USE-HIT Projects 2018-2019

Final Report

Beating the Circadian Cycle

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Introduction*a) Societal and/or scientific reasoning*

In the past years, researchers have struggled figuring out the ideal temperature at offices, universities, and other workplaces for people to be the most productive. Take for example, the new Atlas building of TU Eindhoven, one of the most sustainable educational buildings in the world. Atlas is designed to create a healthy and comfortable working environment for the users by for example enabling good daylight entry (TU/e, 2018). But do these kind of "smart" buildings take into account ambient temperature and its effect on productivity? This might be the beginning of research to try and create the perfect workspace environment to perform. Several studies have made clear that ambient temperature affects productivity (Gorvett, 2016; Tham & Willem, 2010; Wright, Hull, & Czeisler, 2002) . In the study by Gorvett (2016) it was shown that when the ambient temperature dropped in the office, so did productivity. The study by Tham & Willem (2010) concluded that ambient temperature has considerable effects on work performance, more specifically it was stated that a lower ambient temperature can activate the brain resulting in increased mental alertness (Tham & Willem, 2010). Studies like Wright, Hull, & Czeisler (2002) report that a higher body temperature represents physiological arousal, enhancing human performance and improving alertness. (Wright, Hull & Czeisler, 2002). These results still leave discussion points, does a lower ambient temperature activate the body, raising ones body temperature, and how does this relate to alertness and productivity? Leaving the question how to optimize ambient temperature to create ideal working conditions. To study the optimal ambient temperature, skin temperature and ambient temperature will be measured, in order to determine how these values affect human performance. The question for this research remains: what is the best way to acquire skin temperature data, which is comparable to the core temperature and is there indeed a relationship with alertness? This study will consist of a combination of a literature study and a small-scale field study. The literature study will focus on finding the best locations to measure skin temperature when trying to approach core temperature values, whereas the field study is focused on finding a relation between skin temperature and alertness. Leading to two different research questions.

b) Research questions

1. When measuring skin temperature, which locations on the human skin approach the core temperature the most accurate?

2. How does alertness relate to the skin temperature as measured at the found locations?

c) Hypothesis

1. It is expected that the location where the skin temperature can be measured ideally and approaches the core temperature the best is not covered with clothes, but neither is exposed to external factors (MacRae, Annaheim, Spengler & Rossi, 2018; McFarlin, Venable, Williams & Jackson, 2015).
2. It is expected that the measured skin temperature relatively corresponds to the core temperature. Consequently, this indicates that the higher the skin temperature the more physiological arousal the higher the level of alertness. When skin temperature is raised or lowered in a more extreme fashion, impairment of alertness is expected.

Literary Research

Circadian rhythms are biological processes that follow a 24 hour cycle. Natural factors within the body produce circadian rhythms. However, environmental signals may also affect them. The main factor influencing circadian rhythms is daylight. Daylight can activate and deactivate genes that control the molecular structure of biological clocks. Changing the light-dark cycles can speed up, slow down, or reset biological clocks as well as circadian rhythms (Turek & Vitaterna, 2007). Circadian rhythms can influence sleep-wake cycles, hormone release, eating habits and digestion, body temperature, and other important bodily functions. Biological clocks that run fast or slow can result in disrupted or abnormal circadian rhythms. Irregular rhythms have been linked to various chronic health conditions, such as sleep disorders, obesity, diabetes, depression, bipolar disorder, and seasonal affective disorder (Farhud D., 2018).

The studies of Wright et al.(2002) and Xu et al.(2013) show that performance improves when body temperature is high or near its circadian peak and performance deteriorates when body temperature is low or near its circadian minimum. The study of Wright et al.(2002) studied fourteen subjects, the participants followed a forced desynchronized protocol which allowed a determination if there is a relation between body temperature and performance. The study was conducted while controlling the circadian phase and hours awake, resulting in a found correlation between increased body temperature and enhanced performance and alertness.

Krauchi and Wirz-Justice (1994) performed a study where a peak and a minimum appeared in a smoothed circadian rhythm of temperature. The reduction in amplitude indicated the effects of the sleep-wake cycle upon the circadian rhythm. This rhythm in temperature is only attributed in a constant routine upon which it is attributed to the body clock alone, which has a more clearly defined maximum at 17:00h. Results from a study of Waterhouse et al.(2005) show a peak in core temperature (measured as rectal temperature) at 22:00h and a minimum at 05:00h just after the mid-point of sleep. Baehr et al. found that, in young adults, the daily body temperature minimum occurred at about 04:00h for morning types and at about 06:00h for evening types. This minimum occurred at approximately the middle of the eight-hour sleep period for morning types, but closer to the moment of awakening in evening types. These results combined with the graph of Beersma and Gordijn (2007) indicate a maximum of alertness nearing the end of the day and a minimum early in the morning. Thus, providing proof for a relation between the rhythm of core temperature and alertness.

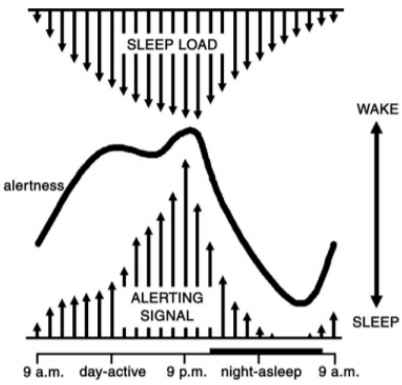


Figure 1: Illustration of circadian cycle with alertness.(Beersma & Gordijn, 2007)

In addition, physiological and biochemical bodily processes (such as heart rate, blood pressure, and body temperature) generally are found temperature dependent and change with ambient temperature. Hence, the effects of the temperature on the regulation of circadian rhythms also depend on environmental factors (Zheng et al., 2019).

Choosing an appropriate location to measure skin temperature

The accuracy of the measurement of skin temperature depends on the selection of a suitable location for carrying out the measurement and the use of a suitable procedure. The core and skin temperature of a healthy person change during the course of the day, depending on their activity and exposure to external factors. The research of Nielsen and Nielsen (1984) showed that in cold environmental conditions the temperature of certain skin areas differ from the average skin temperature. The sensitivity to thermal stimuli is different between skin surface areas (Nielsen & Nielsen, 1984).

Selecting the right location to measure skin temperature is important to determine a relation between alertness and ambient temperature.

Huizenga, Zhang, Arend, and Wang (2004) observed fluctuations in hand and finger skin temperature in neutral conditions. This suggests that near the thermal neutral zone, the temperature does not represent the body's thermic status. The research found that muscular activity can cause a fluctuation in skin temperature as much as 3°C in a cold environment. The core temperature was measured to be very stable in steady-state, uniform thermal environments. It responded to the cooling and warming of local body parts by reacting in the opposite direction of the skin temperature. When tested on the scalp, a relationship was observed between scalp temperature and the core temperature (Daanen et al., 2015). If the scalp was cooled down with certain degrees, the core temperature of the patient increased with the same amount of degrees.

Several locations have to be considered when measuring skin temperature. Oral and rectal temperature measurements would correspond most closely to the core temperature. The rectal temperature is generally 0.3 °C – 0.4 °C higher than the oral temperature (Geratherm, (n.d.)). However, oral and rectal measurements are disregarded from a practical point of view. A different possible measuring location would be the eardrum. The eardrum should be a sufficient location for temperature measurements, as it is supplied with the same blood as the hypothalamus which is involved in the regulation of body temperature (Wright et al.,2002). However, with the available equipment, this location is not realizable. Another possibility to measure temperature is the armpit. The armpit is probably the oldest location for determining body temperature. The first temperature investigations by the German physician Wunderlich a century ago were carried out using exclusively axillary measurement (Mackowiak & Worden, 1994). This led to the introduction of daily temperature measurement in hospitals all over the world where axillary measurement became standard practice. Since this location is as pleasant as realizable, axillary measurements are found appropriate to measure skin temperature. In the end, ideal measurement points are body cavities close to major blood vessels. Hence, a different precise measurement result can be obtained from the forehead because it is close to major blood vessels (Geratherm, (n.d.)). Therefore, measurements on the forehead were applied as well.

The goal of this literary research was to determine time and location to perform the experimental research. This resulted in taking three tests at different times during the day: Near the circadian minimum (09:00h) and maximum (17:00h) of alertness and in between this minimum and maximum (12:00h). In addition, the determined locations for skin measurement are the forehead, diaphragm, armpit and dominant hand.

2. **Method**

Brief explanation of the field study

In order to measure skin temperature, the iButton can be used. In part 1 of this research, a literature study, the ideal location(s) on the body for the iButton were determined from which the most accurate value of skin temperature could be obtained. In the second part of this research this information is used to study the influence of skin temperature on subjective and objective alertness of people. In the field study that is performed the room temperature of the room in which subjects will perform a psychomotor vigilance task (PVT) (alertness test), will vary on the days of testing.
For 2 days, a subject performs a PVT of 10 minutes three times a day, every day in the same time slots. Each day the subject will be exposed to a different room temperature while performing the PVT. Because the test is performed every day in the same time slots, the influence of the body temperature due to the circadian cycle can be neglected, which means that possible differences in alertness may be due to a change in room, and thus skin, temperature.

Goal

The goal of the field study is to conclude whether skin temperature, influenced by the room temperature, influences one's alertness. Data necessary for this goal is a curve of a subject's skin temperature from which the skin temperature at the time of performance of the PVT can be obtained. The second set of data required for the goal are the values of alertness, obtained from the subjects' PVT for three times a day, three days in a row.

Participants

For the field study three male university students from Eindhoven University of Technology agreed voluntarily to participate in the study for alertness testing. All three participants were between the age of 19 and 23 and have a dutch origination. Because of a lack of choice for this field study these participants were chosen for no comparisons but their sex. This means the participants differed in weight, height and physical conditions.

Materials

- 13 iButtons
  (4 per participant, 1 for room temperature)
- Tape
  (To fasten the iButtons to the skin)
- Room with adjustable room temperature
  The temperature of the room where the PVT will take place has to be adjustable and visible via a thermostat. This way the given temperature and the measured temperature of the iButton's can be compared for the results.
- 3 laptops
  (for performing the PVT)
- PVT
  The PVT has to be installed on the laptops before starting the study. The PVT used was free to download from http://bhsai.org/downloads/pc-pvt/.

Design

The field study uses a within-groups design where the outcome of the individual participants is compared the outcome of the others. The study makes use of several independent variables, like age, physical condition, height, weight and the set room temperature. Dependent variables that are measured are the subjective and objective alertness of the participants, and the measured temperature by the buttons, as well the buttons fastened on the skin as the button that measures the room temperature.

Procedure

Preparing the location

To make sure that the field study can be executed in a consistent way, some preparations concerning the test setup have to be made in advance, starting with the location of the test. To make sure that external factors will not affect the outcome of the study the design has to be as consistent as possible. To accomplish this, a room in the house of one of the group members will be used for two days (Wednesday the 13th of March and Friday the 15th of March). At the beginning of each of these days, at 8:45 AM, the temperature of the room will be set at the desired temperature using the thermostat. The temperatures on Wednesday and Friday are respectively 17 and 22 degrees Celsius.

Preparing the sensors

To measure the temperature, 13 iButtons will be used in total, 4 on each of the 3 subjects one layed down to measure the room temperature. The buttons have to be activated to be ready for use in advance. The buttons will measure temperature every 300 seconds with an accuracy of 0.0625 degrees Celsius, the start time for each button was set to be activated at the same time.

Execution of the experiment

When the desired (stable thermostat) temperature is reached the 3 subjects can enter the room. All 3 subjects are male and in the same age range to keep the conditions consistent. The buttons are attached to the 4 locations on the skin of each subject using tape. The location of the 4 buttons is the same for each of the 3 subjects. The locations obtained from the literary study are as followed: the center of the forehead, the upside of the dominant hand, 5 cm below the diaphragm, and 5 cm below the armpit on the side of the dominant hand. When attached, the buttons get 15 minutes to acclimatize to the temperature of the skin.

Each subject needs a laptop, on which the PVT will be executed. Before taking the test, during the acclimatization of the buttons, the subjects will be informed about the study and need to sign a consent form. After signing, the subjects will be instructed on the test. During the test participants must remain silent. At the start of the test the participants set a value between 1-10 on the sleepiness scale, after answering the participants remain idle till the 'start'-signal is given. When a subject finishes, he has to remain silent. When all subjects have finished the PVT, the buttons can be removed. The PVT will last 10 minutes.

3. Results

a. *Hypothesis testing*

The hypothesis by this methodological research was the expectation of a correspondence between the core temperature and the measured skin temperature. However, as the core temperature is not measured, it is not possible to determine a correspondence between the core temperature and the measured skin temperature. It was also expected that an altered skin temperature would relate to alertness. Measurements of alertness were performed with the PVT. Figure 2 shows the relation between the skin temperature per different location and the response speed as a rate of alertness, at a certain ambient temperature kept as constant as possible during the day of measurement.

During Wednesday (measurement day 1) the temperature of the forehead increased from 30.97°C measured in the morning to 31.41°C measured in the afternoon, an 0.44°C increase. The diaphragm temperature increased from 30.53°C measured in the morning to 32.30°C measured in the afternoon, an 1.77°C increase. The armpit temperature increased from 31.86°C measured in the morning to 34.27°C measured in the afternoon, an 2.41°C increase. The temperature of the hand decreased from 26.79°C measured in the morning to 26.27°C measured in the afternoon, an 0.52°C decrease. On Friday (measurement day 2) the temperature of the forehead between the morning and afternoon measurement increases with 0.02°C, between 33.48°C and 33.50°C. The noon measurement shows an increased temperature with a value of 33.68°C, the highest measured forehead temperature that day and an 0.80°C increase from the lowest forehead temperature measured that day. The diaphragm temperature varies from 32.81°C in the morning to 33.63°C in the afternoon, an 0.82°C increase. The noon measurement shows a decreased temperature with a value of 31.92°C, the lowest measured diaphragm temperature that day, and an 1.71°C decrease from the highest diaphragm temperature measured that day. The armpit temperature varies from 34.25°C in the morning to 34.52°C in the afternoon, an 0.27°C increase. The noon measurement shows a decreased temperature with a value of 33.70°C, the lowest measured armpit temperature that day, and an 0.82°C decrease from the highest armpit temperature measured that day. The temperature of the hand decreased from 32.18°C measured in the morning to 30.40°C measured in the afternoon, an 2.41°C decrease.

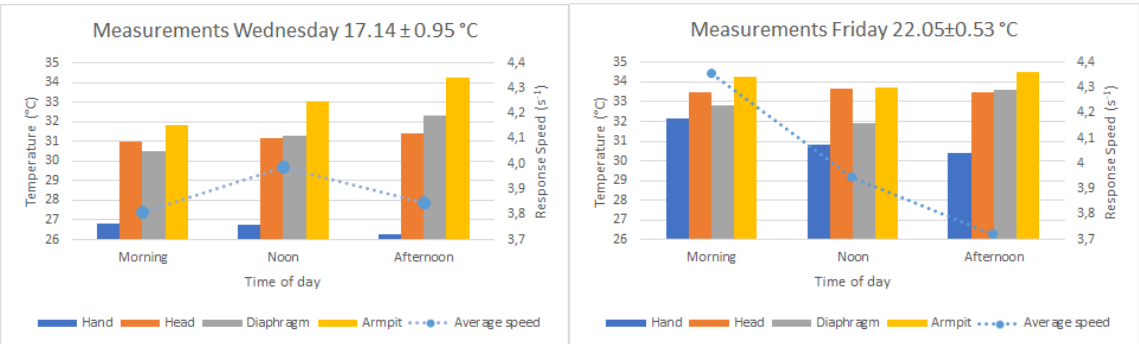
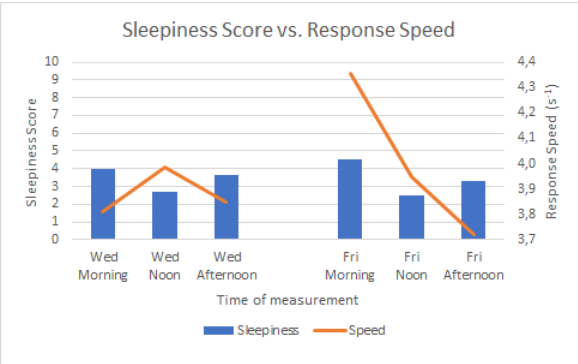


Figure 2) The relation between the skin temperature per different location and the response speed as a rate of alertness

For the level of alertness, the inverse of response time has been chosen, showing the response speed. On wednesday, the response speed in the morning was the lowest of the day, with a value of 3.81 s^-1, the noon PVT gave the highest response speed value at 3.99 s-1. The afternoon PVT value lowered to 3.85 s-1. The Friday PVT response speed values show decreasing values as the day passes. With the morning value at 4.36 s-1, noon at 3.95 and afternoon at 3.72. The skin temperature on Wednesday morning was lower on all locations compared to the skin temperature on Friday morning. At noon the response speed is comparable between both days, the skin temperatures are not comparable. In the

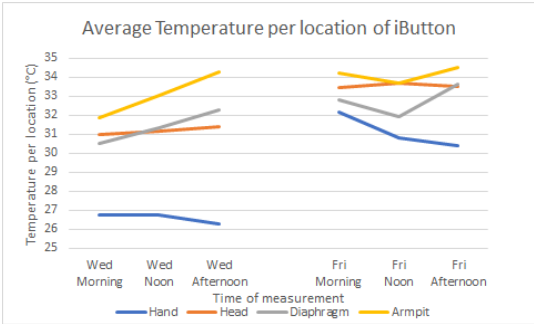
afternoon, Friday reads a lower response speed than Wednesday, the skin temperatures of the hand, head, and midriff are higher.
The results show that there is a difference of 0.55 s-1 in response speed between the response speed on Wednesday morning with a value of 3.81 s-1 and Friday morning with a value of 4.36 s-1. The difference between the noon measurements is 0.04 s-1 (3.99 s-1 on Wednesday, 3.95 s-1 on Friday).
The difference between the afternoon measurements is 0.13 s-1 (3.85 s-1 on Wednesday, 3.72 s-1 on Friday).

In advance of each PVT the participants set a value between 1-10 on the sleepiness scale. Figure 3 shows the results of the average sleepiness score of the participants at that measuring moment versus the average response speed of all participants. Average participant sleepiness values show participants experience the highest sleepiness value in the morning on both days, sleepiness values decrease during the day, but increase again near the end of the day. As stated before, on Wednesday response speed peaks during the noon PVT session, with similar values for the morning and afternoon PVT sessions. On Friday, response speed peaks during the morning PVT session and decreases during the rest of day.

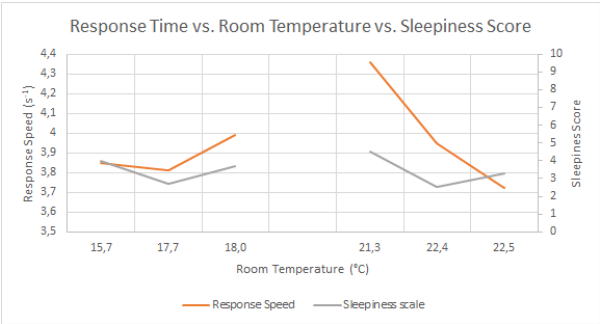


b. Exploratory analysis

Figure 4 represents the time of measurement versus the temperature per location. On Wednesday hand temperature was 26.79°C in the morning, decreasing to 26.27°C in the afternoon. Forehead temperature was 30.94°C in the morning, increasing to 31.41°C in the afternoon. Diaphragm temperature was 30.53°C, increasing to 32.30°C in the afternoon. Armpit temperature was 31.86°C in the morning, increasing to 34.27°C in the afternoon. On Friday hand temperature was 32.18°C in the morning, decreasing to 30.40°C in the afternoon. Forehead temperature was 33.48°C in the morning, comparable to 33.50°C in the afternoon with a maximum temperature of 33.68°C at noon. Diaphragm temperature was 32.81°C, increasing to 33.63°C in the afternoon, with a minimum temperature of 31.92°C at noon. Armpit temperature was 34.25°C in the morning, increasing to 34.52°C in the afternoon, with a minimum temperature of 33.70°C at noon. All temperature values increase compared to Wednesday.



Since it was also important to test the effects of ambient temperature on alertness, figure 5 describes the relation between ambient temperature, response time and sleepiness score. Figure 5 shows that an increase in ambient temperature from approximately 15.7°C to 18.0°C improves subjective, read sleepiness score, as does objective alertness. From 21.3°C to 22.5°C the objective alertness, read response speed, decreases heavily and subjective alertness does not.



4. **Conclusion and Discussion**

a. Brief repetition of what is investigated

Although several studies show that core temperature relates to alertness, skin temperature is easily manipulated by little changes in ambient temperature (Wright K.P., 2002; Xu, X., 2013). Therefore, the question was asked whether skin temperature also influences one's alertness in order to obtain a clear view on how ambient temperature can be adjusted to improve people's alertness. In order to do so, three subjects performed a PVT under differing ambient temperatures in order to be able to draw a conclusion on the relation between skin temperature and objective alertness. The subjects also answered the question of how sleepy they were on a scale from 1 to 10 to determine if the objective and subjective alertness correlated.

The results show an increase in response speed of 0.55 s-1 in morning measurements when the ambient temperature was 22.05±0.53°C compared to the response speed with ambient temperature at 17.14±0.95°C. On all locations where skin temperature was measured, the skin temperature was higher on Friday with the high ambient temperature than on Wednesday with the low ambient temperature. Without statistical testing, there seems to be a relation between alertness and skin temperature in the morning, as a higher ambient temperature relates to a higher skin temperature, which seems to relate to a higher response speed, thus alertness, in the morning.

The results from the noon and afternoon measurements conclude that there seems to be no specific relation between alertness and skin temperature at different moments during the day.

However, there seems to be a relation between hand temperature and ambient temperature. A higher ambient temperature raises the hand temperature, similar results were found for the forehead temperature. Possible explanations for this might be that these body parts are not covered by clothing and are thus more influenced by ambient temperature. Though, one would suspect there to be similar relations between diaphragm and armpit temperature and ambient temperature. A possible reason for this might be the length of the measurements with the iButtons. The iButtons were acclimatized for 15 minutes and were on the body for about 15 minutes during PVT, but covered iButtons might need to be acclimatized even longer to give clear data.

b. What do the findings imply for scientific theory, our scientific understanding?

The findings call for discussion and further research of the scientific theory and field-study. In literature, it is written that there is a relation between alertness and skin temperature. Found data from this study shows that the expected relation between alertness and skin temperature seems to exist, but only in the morning. This could mean that ambient temperature is most important for alertness during the morning, but the rest of the day energy might be saved as ambient temperature

seems to have no relation to alertness during the rest of the day. The test locations on the body for this research were chosen to approach core temperature measurements. The skin measurement locations were chosen to receive the most accurate skin temperature data, corresponding best to the core temperature. Found data implies that the literary research was sufficient. The locations that were found seem to correspond with the core temperature.

c. What do the findings imply for societal issues?

Literary findings imply that to increase alertness at offices and other workspaces where alertness is preferred, ambient temperature should be lowered to circa 18°C in the morning. As the day passes the ambient temperature raises due to the daily processes in that room and people present. However, nearing the end of the workday ambient temperature will have less influence and thus the temperature can be lowered to save energy. Though, data from the field study does not show the same relation. In this case, a higher ambient temperature during the morning should improve alertness, a stable ambient temperature without heating during the rest of the day should be sufficient in workspaces.

d. Limitations

The results from this research show that there seems to be a relation between alertness and skin temperature in the morning, but there is no evident proof of the relation between alertness and skin temperature during the rest of the day. The results might not be as reliable as needed to draw clear conclusions. For example, the experiment was only performed by three participants which is a small sample size. This means that possible outliers have high impact on the data and the conclusions drawn from this data. More data with statistical research could either prove the relation between alertness and skin temperature, or reject this relation. Besides that, participants were chosen in-group, meaning that the participants have not been selected by same height, weight, health, etc., which are possible factors that can influence someone's alertness or skin temperature changes, due to changes in ambient temperature. The experiment was only executed under two different ambient temperatures (17.14±0.95°C and 22.05±0.53°C) which may not be sufficient to get a clear view on the changes in alertness due to changes in ambient temperature, since boundaries of significant temperatures have possibly not been visualized. Moreover, the experiments were not conducted in a climate chamber and the participants were not present in the experiment room for the whole day. This might influence results as temperature fluctuated. Another limitation was that data from iButton no. 27 could not be extracted. This might influence one participants results and thereby the whole dataset.

e. Future research

For future research it might be valuable to repeat the experiment with a larger sample size and a larger range in environmental circumstances. For example, perform the experiments in a climate chamber with the participants isolated during the time being of the experiment, so conditions remain stable during the experiment.

f. Final conclusion.

The final conclusion for this research is that the found locations in the literary research seem to be sufficient implications for measuring the skin temperature which resembling an accurate value close to the core temperature of the participants. Based on the field-study data, without performing statistical tests, there seems to be a relation between skin temperature and alertness in the morning. A higher skin temperature seems to have a positive effect on response speed, thus alertness. It is not possible to determine a relation between skin temperature and alertness during the rest of the day. Nevertheless, without performing statistical tests due to the limited sample size,

there seems to be a visible relation between hand temperature and ambient temperature, since a higher ambient temperature results in a higher hand temperature, a lower ambient temperature results in a lower hand temperature. This conclusion applies for the forehead as well.
The data of the sleepiness score suggests no clear relation between the subjective measurements of alertness from the sleepiness scale and the objective measurements of alertness from the response speed. In addition, there seems to be a small diversive relation between the hand temperature and the other locations where temperature was measured on the body. Once the hand temperature decreases there seems to be a small increase in the temperature at diaphragm, forehead and armpit. Hence, proximal temperature increases when distal temperature decreases.
Data shows no clear connection between subjective and objective alertness, so it could be stated that the ideal ambient temperature to improve alertness is located between 18.0°C and 21.0°C based on the data from this study.

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6. Reflection

Julia de Bode (1249185)

The learning goals of this course was to gain knowledge of working with an on-going research. As to apply the knowledge and skills that were acquired in the USE-HIT Exploratory Course and USE-HIT Advanced Course to a specific HTI-topic. In addition, to report on first-hand experience with actual HTI-research. In this case the research was about the relation between alertness and temperatures. The learning outcomes are correspondent with the learning goals. I gained some knowledge about working with an ongoing research and was able to apply knowledge gained from the previous USE courses.

During this research we had to perform several activities. There were several meetings with the tutor which I was able to attend all times. We had to prepare performing the PVT for which we had to search for an appropriate PVT and download the software. I was able to find an appropriate one in which we collect raw data and was able to explain to the other group members how to download and use the software. Other activities involved separate meetings, these did not happen as often.

There has been some competence development during this project. I improved my skills in Excel by converting all the raw data into usable graphs. I also improved my skills in searching for relevant literature as the correct way to reference sources. At last, gained more experience with working in groups where each member has a busy schedule, which made interdependency difficult. Concerning personal growth, I learned to take more responsibility and initiative in group projects while taking sufficient distance as well.

In my opinion, the personal effort and team effort was not in line with each other. There were several moments in which I felt some other members could put in some more effort to help the research or could put in some more work to help others. The division of labour was also uneven. I do not believe all members put in a same amount of hours into this project. I worked on the literary research and processing the data, both large parts of the project, I worked on this with another member. Before the break it was decided to finish the literary research during the break. This should have been done by 4 members, however only 2 members performed literary research (one is me), 1 member attributed less and 1 member attributed nothing. His explanation was personal problems, which I can understand since we all have some issues regarding school or other personal factors. Some members were able to compensate the difference with volunteering to give the presentations or work on other parts separate from the report.

To continue, although present at meetings, after the meeting some members were not reachable enough. Some members showed initiative by asking questions in the group chat on how they could participate more, however others did not show this effort. This was also one of the issues this group has had; the bad/lack of communication. This is definitely something that should be improved, since it made planning extra meetings difficult as was dividing the work evenly.

Reflection Paul Roelen 1255576

Since I got the feeling that the Industrial Design department does not really focus as much on doing research as other departments I was looking forward to do the USE HIT project course with other departments. On beforehand I hoped to get more knowledge about the general research setup and planning. At the department of Industrial Design, I followed a course that taught us to do a Design Research, to do another kind of research – as seen in this project – would add upon that, I expected.

Because of the multidisciplinary group combination I think I learned a lot of this course. Especially general things about the research. That was partly because the other team members had more experience with executing such a research.
I got familiar with planning a field study, in particular the methodology, and getting aware of things to take into consideration when setting up such a study. This is quite a hassle since you have to do the research as consistent as possible. Besides I learned to write this all down in a way that the reader understands and would be able to replicate.
I also learned to elaborate a small piece of a larger, already ongoing, research. This was quite interesting, since you get another context and specified measurement methods and instruments. Furthermore I learned doing a field study myself, since a lot of research consists of work in advance and documentation, I never did such a field study like this.

During the research we did multiple activities, with the help of our tutor Maaike during the tutor meetings we prepared a small field study based on the previous done literary part that provided information for the field study. I was preparing and writing the methodology part and was a test-person myself. I really liked the way of working, discussing the tasks in the meetings and working on those tasks individually.

One of the things that clearly could have been improved is the communication. Because of the different departments, team members also had different, and often busy, agenda's. This made the planning sometimes hard and it caused team members to work(along) each other, rather than with each other. I didn't really got the feeling that everyone knew what the other team members were doing. Maybe because of the buys agenda's team members worked on tasks on beforehand, without discussing it. One of the team members also responded quite late, which made it even harder. Sometimes people had other, more important, things to do or deadlines were coming up and then their work was passed on.
These are reasons that the work was not completely equally divided I think. There was not a lot of communication about the division of the work. I tried to compensate the inequality of work by taking the responsibility for the presentation.

In general I think that everyone tried to contribute to the project, also during the tutor meetings. Everyone had input in a quite assertive way in my opinion, especially in the meetings. Furthermore, the project was finished in time and I think with a quite high quality as well.

Although such a research was quite new for me I think a learned a lot about the setup of such a research, even when I sometimes got the feeling that my knowledge was quite lacking regarding the subject.

Fabiënne Kremers (1227128)
At the Biomedical Engineering department, we work quite a lot with group projects. More than other departments, I think. So I looked forward to start this course of the USE-HIT. The learning goals for this USE-HIT project were to work together with other departments and to gain some knowledge while you work together on a on-going research. You have to apply the knowledge you acquired in the two courses you have had before of the USE-HIT course.

For me, I think I learned how to work together with a multi-disciplinary group with people from other departments. Everyone has their own point of view of the research and to combine that knowledge is sometimes difficult.
I got familiar with organizing a field study and how to get all the circumstances for the participants as even as possible. As the field study was held at my place, I had to make sure the field study went well and everybody felt the same about the circumstances.
I also have learned to work together on a on-going research. How a real research is going, and how a small group like us can help such a group to get along with their project. That motivated our group the most, I think.

In this project, at the beginning I helped a lot with the finishing of the IRP. I helped a bit with writing the literary part but mostly by preparing the field study and by helping how to process the right data. I put a lot of effort in getting the right data out of the full data with the right times and scores, and I organised the field study. I also attended all the meeting with our tutor Maaike, and prepared this meeting, so I knew what she was talking about. She taught us a lot about how to write a proper report and to write in the right style in English. Finally, I helped a lot with finishing the final report. I checked the whole report on little mistakes and structuring the whole. I converted it and putted all the sources according to de APA-style if not already done.

I think, the personal effort and team effort are not equal. Some team members did quite a lot for the whole research and other did less. The tasks we did divide every meeting, were afterwards less or more work than expected. Some team members did know this and helped the other. Most of the time, if someone felt that it was a lot of work, they asked in the WhatsApp group chat for help.

The issues that there were for our group, is the lack of communication and division of labor. Sometimes, some team members were not that reachable. That came because of our busy agenda, because everyone has another department with other courses. This was for us as a team hard, because we had to plan meetings and we had to get this report finished in time. But I also think not everybody in the group had the same knowledge about the project, but I think everybody compensated that with other activities in the project and I think everybody has contributed their own part of the project.

Nevertheless, I think this was an educational course of the USE-HIT course. I hope we did enough to get a great grade for this course. I learned a lot from this course and also about the subject we talked about in our research.

Post-hoc reflection J. W. Baartman (1264621)

Before I started this USE-HIT project course, I wanted to apply my knowledge as a biomedical engineer in our multidisciplinary group. However, our group contained of one Industrial Design student and five Biomedical Technology students. This lead to a level of basic knowledge in our group that was alike, since most of us study the same discipline.
I wanted to apply the knowledge that I had gained in the previous USE courses as well, which was what I really liked about this course. We were free to use all the principles that we were taught we all could choose the project that we liked the most. I liked this a lot, because this project is way more fun for me than a programming project would have been. The field study, that this project was partly about, was different than the projects that I usually participate to, which I thought was really fun. I think that we should have done more measurements, but this was not possible in the tight time-schedule.

Our research consisted of two different parts, literary research and field studies. We used literature to find the best locations for the sensor to measure skin temperature and to gain more insights about the circadian cycle for instance. In my field, literary research is common for most projects, but the field study with the iButtons was a new aspect for me.
I gave the midterm presentation, together with Rens Meijers. This helped me to work on my personal goal to become better at presenting in English for a big audience. In English, I tend to struggle more than with presenting in Dutch, so this was a good moment for me to work on this.

In this course, I contributed to the presentation and preparing this, the method, hypothesis and the field study. I learned a lot from our supervisor and how she looks at writing reports. She taught me several techniques and English writing enhancing skills. I think it was very useful to have this personal contact with our supervisor, since she gave many tips in every meeting that we had.

In this course, it was a bit hard to work on the report together, since we all had different time schedules throughout the weeks. There were almost no moments when we all were able to work on the project together. This lead to the point that we were not up to date of what others did and knew about the topic. If we would have more meetings, this might not have been the case, since we could update each other on what we have been working on. During our meetings, we usually only had time to talk about the report and not enough time to inform the others on what has been done.
Besides that, the division of labour was skewed, some members of our group participated more than others. This should have been better, starting with the communication among group members.
More meetings, without supervisor, could have contributed to this as well, since every group member would have felt more responsibility for the project.

The first weeks of this course had a tighter schedule than the last weeks, at least in my opinion. We had to work hard to get the intermediate report ready in time, because we had to learn about our project first, before we could start working on our report. Together with this came the presentation, for which I had less time to prepare than I would have wanted. Nevertheless, I was satisfied with the outcome of the report and presentation. In the weeks after, we had more time to do our research and field study and to work on the final report. This was more balanced in my opinion.

Post-hoc reflection R.B.B. Meijers, 0953346

Learning goals and outcomes

Learning goals were to apply the knowledge and skills as acquired from the past HTI courses on a specific HTI topic, in our case: Cold focus, the relationship between alertness and bodily temperatures. Also, it was intended to get first hand experience with HTI research In my opinion, there is social relevance in the subject of cold focus so skills from the HTI courses can be applied. The field-study we did was indeed a good way to get first hand experience with HTI research. However, the field-study could not be very elaborate because of the timeframe, which was a bit disappointing.

Activities

Our report was divided into two parts, the literary research and the field-study. Writing the literary research was comparable to the literary research of a biomedical engineering project. The field-study with the iButtons and PVT was a good introduction in the HTI field. Also the presentation I gave and the IRP were activities that had to be finished during the project.

Competence development

For competence development, giving the IRP presentation was an extra moment to develop presentation skills. Also working in a different research group than BME can be seen as development.

Individual growth and evaluation of personal effort

For individual growth, working in a multidisciplinary group in a different field is a perfect way to grow as an engineer. Performing presentations and writing reports in English is always important to grow as an individual. My personal effort focused on the presentation, IRP and writing the conclusion/discussion and describing the results. In the end, a lot of work was put in re-writing and adjusting the report.

Team effort and division of labor

Team effort proved to be quite tough this course, full schedules from the students as well as the supervisors can be seen as the main cause. Freedom to plan your own meetings can give stress and is not necessarily good for team effort and division of labor. Labor was not always fairly distributed in my opinion. Julia's effort stood out compared to the rest of the group, doing the largest part. After the IRP and presentation, I thought other students would become more active and contribute more, this did not happen as much as expected.

Relevant personal and group issues that went well or could be improved

In my opinion, the IRP and presentation went well, but deadlines in advance of this seemed hard for the group. I had to finish a large part of the IRP not far before the deadline when I actually wanted to work on the presentation. The final report was finished on time, without large problems. The largest thing to improve is communication and division of labor. Cause not everyone contributed enough in my opinion.

Amy Roos (0995977)

Learning goals and outcomes:

However with the previous USE project that I executed for the course "User experience for intelligent systems" I felt that the subject of the project was was not something I was interested in, I was really happy that in this course projects were offered in which I believed I could combine my biomedical knowledge with the knowledge I gained from previous USE courses. I liked that we had to set up a field study ourselves from the beginning and hoped to learn more about how a setting up proper research question and execution could be done. I learned that with setting up a research question a lot of details have to be taken in consideration before you can expect proper results to draw a conclusion. Besides the field study I was really looking forward to cooperate with students from other departments, but it turned out that most of the student were actually from the BMT department, so this was not the case.

activities:

For this project we divided the report in a literary study and a field study, where we used the outcome

of the literary study for the execution of the field study. Halfway the course a presentation had to be done about the research proposal. Furthermore, besides the literature study, the field study had to be executed which was done on 2 days. Besides finishing the report a poster had to be made which presents the whole process the project went through and the outcomes of the studies.

competence development
One aspect that was very helpful was the close communication with the tutor who could directly give useful feedback from which we learned a lot as a group. Furthermore, working with different people from different years and different studies is something a group can learn a lot from. The presentations (the IRP presentation and the final pitch) and the making of the poster were besides groupwork also moments for groupmembers to develop themselves.

individual growth and evaluation of personal effort
I learned a lot about how to address projects like this and specifically how to write proper methodology (which I also completely finished for the final report). Besides that and general contribution at the start of the project, I came up with a design of the field study, provided a basis for the conclusion and discussion section and put a lot of work in the design and content of the poster which I made all by myself. I really liked that I could contribute to this project with the creative qualities I possess such as the design for the field study and the making of the poster

Team effort and division of labor
In the beginning it really bothered me that group members followed other courses in the same time slots as this project. This caused that OR the group had to plan meetings outside the time slots planned for this subject, OR having meetings with not everyone present. This made it very hard to keep everyone up to date on the process of the project and made the communication sometimes somewhat hard. However some group members contributed a little bit more of less to the project then others, everyone approximately contributed evenly to the project. Though I experienced a lack of responsibility with almost all group members, which I think results from the size of the group. I think the project could have also been done by 4 group members which would have resulted in better commitment. Division of labor mostly went well since everybody was willing to contribute to the project and everybody delivered a valuable contribution to the project.

Relevant personal and group issues that went well or could be improved:
As I said before I would have preferred a smaller group size to reduce the chance of lack of responsibility, so the group size is something that could be improved. However all deadlines were easily completed so I think no one in the group really experienced deadline stress, which was very nice. Overall I am satisfied with the results of the project.