

The effect of thermal comfort conditions during work hours on social disconnection

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Abstract. Studies have focused on people's physiological reactions to thermal conditions in indoor environments, neglecting the social consequences that could arise from them. Therefore, there is a gap in literature how these thermal comfort conditions could influence psychosocial aspects of our lives, such as how disconnected we feel from other people around us or how connected we feel with them, especially after being exposed to these conditions for many hours within an occupational context. This study attempted to address this gap in literature by exposing participants to two thermal conditions: a warm condition (28 °C) and a cool condition (21 °C) in a simulated office environment. The purpose of the study was to observe possible social consequences arising from a day at work under either of those conditions by focusing on social distance and empathy levels. 31 participants were recruited and exposed to both conditions, each condition at a different day (gap between days of at least one day for washout), and were asked to remain in the temperature-controlled environment for eight hours (between 9 a.m. and 5 p.m.). Additionally, they were asked to complete a series of questionnaires, investigating their levels of social disconnection and empathy before and after both testing days. The temperature of the room was monitored throughout the process. The difference observed between pre- and post-measures for both conditions was not significantly different with regards to the feelings of social disconnection, despite the difference in responses observed within the raw data for each condition. In contrast, the difference observed in empathy levels between pre- and post-measures was significantly different between conditions. Individuals exposed to the cool condition reported lower levels of empathy after exposure, while participants exposed to the warm condition exhibited higher empathy levels after exposure. The results suggest that thermal conditions could influence people's levels of empathy, which could have consequences both within a work environment and in private life. Further research is needed to support this. Implications of these outcomes and recommendations for further research are discussed.

Keywords. temperature, social disconnection, empathy, work

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1. Introduction

Considering indoor environmental conditions and their consequences is of primary importance within an occupational context. Several studies have looked at the association between environmental conditions and health-related issues [1, 2]. However, the relationship between indoor environmental conditions and social relationships between colleagues has received less attention within the indoor environment literature [3]. Studies have

shown that social support at work can be related to higher control over work and reduction in depression levels [4], highlighting the value of investigating the effect of indoor environmental conditions on social relationships.

Indoor environmental conditions are characterized by four different dimensions: 1) air quality, 2) temperature, 3) light, and 4) acoustics. Although all dimensions are considered essential when investigating the indoor environment, the current

paper will focus on the effects of indoor temperature (operative temperature) on social connection, as it is hypothesized by the authors to have the strongest association to social variables compared to the other environmental dimensions. Additionally, temperature has been rated by building occupants as the most important aspect of the indoor environment compared to visual and acoustic comfort, and air quality [5].

Temperature has been found to have a bidirectional relationship with social variables; especially social warmth/connection [6]. People report higher levels of physical warmth when reading messages reflecting social connection with another person, and they feel more connected when holding a warm pack (peripheral body temperature [7]). Additionally, Inagaki and Eisenberger [7] found that there is a shared neural mechanism underlying physical and social warmth, suggesting that modification in one of the variables will probably lead to the modification of the other.

According to Bargh and Shalev [6], people who experience physical coldness are feeling significantly more lonely than individuals with physical warmth. Additionally, people who score higher on loneliness tend to take more frequent warm baths/showers [6]. The aforementioned associations make us wonder how this could be translated within an occupational context and to the indoor temperature. In a study conducted by Kolb, Gockel and Werth [8], student participants demonstrated more customer-oriented behaviour and gave more discounts when they were exposed to lower temperatures compared to when exposed to higher temperature. However, there is still a gap in literature on how temperature conditions within a work environment can influence feelings of social connectedness.

The majority of studies investigating the effect of temperature on social connectedness have focused on the haptic experience of temperature (peripheral body temperature), instead of the actual indoor temperature, leading to weak and inconclusive findings with regards to the effects of indoor temperature on social connectedness [9]. Furthermore, studies have investigated internal body temperature conditions, which demonstrate a positive association with social connectedness [10, 11]. This contradicts the negative association demonstrated between indoor temperature conditions and prosocial behaviours in the Kolb, Gockel and Werth [8] study. Distinguishing internal thermal conditions from external thermal conditions and their effects, reminds us of the saying “cold hands, warm heart”, which further supports the existence of these contradictory thermal conditions.

In addition to social connectedness, temperature has been associated to changes in empathy levels. Interestingly, Salazar-Lopez et al. [12] found a positive association between facial temperature changes and empathy scores. In general, empathy

positively predicts social connectedness [13]. Consequently, investigating the association of indoor temperature with empathy levels could provide insights into an underlying pathway leading to social connectedness or a moderator to the association. However, taking into consideration the difference observed between indoor temperature and body temperature and their association with social variables, it is not yet known whether indoor temperature could have an effect on empathy levels. Empathy is a core social characteristic, which develops early in life, hence, it might require a targeted empathy training to modify it [14]. A possible explanation of the observed effect in the Salazar-Lopez et al. [12] study could be that the shared neural mechanism is driving the facial temperature changes as an outcome of the empathic responses. Consequently, investigating the effect of indoor temperature on empathy levels in this study could provide important preliminary outcomes for future studies.

People evaluate a wide range of indoor conditions as thermally neutral before perceiving them as too cold or too hot. This range is depending on a variety of variables, like air temperature, air velocity, clothing, metabolic rate, running mean outdoor temperature, among others. In addition, thermal conditions within office spaces have a wide range, too, easily ranging between 21 °C and 28 °C and beyond, depending strongly on the type of building. However, it is not yet known if this wide range of thermal conditions people experience at work is reflected in social relationships, too, particularly with respect to social connectedness and empathy.

The current study aimed to investigate the effects of indoor temperature on social connectedness and empathy, by exposing participants to two distinct thermal conditions (21 °C vs. 28 °C) during the summer.

Based on the Kolb, Gockel and Werth [8] study, it was hypothesized that:

- 1) A negative association will be observed between social connectedness and indoor temperature.
- 2) A negative association will also be observed between empathy and indoor temperature.

2. Research Methods

2.1 Procedure and ethical considerations

After ethical approval was granted by the relevant ethics committee, a sample of 32 participants was recruited via convenience sampling from participant lists, snowball sampling and via adverts on social media platforms and local amenity shops during summer 2021. One of the participants did not complete the study for personal reasons. A pre-screening assessment was conducted before

participating in the study. Participants were excluded if they: 1) were active cases of COVID-19, 2) had a medical condition that could interact with thermoregulation and/or cognitive performance, 3) were suffering from insomnia, 4) had an unstable body weight, 5) exhibited high alcohol consumption (more than 2 servings per day for men and more than one serving per day for women) and 6) were regular smokers in the past 12 months. Women were also excluded if they were pregnant, or in case they were in the older age group, if they were not in a stable post-menopausal stage, since this could interfere with the measurements. Participants who were eligible to participate in the study were invited to attend a two-day hybrid study involving eight hours in the laboratory and field assessment at home on both study days. Before participation, written informed consent was obtained. During the two experimental days, participants were asked to wear similar clothes (long-sleeved light top or short-sleeved light top, long trousers, underwear, socks and low shoes) and they were exposed to two temperature conditions, a cool condition (21 °C) and a warm condition (28 °C) in a cross-over design. A gap of at least one day was maintained between the two experimental days to ensure the washout of any effects from the preceding condition.

Visual, acoustic and air quality aspects were kept constant for both temperature conditions and only indoor temperature varied. Indoor temperature and thermal perception were monitored throughout the day during both conditions. Pre-post measurements of social disconnection and empathy were collected for both conditions and were analysed at the end of the study.

2.2 Demographics

During the pre-screening process, participants' demographic data was collected. The demographic data included participants' sex (male, female), year of birth, nationality and employment status.

2.3 Indoor temperature

Indoor temperature was recorded in degrees Celsius every minute throughout the experimental days using a commercial air temperature sensor. However, for the purposes of this study, only the average indoor temperature, which represented the condition, was used for the analysis.

2.4 Thermal perception

Thermal perception was assessed using one of the most prominent scales for thermal sensation, the ASHRAE 7-point scale. Items assessed participants' thoughts on the thermal environment (acceptable vs. unacceptable), how they felt (on a scale from cold to hot), their perception of the environment (on a scale from very comfortable to very uncomfortable), how they would prefer it (on a scale from much cooler to much warmer), if they shivered (Yes, No), if they were sweating (Yes, No) and if they would change

the temperature if they had the opportunity (Yes, No). The analysis of these variables will be presented in a different paper.

2.5 Social disconnection

Feelings of social disconnection were assessed using a 5-item scale, previously used in the Inagaki and Eisenberger [15] study. Items included questions on how close the participants feel and want to be with other people, which were rated on a 5-point Likert scale from 1 (Not at all) to 5 (Very strongly). Higher scores indicate stronger feelings of social disconnection.

2.6 Empathy

Empathy levels were assessed using specific scenarios, which were developed for the purposes of this study. Similar scenarios were used and validated in other studies [16], but were addressing a different population (i.e. child victims) and hence, they only served as an example for the development of these empathy scenarios, which the authors plan to validate in the future. The scenarios investigated participants' reaction to: 1) returning home after work and finding their partner or family member having a bad day, 2) returning home tired from work and being informed that their partner/family member had to stay longer at work because of a deadline, missing in this way important plans for the afternoon and 3) returning tired from work and finding their partner/family member lying on the sofa/bed looking very ill. Answers were scored from 0 to 2 points depending on the response and were summed to form a total score. Higher scores indicate greater expression of empathy.

2.7 Statistical analysis

Outcomes were analysed using R Studio and descriptive statistics were calculated using the "psych" package. In order to identify differences between baseline data and post-testing day data and differences in the outcomes between conditions, a series of Wilcoxon-Signed Rank tests were conducted.

3. Results

3.1 Participant characteristics

The sample included 16 female participants (51.6%) and 15 males (48.4%), of whom 13 participants (41.9%) were considered in the older participants category (i.e. between the age of 50–71 years) and 18 participants (58.1%), formed the young participant group (i.e. between the age 20–35 years old). The average age of all participants was 40.7 years old ($SD=16.5$). The majority of the participants had a German nationality (90%), one participant was Greek, one was Belgian and one was Portuguese, all of whom had a native or close to native German language proficiency. The majority of younger participants were university students, while older

participants were employed at a wide range of sectors, such as engineering, law, psychology, medicine, business and insurance. Participants had an average Body Mass Index (BMI) of 23.8 ($SD=3.2$).

3.2 Thermal perception

A series of Wilcoxon-Signed Rank tests demonstrated that participants reported significantly different thermal sensation votes during the two experimental conditions, with participants being exposed to the 21 °C stating that the room was cold and participants exposed to the 28 °C stating that the room was warm. Additionally, participants exposed to the 21 °C expressed the preference for a warmer environment, while participants exposed to the 28 °C expressed the preference for a cooler environment. Still, on average, participants reported that both conditions were acceptable and just comfortable for them.

3.3 Social disconnection

The Wilcoxon-Signed Rank tests demonstrated that there were no significant differences between baseline data on feelings of social disconnection before being exposed to the two experimental conditions on the two different days ($V=161, p= .98$, Effect size=0.02). Additionally, there were no significant differences between conditions on post-testing day measures of social disconnection ($V=132, p= .42$, Effect size=0.14). The difference between pre- and post- outcomes was also found to be not significantly between the two conditions ($V=162.5, p= .75$, Effect size=0.05), although a small difference is demonstrated in Figure 1, with participants being exposed to the 21 °C demonstrating more variation in levels of social disconnection after the experimental day than after the 28 °C.

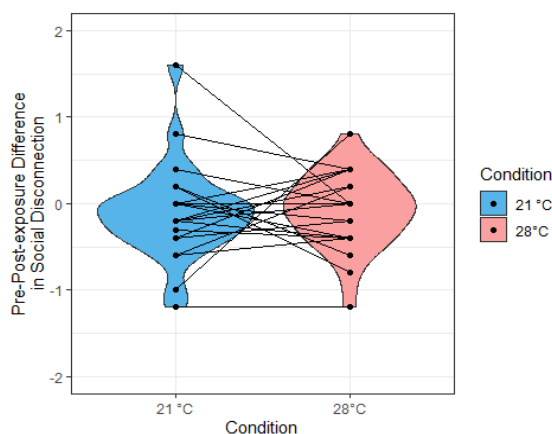


Fig. 1 - Difference between pre- and post-measures of social disconnection for both experimental conditions (21 °C vs. 28 °C). Note: Lower values represent lower levels of social disconnection.

3.4 Empathy

Similarly to the social disconnection outcomes, the Wilcoxon-Signed Rank test demonstrated no significant differences in empathy levels in pre-testing day measures between the two conditions ($V=13.5, p=.59$, Effect size=0.02). However, a difference very close to significance was observed in the post-testing day measures between the two conditions ($V=15, p=.05$, Effect size=0.34). The difference between pre- and post-measures was found to be significantly different between the two conditions ($V=15, p=.03$), with the outcomes indicating a moderate effect (Effect size=0.42). The difference between the two conditions is indicated in Figure 2.

Supplementary analyses indicated that the difference in empathy levels between pre- and post-exposure measures was only significant for the cool condition (21 °C; $Z=-2.27, p=.02$), since the difference between pre- and post-exposure measures for the warm condition (28 °C) was not significant ($Z=-1.31, p=.19$).

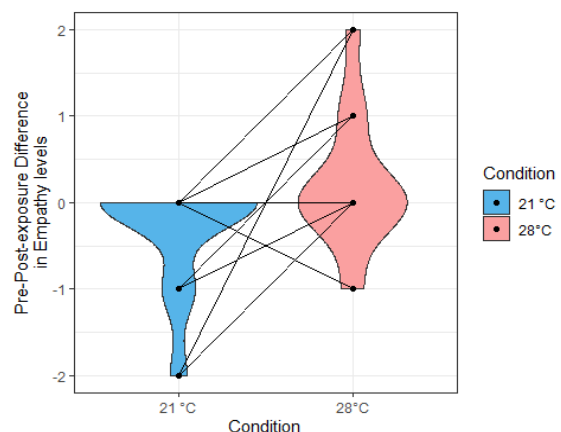


Fig. 2 - Difference between pre- and post-measures of empathy for both experimental conditions (21 °C vs. 28 °C). Note: Lower values represent lower levels of empathy.

4. Discussion

The study followed a cross-over design to investigate differences in social disconnection and empathy between pre- and post-exposure measures, and between warm and cool conditions in a simulated office environment. The findings indicated no significant differences between conditions for social disconnection, although a greater variation of responses was observed for the social disconnection scale in the cool condition compared to the warm condition. When taking into consideration the whole sample, participants demonstrated both increases and decreases in feelings of social disconnection after exposure to both conditions. However, more participants demonstrated an increase in social disconnection after exposure to the 21 °C, compared

to the 28 °C. The difference in empathy levels between the pre- and post-exposure outcomes was significantly different between the two conditions. Participants reported lower empathy levels after exposure to the cool condition and higher empathy levels after exposure to the warm condition.

The findings for empathy levels are not consistent with the Kolb, Gockel and Werth [8] study, which found that more prosocial behaviours were exhibited after exposure to lower temperatures compared to higher temperatures. Our findings indicate a positive association between indoor temperature and empathy, which is in accordance to the positive association between peripheral temperature and empathy found in the Salazar-Lopez et al. [12] study. This outcome could provide additional support to the shared neural mechanism suggested by Inagaki and Eisenberger [7] between physical and social warmth, although further research is needed to support this.

Additionally, contrary to the hypotheses of this study, there were no significant differences between conditions with regard to changes in feelings of social disconnection after exposure to the two thermal conditions. This could be attributed to the observed bidirectional change in social disconnection presented within our sample under both conditions, which could have overshadowed the differences observed in the raw data. When exposed to the cool condition, some of the participants reported reduction in feelings of social disconnection (i.e. they were feeling more socially connected). At the same time under the same condition, some other participants reported increased feelings of social disconnection (i.e. less socially connected). This contradiction within outcomes, which is probably a consequence of an uncontrolled variable, could mask the change in feelings of social disconnection driven by the indoor temperature. This bidirectional change in social disconnection could be explained by other variables, influencing the association between indoor temperature and social disconnection, which are affected particularly by cool temperature conditions, since the variation in social disconnection ratings after exposure to the warm condition was less compared to the cool condition. A potential variable influencing this association could be the presence of another participant within the room or the general social network availability of the participants. According to the social thermoregulation theory, body temperature could be regulated based on social connections, a process more prominent under cool conditions [17]. However, further research is needed to investigate these potential moderating effects on the association between indoor temperature and social disconnection.

Taking into consideration the outcomes of this study, supporting the influence of indoor temperature on social behaviours, such as empathy, it is suggested that controlling indoor temperature within an office environment might provide the necessary conditions

for a more socially-friendly environment. Although further research is needed to support the outcomes, higher temperatures might be preferred to encourage more empathy between colleagues, where preferable.

This study, however, is not without limitations. The assessment of social disconnection and empathy relied heavily on self-report data, which are prone to several biases, such as desirability bias [18]. Additionally, the study was conducted only in the summer, and hence, seasonal effects on the experience of temperature could not be controlled. When considering thermal comfort of indoor environments, it is recommended to take into account the outdoor conditions and the seasonal effects that might influence outcomes [5]. Moving from a warm outdoor environment will make a cool indoor environment to be perceived cooler than it is, which could also have an effect on the association between temperature and social connectedness and empathy levels. Unfortunately, though, summer 2021 was also cooler than expected during the data collection (end of June until beginning of October 2021), therefore, typical summer conditions could not be taken into consideration.

Nevertheless, the study provided some preliminary outcomes on the association between indoor temperature, social disconnection and empathy, which could form the basis for future and more elaborate research.

5. Conclusions

In conclusion, a laboratory study was conducted, which investigated the effect of indoor temperature on measures of social disconnection and empathy. Differences between pre- and post-exposure to thermal conditions were reported for empathy levels between the cool (21 °C) and warm (28 °C) condition. However, no significant differences were observed for social disconnection. Further research is needed to assess the role of thermoregulation in these associations. However, the outcomes have already implications in the preferred temperature conditions that an office should hold to maintain prosocial behaviours between colleagues, favouring higher temperature conditions.

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Data access statement: The datasets generated during and/or analyzed during the current study are not available because the authors are still processing the data, but the authors will make every reasonable effort to publish them in near future.