupancy

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Course Code: PSYC 421

University of British Columbia

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No chill: Heat-related student stress in varied classroom occupancy

Group 14: Mission Possible

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Executive Summary

Our group did a study based on the research question “How does classroom occupancy influence students’ well-being during extreme summer weather?” We initially hypothesized that higher occupancy classroom on campus will have greater negative impact on students’ well-being. We used a within-in-subject design and measured participants' well-being in five aspects (anxious, hot, stressed, comfortable, and relaxed). We got 90 participants who answered the survey and one-way repeated ANOVA revealed a significant main effect of the room occupancy on the perception of anxiety, hot, stress, comfortable, and relaxed levels in extremely hot weather. Our results strongly supported our hypothesis, and 110 (44% occupancy) was a cutoff point where there was a significant increase or decrease depending on whether it is a positive or negative aspect. Therefore, we came to the conclusion that universities should limit the room occupancy to 110(44%) during extreme heatwave conditions in summer, and cooling Interventions could also be a potential resolution.

Keywords: heatwave, well-being, stressed, hot, relaxed, anxiety, and comfortable

Introduction

Extreme weather due to global climate change has caused Canada to experience multiple heat waves in the summer, and a heat wave is defined as "a temperature exceeding 32°C for three or more consecutive days". (Smoyer-Tomic et al., 2003) One of the most important impacts of climate change is human health (Deschenes, 2014) Previous research has discovered that heat-related health effects and perceived health symptoms may be an issue, especially in public schools with limited resources. (Bidassey-Manilal et al., 2016). Statistical data showed that when room temperatures ≥ 32 °C students reported an increase in thermal health-related symptoms of fatigue and dyspnea (Bidassey-Manilal et al., 2016). Further, physical characteristics of the classroom environment have been shown to correlate with student anxiety, and anxiety negatively impacts student health and achievement. As heat events become more frequent, institutions should adapt the classroom environment to better support student well-being. According to stage-environment fit theory, human behavior, emotions, and cognition are influenced by the characteristics of the individual and their environment. Although studies have shown that students' performance is influenced by the temperature they feel in classrooms. There is not a lot of research on the relationship between classroom occupancy and students' well-being. Studying the effects of different classroom occupancies on students' well-being in a heat wave environment could help create a better learning environment for students. As a result, we set our research question: How does classroom occupancy influence students' well-being during extreme summer weather? And we hypothesized that higher occupancy in the classroom will have a greater negative impact on students' well-being.

Methods

Participants are undergraduate students with an average year level of 3.62 recruited from the UBC campus (Mean Age=22.88, M=36/F=54). Of the students who completed the data form (N=90), 10 participants are in their first or second year of study, while 80 are in their senior years. The female takes over most of our participants, which is 57.8% of our study, where the male takes over 40%, and the rest are the third gender at 2.2%. Using G*Power version 3.1.9.4 to determine the minimum sample size required to test the study hypothesis. Results indicated the required sample size to achieve 80% power for detecting a medium effect [f=o.1], at a significance criterion of α = .05, was N =121 for one-way repeated measures ANOVA [within factors] (see Appendix B). Thus, the obtained sample size of N = 121 is adequate to test the study hypothesis. Participants are then shown five different classroom occupancies (IV) in random order and asked to self-report how they would feel if there was minimal air conditioning for each of the IVs. Our DVs include 3 negative factors, Anxious, Stressed, Hot and 3 positive factors Comfortable, Excited, and Relaxed to ensure participants are consistent in their answers and prevent reporting biases. We chose our DVs based on the study done by Dias-Viana and Joao Lucas, they included some negative emotions such as, Anxious, Tense, Impatient and Tired, and also positive emotions, Full of energy, Motivated and feel well in their questionnaire in order to develop the School Subjective Well-Being Scale (Dias-Viana, J. L. & Noronha, A. P,2021). The DVs are measured using a Likert scale ranging from 1(not at all) to 7 (extremely) to indicate if they would experience each DVs emotion. The Likert scale is effective in this scenario because it is proven to be an effective method for measuring subjective feelings and reactions and provides a salient indication of the strength of belief (Jebb, Ng & Tay, 2021). This thus allows for the operationalization of our DVs so that they can be measured and quantified to address our research question and test the hypothesis. The 6 IVs are a pictorial representation of different occupancy levels (210, 160, 110, 60, and 10), shown using a number of stick figures on an image of a UBC lecture hall. At the end of the survey, the participant's age (16-35+), gender (Male, Female, Non-binary/third gender, prefer not to answer), year of study (1,2,3,4,5 or higher), and whether they are a current UBC student (Yes, No) are collected.

To address the research question, we used a within-subject design where all participants were randomly subjected to different five conditions. Participants are asked to read about the increasing number of hot days in

Vancouver and how heat waves are increasing in the city. They are then asked to imagine that they are a student attending a lecture during a heat wave, with the outdoor temperature being 33°C/91°F. The survey component of our research procedure consists of six pages. The first five pages include an image of an imaginary classroom environment filled with a certain number of stick figures. The stick figures represent students in the classroom, and we use this to manipulate our IVs which are the different classroom densities (10,60,110,160,210) The text below the image reminds the participants about the lack of air conditioning and the heat condition outside. The participants will then answer a Likert scale from 1 (Not at all) to 7 (Extremely) about how they feel about each of the IVs. Participants will need to click the arrow button to move to the next page after they complete the survey on the page. Participants who did not complete all questions will be asked to complete the survey questions before being allowed to move on. The questions are arranged the same way in all five conditions but in random order. After completing the five pages, the participants are taken to the last page of the survey, which collects information about their age, gender, year of study, and whether they are current UBC students. The survey is completed and recorded once the participant completes all information on the last page. Overall, 140 participants participated in the survey study, but only 90 participants completed the study (N=90), with some participants not completing the information (N=50) and thus had their data excluded from the study. This was one of the challenges we met while collecting data; many of our participants did not finish the survey completely. When we noticed this problem, we solved this by asking each participant to screenshot the completion page at the end of the survey and send it to us; however, we still got 50 people who didn't finish. In the end, we concluded that this happened due to our logy detection; if we had discovered this problem several days before we had started to run the data, we would have prevented it.

Results

A one-way within group ANOVA to analyze five different classroom occupancies on participants' well-being, as reflected in the measurements of anxious level, hot level, stress level, comfortable level, excited level and relaxed level.

Anxious level:

A one-way within group ANOVA revealed a significant main effect of the room occupancy on anxious levels in extreme hot weather, F (4, 356) =34.63, p<.001, η_p^2=.28 (see appendix C Figure 1). Post hoc comparisons using Holm test indicated that, in extreme hot weather, the anxious level of participants in 210 occupancy room (M=4.98, SD=1.64) were significantly higher than the 110 occupancy room (M=3.90, SD=1.86) (p <.001), than the 60 occupancy room (M=3.52, SD=1.87) (p <.001), and than 10 occupancy room (M=3.19, SD=1.88) (p <.001). The anxious level of participants in 160 occupancy room (M=4.89, SD=1.69) were significantly higher than the 110 occupancy room (M=3.90, SD=1.86) (p <.001), than the 60 occupancy room (M=3.52, SD=1.87) (p <.001), and than 10 occupancy room (M=3.19, SD=1.88) (p <.001). The anxious level of participants in 110 occupancy room (M=3.90, SD=1.86) were significantly higher than 10 occupancy room (M=3.19, SD=1.88) (p =.015) (see Appendix C Figure 1). The results suggest that in extremely hot weather, room occupancy can affect students' well-being. The result indicates that the room occupancy higher than 110 has significantly increases the anxious level of the students in extremely hot weather, which supports the hypothesis that high occupancy classroom on campus impacts students' social well-being negatively as reflected in increasing anxious level in the students.

Hot level:

A one-way within group ANOVA revealed a significant main effect of the room occupancy on hot levels in extreme hot weather, F (4, 356) =46.55, p<.001, η_p^2=.34 (see appendix C Figure 2).

Post hoc comparisons using Holm test indicated that, in extremely hot weather, the stress level of participants in 210 occupancy room (M=5.63, SD=1.60) were significantly higher than the 160 occupancy room (M=5.38, SD=1.73) (p=.02), than the 110 occupancy room (M=4.50, SD=1.72) (p <.001), than 60 occupancy room (M=3.92, SD=1.92) (p <.001), and than 10 occupancy room (M=3.51, SD=2.02) (p <.001). The hot level of participants in 160 occupancy room (*M*=4.86, *SD*=1.65) were significantly higher than the 110 occupancy room(*M*=4.50, *SD*=1.72)(p <.001), than 60 occupancy room (*M*=3.92, *SD*=1.92)(p <.001), and than 10 occupancy room (*M*=3.51, *SD*=2.02)(p <.001).The hot level of participants in 110 occupancy room(*M*=4.50, *SD*=1.72) were significantly higher than 60 occupancy room (*M*=3.92, *SD*=1.92)(p =.004), and than 10 occupancy room (*M*=3.51, *SD*=2.02)(p <.001).The hot level of participants in 60 occupancy room (*M*=3.92, *SD*=1.92) were significantly higher than 10 occupancy room (*M*=3.51, *SD*=2.02)(p =.009) (see Appendix C Figure 2). The results suggest that in extremely hot weather, room occupancy can affect students' well-being. The result indicates that the room occupancy higher than 110 has significantly increases the hot level of the students in extremely hot weather, which supports the hypothesis that high occupancy classroom on campus impacts students' social well-being negatively as reflected in increasing hot level in the students.

Stress level:

A one-way within group ANOVA revealed a significant main effect of the room occupancy on stress levels in extremely hot weather, F (4, 356) =25.53, p<.001, η_p^2=.22 (see appendix C Figure 3). Post hoc comparisons using Holm test indicated that, in extreme hot weather, the stress level of participants in 210 occupancy room (*M*=4.92, *SD*=1.68) were significantly higher than the 110 occupancy room (*M*=3.94, *SD*=1.80) (p <.001), than the 60 occupancy room (*M*=3.59, *SD*=1.80) (p <.001), and than 10 occupancy room (*M*=3.38, *SD*=1.88) (p <.001). The stress level of participants in 160 occupancy room (*M*=4.86, *SD*=1.65) were significantly higher than the 110 occupancy room (*M*=3.94, *SD*=1.80) (p <.001), than the 60 occupancy room (*M*=3.59, *SD*=1.80) (p <.001), and than 10 occupancy room (*M*=3.38, *SD*=1.88) (p <.001). The stress level of participants in 110 occupancy room (*M*=3.94, *SD*=1.80) were significantly higher than the 10 occupancy room (*M*=3.38, *SD*=1.88) (p <.020) (see Appendix C Figure 3). The results suggest that in extremely hot weather, room occupancy can affect students' well-being. The result indicates that the room occupancy higher than 110 has significantly increases the stress level of the students in extremely hot weather, which supports the hypothesis that high occupancy classroom on campus impacts students' social well-being negatively as reflected in increasing stress level in the students.

Comfortable level:

A one-way within group ANOVA revealed a significant main effect of the room occupancy on a comfortable level in extreme hot weather, F (4, 356) = 25.69, p<.001, η_p^2=.22 (see Appendix C Figure 4). Post hoc comparisons using Holm test indicated that, in extreme hot weather, the comfortable level of participants in 210 occupancy room (*M*=2.31, *SD*=1.40) were significantly lower than the 110 occupancy room (*M*=3.09, *SD*=1.58) (p <.001), than the 60 occupancy room (*M*=3.71, *SD*=1.77) (p <.001), and than 10 occupancy room (*M*=3.86, *SD*=1.83) (p <.001). The comfortable level of participants in 160 occupancy room (*M*=2.52, *SD*=1.59) were significantly lower than the 110 occupancy room (*M*=3.09, *SD*=1.58) (p <.001), than the 60 occupancy room (*M*=3.71, *SD*=1.77) (p <.001), and than 10 occupancy room (*M*=3.86, *SD*=1.83) (p <.001). The comfortable level of participants in 110 occupancy room (*M*=3.94, *SD*=1.80) were significantly lower than the 60 occupancy room (*M*=3.71, *SD*=1.77) (p <.001), than the 10 occupancy room (*M*=3.86, *SD*=1.83) (p <.001) (see Appendix C Figure 4).

The result indicates that the room occupancy higher than 110 has significantly decreases the comfortable level of the students in extremely hot weather, which supports the hypothesis that high occupancy classrooms on campus impacts students' social well-being negatively as reflected in decreasing comfortable levels in the students.

Excited level:

A one-way within group ANOVA revealed a significant main effect of room occupancy on excited levels in extreme hot weather, F (4, 356) =22.70, p<.001, η_p^2=.22 (see Appendix C Figure 5). Post hoc comparisons using Holm test indicated that, in extreme hot weather, the excited level of participants in 210 occupancy room (*M*=2.03, *SD*=1.48) were significantly lower than the 110 occupancy room (*M*=2.79, *SD*=1.57) (p <.001), than the 60 occupancy room (*M*=3.10, *SD*=1.73) (p <.001), and than 10 occupancy room (*M*=3.18, *SD*=1.82) (p <.001). The excited level of participants in 160 occupancy room (*M*=2.52, *SD*=1.59) were significantly lower than the 110 occupancy room (*M*=2.79, *SD*=1.57) (p <.001), than the 60 occupancy room (*M*=3.10, *SD*=1.73) (p <.001), and than 10 occupancy room (*M*=3.18, *SD*=1.82) (p <.001) ((see Appendix C Figure 5). The result indicates that the room occupancy higher than 110 has significantly decreases the excited level of the students in extremely hot weather, which supports the hypothesis that high occupancy classrooms on campus impacts students' social well-being negatively as reflected in decreasing excited levels in the students.

Relaxed level:

A one-way within group ANOVA revealed a significant main effect of the room occupancy on a relaxed level in extreme hot weather, F (4, 356) = 41.27, p<.001, η_p^2=.32 ((see Appendix C Figure 6). Post hoc comparisons using Holm test indicated that, in extreme hot weather, the excited level of participants in 210 occupancy room (*M*=2.03, *SD*=1.48) were significantly lower than the 110 occupancy room (*M*=2.79, *SD*=1.57) (p <.001), than the 60 occupancy room (*M*=3.10, *SD*=1.73) (p <.001), and than 10 occupancy room (*M*=3.18, *SD*=1.82) (p <.001). The relaxed level of participants in 160 occupancy room (*M*=2.52, *SD*=1.59) were significantly lower than the 110 occupancy room (*M*=2.79, *SD*=1.57) (p <.001), than the 60 occupancy room (*M*=3.10, *SD*=1.73) (p <.001), and than 10 occupancy room (*M*=3.18, *SD*=1.82) (p <.001). The relaxed level of participants in the 110 occupancy room (*M*=2.52, *SD*=1.59) were significantly lower than the 10 occupancy room (*M*=2.79, *SD*=1.57) (p <.001) ((see Appendix C Figure 6). The result indicates that the room occupancy higher than 110 has significantly decreases the relaxed level of the students in extremely hot weather, which supports the hypothesis that high occupancy classrooms on campus impacts students' social well-being negatively as reflected in decreasing relaxed levels in the students.

Discussion

Our findings supported our hypothesis that higher occupancy in the classroom will have a greater negative impact on students' well-being in extreme heat weather. There was a significant (p<0.05) decrease in positive emotions and an increase in negative emotions as the occupancy of the classroom increased (see Appendices C). These results suggest there is an inverse relationship between students' well-being during a heat wave and classroom occupancy level.

There are several limitations to our study. There is limited generalizability, the ability to extrapolate our findings to the larger university student population, due to a small sample size (*N*=90, 57.8% female), which is lower than our calculated target of 121 participants. Moreover, while we targeted all university students as participants, there was an average of 4th year level (Mean=3.6±1.1) and 23-year-old (Mean=22.9±2.2) participants, an older undergraduate population who may not attend large lectures as often as lower year levels or younger aged students. This can be attributed to how participants were recruited; they tended to be our friends who are similar demographics to us. Thus, our results may only be applicable to this sample and not to all university students. To prevent this generalizability issue in future iterations of the study, efforts should be made to have equal and plentiful representation from students of all year levels and would require recruitment of strangers outside our own social networks, most easily achieved through social media advertising.

Another limitation of our study is the threat to the internal validity, that we measured what we sought to measure. There was a lack of a measure of the effectiveness of the heat manipulation, which our study was contingent on. The heat priming that occurred prior to exposure to the occupancy conditions explained that the survey questions were to be answered while imagining yourself in a heat wave (32°C). However, some participants reported that this manipulation was not effective, or some even missed it all together. Without the heat manipulation, the results only explain the relationship between occupancy and student well-being and does not consider the climate impact. Another notable threat to internal validity is the confounding variable of familiarity with social distancing due to the COVID-19 pandemic. It is entirely possible that participants reported negative well-being after a certain occupancy because they are motivated to be spread apart, a vestigial effect from public health orders, and not due to heat. To prevent both these issues, future iterations of the study should have a pretest-posttest design, where well-being due to exposure to different occupancy levels is measured, *then* the heat manipulation is introduced, and finally, well-being is measured again. If there was no difference between the pretest and post-test, we could conclude that the heat manipulation was not effective. This also controls for social distancing effects, as participants would be measured twice against themselves. This extra step would increase confidence that the reported well-being is due to changes in thinking about occupancy in extreme heat-related weather.

While previous research (see Introduction) has described the relationship between well-being and room occupancy, and student well-being and heat, this is the only research we are aware of that investigates the relationship between well-being, occupancy, and heat for a university students' population. This research can be utilized by post-secondary institutions to improve their students' experience in classrooms during heat waves, particularly as the frequency of weather events increases due to climate change.

UBC Client Recommendations

Based on our research, we offer three key recommendations to our UBC client to achieve the SEEDS Sustainability Goal, "Accelerate Climate Action," through adapting lectures to the rising occurrence of heat waves in Vancouver/Musqueam territory where campus is situated. Moreover, we argue that implementing our recommendations will contribute to UBC's Strategic Priority VI "Support community wellbeing in the face of the climate crisis," through the prioritization of student well-being and capacity to learn in a safe environment during extreme summer weather events (CETF, 2022).

First, we recommend limiting course registration to a maximum of 110 students in 250 seat classrooms during the summer semesters, when extreme heat events are most likely to happen. We found a statistically significant relationship between student well-being and classroom occupancy in heat waves, wherein well-being decreased as classroom occupancy surpassed 110. By strategically scheduling summer courses, which are typically smaller capacity than winter courses, in larger classrooms, UBC can increase student positive affect and reduce student negative affect in extreme summer weather events. We find this to be a zero financial investment and rapid intervention that could be implemented via the Student Service Center (SSC).

Second, we recommend prioritizing air-conditioning (AC) and other cooling interventions in classrooms where high occupancy cannot be controlled (i.e., as per Recommendation 1). AC is costly to run, both fiscally and energy consumption-wise. Based on our findings, UBC should focus the finite AC available in classrooms not of a certain size, but rather of a certain student occupancy level. Using our findings to illustrate, in a 250-seat classroom, AC should be turned on when occupancy reaches 160 students to reduce statistically significant heat-related stress but could be turned off to save resources when occupancy falls below 110. It is not a classroom of 250 that inherently causes student distress during extreme weather events, but rather the number of students in the classroom. We find this to be a novel feedback system that could be exploited for both UBC to benefit from limiting AC, and students to benefit in their well-being.

Finally, we recommend investigating this relationship between occupancy and extreme heat weather-related stress in other campus spaces. High traffic areas for students, including libraries, dining halls, and residence buildings, are not immune to extreme heat weather events, and student well-being in these spaces will evitability impact how students interact in their daily lives. Based on our findings, we predict that high occupancy and extreme heat weather-related stress is not limited to learning environments. We find this to be a worth-while investment in research as extreme weather events become more prevalent due to climate change. This may help UBC in architectural design of ongoing construction projects, to better prepare for the future.

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Appendix A

Survey Tool

Consent

Consent Form

Class Research Projects in PSYC 421 - Environmental Psychology

Principal Investigator:
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Course Instructor
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Institute for Resources, Environment and Sustainability
Email: jiayingz@psych.ubc.ca

Introduction and Purpose

Students in the PSYC 421 – Environment Psychology class are required to complete a research project on the UBC campus as part of their course credit. In this class, students are required to write up a research proposal, conduct a research project, collect and analyze data, present their findings in class, and submit a final report. Their final reports will be published on the SEEDS online library (https://sustain.ubc.ca/teaching-applied-learning/seeds-sustainability-program). Their projects include online surveys and experiments on a variety of sustainability topics, such as waste sorting on campus, student health and wellbeing, food consumption and diet, transportation, biodiversity perception, and exercise habits. The goal of the project is to train students to learn research techniques, how to work in teams and work with UBC clients selected by the UBC SEEDS (Social Ecological Economic Development Studies) program.

Study Procedures

If you agree to participate, the study will take about 10 minutes of your time. You will answer a few questions in the study. The data will be strictly anonymous. Your participation is entirely voluntary, and you can withdraw at any point without any penalty. Your data in the study will be recorded (e.g., any answer you give) for data analysis purposes. If you are not sure about any instructions, please do not hesitate to ask. Your data will only be used for student projects in the class. There are no risks associated with participating in this experiment.

Confidentiality

Your identity will be kept strictly confidential. All documents will be identified only by code number and kept in a locked filing cabinet. You will not be identified by name in any reports of the completed study. Data that will be kept on a computer hard disk will also be identified only by code number and will be encrypted and password protected so that only the principal investigator and course instructor, Dr. Jiaying Zhao and the teaching assistants will have access to it. Following the completion of the study, the data will be transferred to an encrypted and password protected hard drive and stored in a locked filing cabinet. Please note that the results of this study will be used to write a report which is published on the SEEDS library.

Remuneration

There is no remuneration for your participation.

Contact for information about the study

This study is being conducted by Dr. Jiaying Zhao, the principal investigator. Please contact her if you have any questions about this study. Dr. Zhao may be reached at (604) 827-2203 or jiayingz@psych.ubc.ca.

Contact for concerns about the rights of research subjects

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

Consent: Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time. You also may postpone your decision to participate for 24 hours. You have the right to choose to not answer some or any of the questions. By clicking the "continue" button, you are indicating your consent to participate; hence, your signature is not required. The researchers encourage you to keep this information sheet for your records. Please feel free to ask the investigators any additional questions that you have about the study.

Ethics ID: H17-02929

Do you consent to participate?

- Yes, I consent to participate.
- No, I do not consent to participate.

Block 1

Please Read Before Proceeding

The University of British Columbia - Vancouver campus, is situated on the traditional, ancestral, and unceded territory of the Musqueam people.

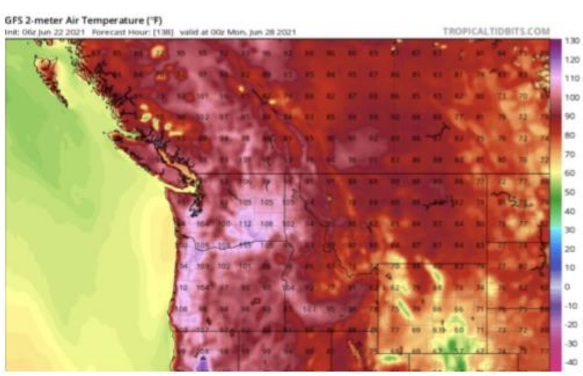
Vancouver, a coastal urban centre, is predicted to see increases in temperature due to climate change in the upcoming years.

In 2016, 18 days over 25˚C/77˚F were recorded in Vancouver during the summer months. The number of hot days is expected to double by 2050, with forecasters predicting 43 days over 25˚C/77˚F during Vancouver summers.

Please Read Before Proceeding

A heat wave in Vancouver is defined by Environment Canada as temperatures at or above 33˚C/91˚F for two (2) or more days.

In the summer of 2021, the previous heat record for Vancouver held for 123 years prior, was broken by a severe heat wave.



An increase in the frequency and severity of summer heat in Vancouver has led to societal problems, including water shortages, power outages, an increase in heat-related illness, and making everyday tasks unbearable.

A need to adapt to heat-related change in Vancouver and on the UBC-Vancouver campus is necessary as temperatures continue to increase.

Instructions for Exp

For the rest of this experiment, please **imagine you are a student attending lecture during a heat wave.** The outdoor temperature is at 33°C/91°F.

You will now be shown a series of spaces on the UBC-Vancouver campus and asked to indicate how you feel **if there was MINIMAL air conditioning available.**

Experimental Conditions

Imagine you are a student attending lecture during a heat-wave (33°C/91°F outdoors) and there is **MINIMAL air conditioning available** in this room. The stick figures represent students in the lecture.

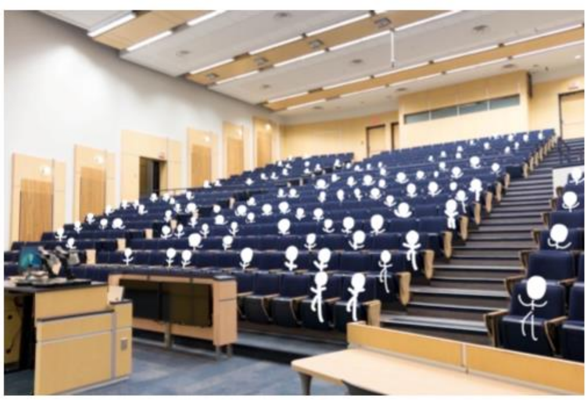
How would you feel?

	Not at all 1	2	3	Moderately 4	5	6	Extremely 7
Anxious	O	O	O	O	O	O	O
Stressed	O	O	O	O	O	O	O
Hot	O	O	O	O	O	O	O
Comfortable	O	O	O	O	O	O	O
Excited	O	O	O	O	O	O	O
Relaxed	O	O	O	O	O	O	O

Imagine you are a student attending lecture during a heat-wave (33˚C/91˚F outdoors) and there is **MINIMAL air conditioning available** in this room. The stick figures represent students in the lecture.

How would you feel?

	Not at all 1	2	3	Moderately 4	5	6	Extremely 7
Anxious	O	O	O	O	O	O	O
Stressed	O	O	O	O	O	O	O
Hot	O	O	O	O	O	O	O
Comfortable	O	O	O	O	O	O	O
Excited	O	O	O	O	O	O	O
Relaxed	O	O	O	O	O	O	O



Imagine you are a student attending lecture during a heat-wave (33˚C/91˚F outdoors) and there is **MINIMAL air conditioning available** in this room. The stick figures represent students in the lecture.

How would you feel?

	Not at all 1	2	3	Moderately 4	5	6	Extremely 7
Anxious	O	O	O	O	O	O	O

	Not at all 1	2	3	Moderately 4	5	6	Extremely 7
Stressed	O	O	O	O	O	O	O
Hot	O	O	O	O	O	O	O
Comfortable	O	O	O	O	O	O	O
Excited	O	O	O	O	O	O	O
Relaxed	O	O	O	O	O	O	O

Imagine you are a student attending lecture during a heat-wave (33˚C/91˚F outdoors) and there is **MINIMAL air conditioning available** in this room. The stick figures represent students in the lecture.

How would you feel?

	Not at all 1	2	3	Moderately 4	5	6	Extremely 7
Anxious	O	O	O	O	O	O	O
Stressed	O	O	O	O	O	O	O
Hot	O	O	O	O	O	O	O
Comfortable	O	O	O	O	O	O	O
Excited	O	O	O	O	O	O	O
Relaxed	O	O	O	O	O	O	O

Imagine you are a student attending lecture during a heat-wave (33˚C/91˚F outdoors) and there is **MINIMAL air conditioning available** in this room. The stick figures represent students in the lecture.

How would you feel?

	Not at all 1	2	3	Moderately 4	5	6	Extremely 7
Anxious	O	O	O	O	O	O	O
Stressed	O	O	O	O	O	O	O
Hot	O	O	O	O	O	O	O
Comfortable	O	O	O	O	O	O	O
Excited	O	O	O	O	O	O	O
Relaxed	O	O	O	O	O	O	O

Demographic Info

What is your age?

What is your gender?

- O Male
- O Female
- O Non-binary/third-gender
- O Prefer not to answer

What year of university are you in?

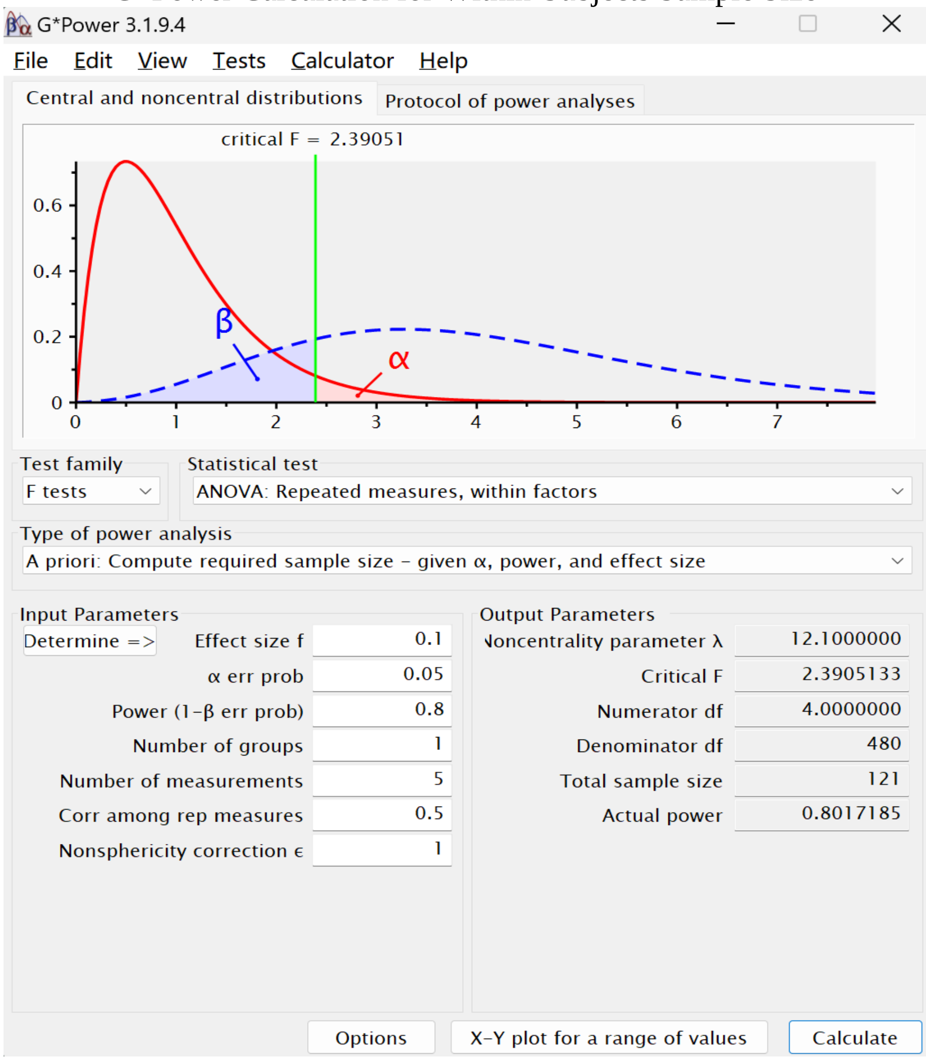
- O 1
- O 2
- O 3
- O 4
- O 5 or higher

Are you a current UBC student?

- Yes
- No

Appendix B

G*Power Calculation for Within-Subjects Sample Size



Appendix C

Figure 1: ANOVA Data Analysis for anxious level

Anxious level Within Subjects Effects:

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Condition	233.702[a]	4[a]	58.426[a]	34.626[a]	< .001[a]	0.280
Residuals	600.698	356	1.687			

Note. Type III Sum of Squares

[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Anxious level Descriptives:

Condition	N	Mean	SD	SE	Coefficient of variation
Occupancy 10	90	3.189	1.878	0.198	0.589
Occupancy 60	90	3.522	1.868	0.197	0.530
Occupancy 110	90	3.900	1.861	0.196	0.477
Occupancy 160	90	4.889	1.692	0.178	0.346
Occupancy 210	90	4.978	1.635	0.172	0.328

Anxious level Post Hoc Comparisons - Condition:

			95% CI for Mean Difference					95% CI for Cohen's d		
		Mean Difference	Lower	Upper	SE	t	Cohen's d	Lower	Upper	p_{holm}
Occupancy 210	Occupancy 160	0.089	−0.247	0.425	0.117	0.761	0.050	−0.257	0.356	0.449
	Occupancy 110	1.078	0.598	1.558	0.167	6.467	0.602	0.270	0.934	< .001***
	Occupancy 60	1.456	0.850	2.061	0.210	6.921	0.813	0.461	1.165	< .001***
	Occupancy 10	1.789	1.086	2.491	0.244	7.331	1.000	0.627	1.373	< .001***
Occupancy 160	Occupancy 110	0.989	0.540	1.438	0.156	6.338	0.553	0.224	0.881	< .001***
	Occupancy 60	1.367	0.809	1.925	0.194	7.051	0.764	0.417	1.111	< .001***
	Occupancy 10	1.700	1.015	2.385	0.238	7.149	0.950	0.583	1.317	< .001***
Occupancy 110	Occupancy 60	0.378	−0.130	0.885	0.176	2.142	0.211	−0.099	0.521	0.097
	Occupancy 10	0.711	0.025	1.397	0.238	2.985	0.397	0.079	0.715	0.015*
Occupancy 60	Occupancy 10	0.333	−0.108	0.774	0.153	2.176	0.186	−0.123	0.495	0.097

* p < .05, *** p < .001

Note. Computation of Cohen's d based on pooled error.

Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the bonferroni method).

Anxious Level Descriptives plots:

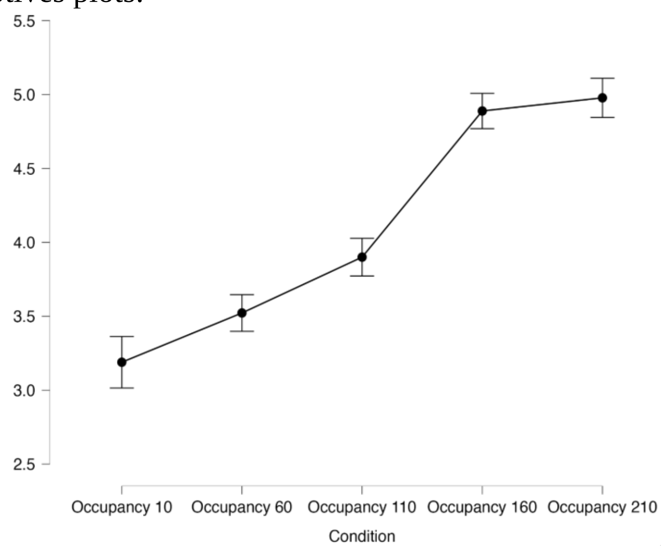


Figure 2: ANOVA Data Analysis for hot level

Hot level Within Subjects Effects:

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Condition	299.444[a]	4[a]	74.861[a]	46.547[a]	< .001[a]	0.343
Residuals	572.556	356	1.608			

Note. Type III Sum of Squares
[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Hot level Descriptives:

Condition	N	Mean	SD	SE	Coefficient of variation
Occupancy 210	90	5.633	1.597	0.168	0.283
Occupancy 160	90	5.378	1.733	0.183	0.322
Occupancy 110	90	4.500	1.717	0.181	0.382
Occupancy 60	90	3.922	1.915	0.202	0.488
Occupancy 10	90	3.511	2.018	0.213	0.575

Hot level Post Hoc Comparisons - Condition:

			95% CI for Mean Difference					95% CI for Cohen's d		
		Mean Difference	Lower	Upper	SE	t	Cohen's d	Lower	Upper	p_{holm}
Occupancy 210	Occupancy 160	0.256	−0.055	0.566	0.108	2.370	0.142	−0.157	0.441	0.020*
	Occupancy 110	1.133	0.683	1.584	0.157	7.238	0.629	0.303	0.955	< .001***
	Occupancy 60	1.711	1.116	2.306	0.207	8.275	0.949	0.590	1.309	< .001***
	Occupancy 10	2.122	1.449	2.795	0.234	9.079	1.178	0.789	1.566	< .001***
Occupancy 160	Occupancy 110	0.878	0.482	1.274	0.138	6.379	0.487	0.172	0.802	< .001***
	Occupancy 60	1.456	0.847	2.064	0.212	6.882	0.808	0.464	1.151	< .001***
	Occupancy 10	1.867	1.156	2.578	0.247	7.560	1.036	0.666	1.406	< .001***
Occupancy 110	Occupancy 60	0.578	0.080	1.076	0.173	3.338	0.321	0.015	0.626	0.004**
	Occupancy 10	0.989	0.348	1.630	0.223	4.442	0.549	0.229	0.868	< .001***
Occupancy 60	Occupancy 10	0.411	0.007	0.815	0.140	2.929	0.228	−0.073	0.529	0.009**

* p < .05, ** p < .01, *** p < .001
Note. Computation of Cohen's d based on pooled error.
Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the bonferroni method).

Hot Level Descriptives plots:

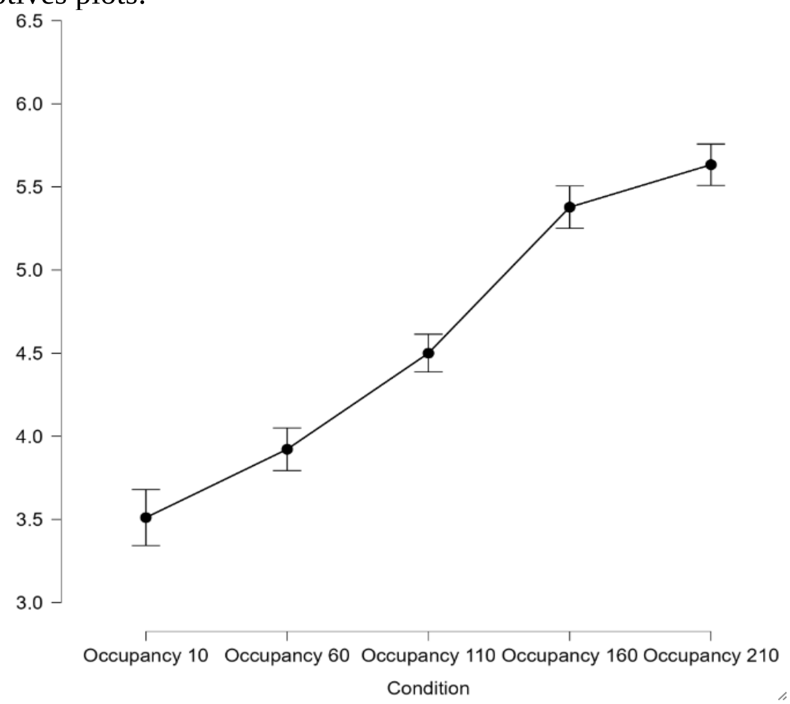


Figure 3: ANOVA Data Analysis for stress level

Stress level Within Subjects Effects:

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Condition	184.213[a]	4[a]	46.053[a]	25.530[a]	< .001[a]	0.223
Residuals	642.187	356	1.804			

Note. Type III Sum of Squares

[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Stress level Descriptives:

Condition	N	Mean	SD	SE	Coefficient of variation
Occupancy 210	90	4.922	1.684	0.178	0.342
Occupancy 160	90	4.856	1.653	0.174	0.340
Occupancy 110	90	3.944	1.795	0.189	0.455
Occupancy 60	90	3.589	1.872	0.197	0.522
Occupancy 10	90	3.378	1.882	0.198	0.557

Stress level Post Hoc Comparisons - Condition:

			95% CI for Mean Difference					95% CI for Cohen's d		
		Mean Difference	Lower	Upper	SE	t	Cohen's d	Lower	Upper	p_{holm}
Capacity 210	Capacity 160	0.067	−0.276	0.409	0.119	0.560	0.037	−0.281	0.356	0.577
	Capacity 110	0.978	0.465	1.490	0.178	5.491	0.549	0.210	0.889	< .001***
	Capacity 60	1.333	0.697	1.970	0.221	6.027	0.749	0.393	1.105	< .001***
	Capacity 10	1.544	0.841	2.248	0.244	6.320	0.868	0.500	1.236	< .001***
Capacity 160	Capacity 110	0.911	0.401	1.421	0.177	5.144	0.512	0.175	0.849	< .001***
	Capacity 60	1.267	0.670	1.863	0.207	6.116	0.712	0.359	1.064	< .001***
	Capacity 10	1.478	0.773	2.183	0.245	6.034	0.830	0.466	1.194	< .001***
Capacity 110	Capacity 60	0.356	−0.135	0.846	0.170	2.086	0.200	−0.122	0.521	0.119
	Capacity 10	0.567	−0.129	1.263	0.242	2.344	0.318	−0.007	0.644	0.085
Capacity 60	Capacity 10	0.211	−0.240	0.663	0.157	1.346	0.119	−0.201	0.438	0.363

*** p < .001

Note. Computation of Cohen's d based on pooled error.

Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the bonferroni method).

Stress Level Descriptives plots:

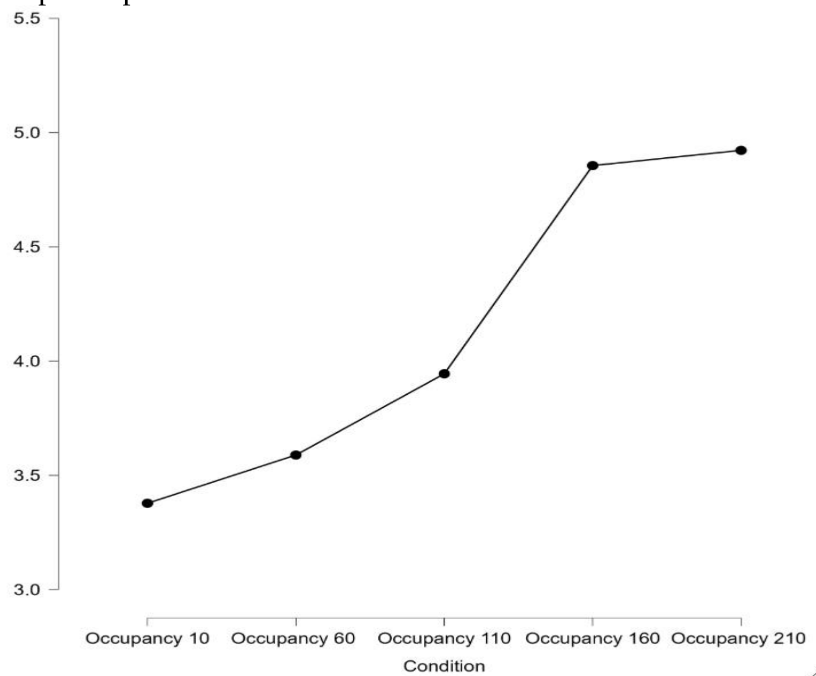


Figure 4: ANOVA Data Analysis for comfortable level

Comfortable level Within Subjects Effects:

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Condition	171.053[a]	4[a]	42.763[a]	25.692[a]	< .001[a]	0.224
Residuals	592.547	356	1.664			

Note. Type III Sum of Squares
[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Comfortable level Descriptives:

Condition	N	Mean	SD	SE	Coefficient of variation
Occupancy 210	90	2.311	1.403	0.148	0.607
Occupancy 160	90	2.522	1.588	0.167	0.630
Occupancy 110	90	3.089	1.577	0.166	0.510
Occupancy 60	90	3.711	1.769	0.186	0.477
Occupancy 10	90	3.856	1.827	0.193	0.474

Comfortable level Post Hoc Comparisons - Condition:

			95% CI for Mean Difference					95% CI for Cohen's d		
		Mean Difference	Lower	Upper	SE	t	Cohen's d	Lower	Upper	p_{holm}
Occupancy 210	Occupancy 160	−0.211	−0.632	0.209	0.146	−1.445	−0.129	−0.462	0.204	0.304
	Occupancy 110	−0.778	−1.333	−0.223	0.193	−4.035	−0.474	−0.821	−0.128	< .001***
	Occupancy 60	−1.400	−1.991	−0.809	0.205	−6.819	−0.854	−1.232	−0.476	< .001***
	Occupancy 10	−1.544	−2.193	−0.896	0.225	−6.857	−0.942	−1.329	−0.555	< .001***
Occupancy 160	Occupancy 110	−0.567	−1.091	−0.042	0.182	−3.109	−0.346	−0.685	−0.006	0.008**
	Occupancy 60	−1.189	−1.723	−0.655	0.186	−6.407	−0.725	−1.091	−0.359	< .001***
	Occupancy 10	−1.333	−1.986	−0.680	0.227	−5.879	−0.813	−1.187	−0.439	< .001***
Occupancy 110	Occupancy 60	−0.622	−1.076	−0.168	0.158	−3.946	−0.379	−0.721	−0.038	< .001***
	Occupancy 10	−0.767	−1.375	−0.158	0.211	−3.626	−0.468	−0.814	−0.121	0.002**
Occupancy 60	Occupancy 10	−0.144	−0.642	0.353	0.173	−0.836	−0.088	−0.420	0.244	0.405

* p < .05, ** p < .01, *** p < .001
Note. Computation of Cohen's d based on pooled error.
Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the bonferroni method).

Comfortable level Descriptives plots:

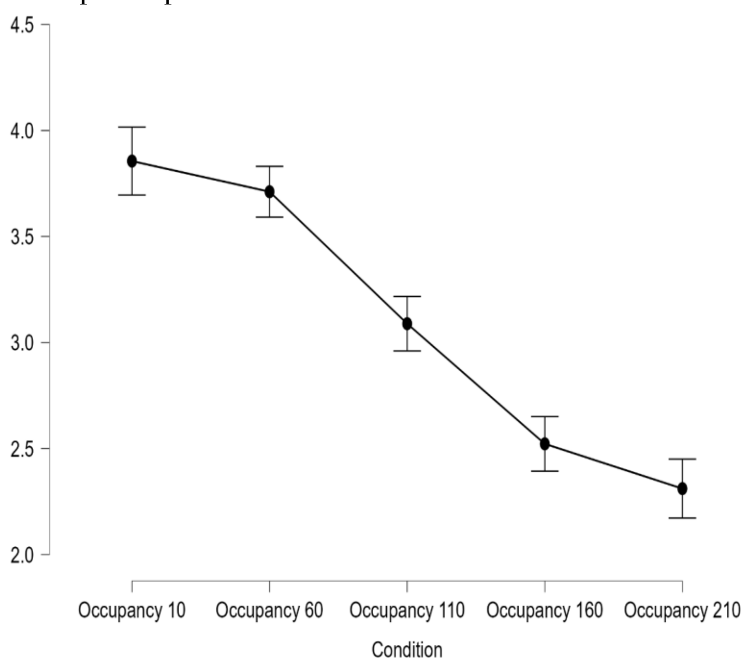


Figure 5: ANOVA Data Analysis for excited level

Excited level Within Subjects Effects:

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Condition	123.298[a]	4[a]	30.824[a]	22.696[a]	< .001[a]	0.203
Residuals	483.502	356	1.358			

Note. Type III Sum of Squares
[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Excited level Descriptives:

Condition	N	Mean	SD	SE	Coefficient of variation
Occupancy 210	90	2.033	1.480	0.156	0.728
Occupancy 160	90	1.944	1.184	0.125	0.609
Occupancy 110	90	2.789	1.569	0.165	0.562
Occupancy 60	90	3.100	1.729	0.182	0.558
Occupancy 10	90	3.178	1.821	0.192	0.573

Excited level Post Hoc Comparisons - Condition:

			95% CI for Mean Difference					95% CI for Cohen's d		
		Mean Difference	Lower	Upper	SE	t	Cohen's d	Lower	Upper	p_{holm}
Occupancy 210	Occupancy 160	0.089	−0.244	0.422	0.116	0.768	0.057	−0.257	0.370	0.889
	Occupancy 110	−0.756	−1.244	−0.267	0.170	−4.453	−0.481	−0.810	−0.151	< .001***
	Occupancy 60	−1.067	−1.633	−0.501	0.197	−5.426	−0.678	−1.023	−0.334	< .001***
	Occupancy 10	−1.144	−1.803	−0.486	0.229	−5.003	−0.728	−1.077	−0.379	< .001***
Occupancy 160	Occupancy 110	−0.844	−1.230	−0.459	0.134	−6.302	−0.537	−0.870	−0.204	< .001***
	Occupancy 60	−1.156	−1.690	−0.621	0.186	−6.227	−0.735	−1.085	−0.385	< .001***
	Occupancy 10	−1.233	−1.832	−0.635	0.208	−5.933	−0.784	−1.139	−0.430	< .001***
Occupancy 110	Occupancy 60	−0.311	−0.701	0.079	0.136	−2.294	−0.198	−0.514	0.118	0.097
	Occupancy 10	−0.389	−0.940	0.162	0.191	−2.032	−0.247	−0.565	0.070	0.135
Occupancy 60	Occupancy 10	−0.078	−0.464	0.309	0.134	−0.579	−0.049	−0.363	0.264	0.889

*** p < .001
Note. Computation of Cohen's d based on pooled error.
Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the bonferroni method).

Excited level Descriptives plots:

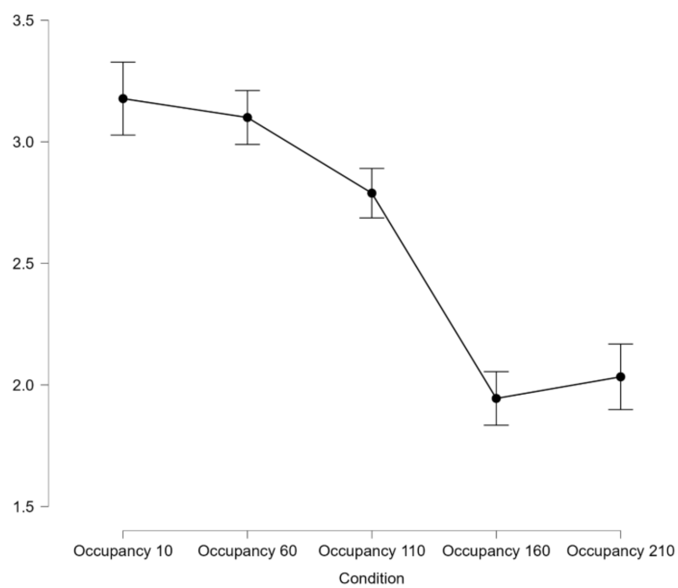


Figure 6: ANOVA Data Analysis for relaxed level

Relaxed Level Within Subjects Effects:

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Condition	267.236[a]	4[a]	66.809[a]	41.265[a]	< .001[a]	0.317
Residuals	576.364	356	1.619			

Note. Type III Sum of Squares

[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Relaxed Level Descriptives:

Condition	N	Mean	SD	SE	Coefficient of variation
Occupancy 210	90	1.933	1.380	0.146	0.714
Occupancy 160	90	1.933	1.305	0.138	0.675
Occupancy 110	90	2.911	1.680	0.177	0.577
Occupancy 60	90	3.422	1.811	0.191	0.529
Occupancy 10	90	3.833	1.831	0.193	0.478

Relaxed Level Post Hoc Comparisons - Condition:

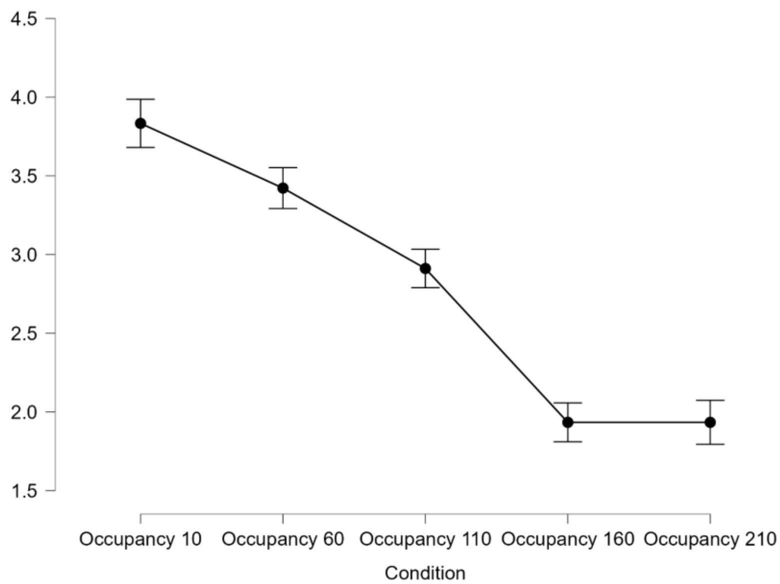
			95% CI for Mean Difference					95% CI for Cohen's d		
		Mean Difference	Lower	Upper	SE	t	Cohen's d	Lower	Upper	p_{holm}
Occupancy 210	Occupancy 160	0.000	−0.346	0.346	NaN	0.000	3.997×10^{-15}	−0.332	0.332	1.000
	Occupancy 110	−0.978	−1.512	−0.443	0.186	−5.268	−0.605	−0.961	−0.249	< .001***
	Occupancy 60	−1.489	−2.111	−0.866	0.216	−6.886	−0.921	−1.306	−0.536	< .001***
	Occupancy 10	−1.900	−2.570	−1.230	0.233	−8.162	−1.175	−1.590	−0.760	< .001***
Occupancy 160	Occupancy 110	−0.978	−1.480	−0.475	0.175	−5.603	−0.605	−0.961	−0.249	< .001***
	Occupancy 60	−1.489	−2.084	−0.894	0.207	−7.200	−0.921	−1.306	−0.536	< .001***
	Occupancy 10	−1.900	−2.514	−1.286	0.213	−8.912	−1.175	−1.590	−0.760	< .001***
Occupancy 110	Occupancy 60	−0.511	−0.967	−0.056	0.158	−3.231	−0.316	−0.655	0.023	0.005**
	Occupancy 10	−0.922	−1.509	−0.336	0.204	−4.527	−0.570	−0.924	−0.217	< .001***
Occupancy 60	Occupancy 10	−0.411	−0.863	0.041	0.157	−2.616	−0.254	−0.591	0.082	0.021*

* p < .05, ** p < .01, *** p < .001

Note. Computation of Cohen's d based on pooled error.

Note. P-value and confidence intervals adjusted for comparing a family of 10 estimates (confidence intervals corrected using the bonferroni method).

Relaxed level Descriptives plots:



Appendix D

Team Member Contribution

Proposal

Research question and hypothesis by all team members
Background literature and anticipated outcomes by Amy and Fengyu
Conditions and measures by Tiffany
Statistical analysis and participant sample by Shuhan
Qualtrics survey by Miranda and graph by Shuhan

Data Collection

Each team member recruited at least 25 unique participants

Presentation

Background and variables by Amy
Demographics and methods by Tiffany
Data analysis and presentation of negative emotions by Shuhan
Data analysis and presentation of positive emotions by Fengyu
Implications and recommendations by Miranda

Final Report

Executive report and introduction by Amy
Methods by Tiffany
Results by Shuhan and Fengyu
Discussion and recommendations by Miranda

Appendix E

Changes to Project Since Proposal

Research Question

Our initial research question in our Proposal asked, "How does classroom capacity impact students' severity of heat-related stress?". After feedback from Dr. Zhao, the teaching assistants, and our SEEDS client, this was altered to "How does classroom occupancy influence students' well-being during extreme summer weather." This change best reflects the purpose of our project to investigate the impact of heat waves on student negative and positive valence in lecture halls of various occupancy levels.

Methods

We reduced the number of conditions in the Proposal from 10 (at occupancy 10, 20, 40, 60, 80, 100, 120, 150, 180, 200) to 5 (at occupancy 10, 60, 110, 160, 210), as to have a G*Power predicted sample size that would be reasonable for the one-month allotted data collection period, as well as to ensure the conditions are evenly spaced apart. Moreover, we changed the manipulations of these numbers from various classrooms of *X* number of empty seats to one classroom with drawn stick figures to represent *X* students occupying the seats. This was done to control the confounding variables of the classrooms having different sizes, lighting, and architectural design. It also makes the manipulation more clear to participants that by occupancy we are referring to students sitting in seats. Additionally, we changed our dependent measure from a Likert-like scale of 3 negative factors (anxious, stressed, and uncomfortable) to 6 factors of both negative and positive qualities (anxious, stressed, hot, comfortable, excited, relaxed) to ensure participants are consistent in their answers and prevent reporting biases.

Data Collection

While we collected over 121 survey responses as G*Power recommended, after sorting through the responses, we found that some submissions were incomplete and had to be removed from the analysis. This may have been done due to our survey being longer or not compatible with mobile screens due to matrix response tables. Thus, we conducted data analysis for only 90 participants, which is lower than the recommended sample size and a reason to question the validity of the results.