THE INFLUENCE OF HUMAN PERIPHERAL TEMPERATURE ON THE FEELINGS OF BELONGING

Mara Shelaeva

ANR: 788009

Supervisor: R. M. Rahal

Second assessor: B. Adams

Master Thesis

Tilburg University

2020

Abstract

Social thermoregulation suggested to be a core feature of human relationships and influence us and our social connections. Social thermoregulation theory also explains the influence of temperature on the feeling of belonging. In spite of replicability crisis in psychology and a small amount of research about social thermoregulation in humans we felt the necessity for further investigation of this phenomenon. The aim of this research was to replicate the study conducted by Chen, Poon and DeWall (2015) and the reported effect that physical warmth leads to more belongingness than physical cold. We also suggested a new method for social thermoregulation research that allows to conduct manipulations without attracting participants' attention to temperature changes – the EmbrWave device. Our study failed to reject the null hypothesis that suggested the same distribution of belongingness in hot and cold temperature conditions. Therefore, we didn't provide evidences in support of the hypothesis that participants in warm condition would report more belongingness than participants in cold condition. Possible reasons for this outcome and ideas regarding improvement of existing studies are discussed.

Keywords: the need to belong, physical cold, social thermoregulation, replication study, EmbrWave

The Influence of Human Peripheral Temperature on The Feelings of Belonging

Temperature is important for our survival, development, and health. Many studies have provided evidence about the increase of morbidity and mortality in periods of cold and hot weather (e.g., Wang et al., 2014; Breitner et al., 2014; McMichael et al., 2008; Monacelli, Aramini & Odetti, 2010; Bai, Woodward & Liu, 2014). A deviation of ± 3.5°C from the regular body temperature of 37°C can cause physiological damage and demise (Moran & Mendal, 2002). Moreover, findings suggest that humans are influenced by physical temperature not only physically but psychologically too (IJzerman et al., 2015). Many studies found that temperature is connected with social processes (for an overview see IJzerman & Hogerzeil, 2017). For example, feeling cold makes people want social connections and increase willingness to forgive others (Van Acker et al., 2016; Wei et al., 2015). Feeling warmth promotes people to perceive robots as more humanlike and friendly and to evaluate brands as warmer and more sincere (Nie et al., 2012; Möller & Herm, 2013). Moreover, even the quality of our social connections is influenced by temperature: people who live in colder climate seem to have more diverse social network that apparently protects them from the cold (IJzerman et al., 2016).

One of the explanations, why we are still so dependent on temperature, is social thermoregulation theory (IJzerman et al., 2015). It suggests that the psychological effects of temperature in humans are caused by the evolutionary development of warm-blooded animals. In order to support essential inner homeostasis and economize thermoregulation warm-blooded animals rely on other animals, live in groups and gather together for saving the warmth. Of course, humans are more complicates than other animals. Still, studies showed that the interaction between physical temperature stimulation and cognition exists (e.g., Williams & Bargh, 2008; IJzerman and Semin, 2009; Inagaki and Eisenberger, 2013;

Zhou, Ho & Watanabe, 2017). And despite the fact that nowadays we are not afraid of winters people still rely on social warmth as a protector from the cold (IJzerman et al., 2018).

Warmth is important for us as physically as psychologically. Psychological and physical warmth apparently involves similar neurobiological mechanisms that can explain the connection between warmth and social processes it influences (Inagaki & Eisenberger, 2013). Bargh and Shalev (2012) demonstrated that people are able to self-regulate their feelings of social warmth by subconscious exposure to physical warmth. It was also shown that warm temperature reduces social distance and promotes trust (IJzerman & Semin, 2009; Kang, Williams, Clark, Gray, & Bargh, 2010). We even perceive others as warmer persons when we physically feel warm (Williams & Bargh, 2008). People also want to become proximate and affiliate with others when they feel physical warmth, and they are more prone to affirmative and acquiescent behavior (Fay & Maner, 2012, 2015; Steinmetz & Posten, 2017). Moreover, under warm condition people report about feeling psychologically closer and more similar to others (IJzerman & Semin, 2009; Steinmetz & Mussweiler, 2011). Warmth also promotes people to feel more belonging (Chen, Poon, & DeWall, 2015). So, there is no doubt that temperature plays a huge role in our personal and social life. And in this study, we focus on the need to belong since the need of social connections is our special feature and the need to belong is one of the strongest desires that motivate humans' attachments (Baumeister & Leary, 1995).

"The need to belong is a fundamental human motivation" (Baumeister & Leary, 1995, p. 497). It reflects the biological universal human urge to form and maintain positive close stable attachments with others. The inability to meet the need to belong leads to negative effects on health and well-being (Newman, Lohman, & Newman, 2007; Baumeister & Leary, 1995). As social thermoregulation, the need to belong is an evolutionary development for survival and reproduction (Baumeister, 2005; DeWall, Deckman, Pond Jr, & Bonser, 2011).

In the past, the acceptance of your group, the existence and maintenance of close connections, avoidance of rejection of the group were crucial for surviving. In today's world close connections still play a big role in people's life: personal and family relationships were named as the main source of meaning in life (Ebersole, 1998; Lambert et al., 2013). Indeed, the desire to belong is inextricably linked with awareness of meaning (Baumeister, 2005). Moreover, belongingness predicts perceived meaningfulness of life, lack of which is associated with psychopathology, stress, and depression while high levels correlated with good physical health and psychological well-being (Lambert et al., 2013; Steger, 2012). The lack of belongingness satisfaction also results in loneliness (Baumeister & Leary, 1995). Cacioppo and Patrick (2008) named loneliness as a social pain that is treated by social connections. It is noteworthy that feelings of loneliness were also found to be influenced by temperature changes. Murphy and Standing (2014) discovered that participants reported less loneliness in warm condition and the opposite for cold condition. Moreover, the sense of belonging predicts the choice of nostalgic products (Loveland, Smeesters, & Mandel, 2010) and low belongingness increase nostalgia (Seehusen et al., 2013). The feeling of nostalgia was also found to be affected by temperature in the predictable with low temperature - low belongingness effect way: colder participants had more nostalgia (Zhou et al., 2012). Thus, feeling of belonging plays an important role in human life, it connects with different emotional responses that shape our life and satisfaction with it; temperature influences these feelings too. So maybe humans are indeed like penguins, need warmth and good social attachments for well-being?

In this study we focus on the idea that social thermoregulation is a core feature of human relationships. Precisely, we interested in the effects of temperature on the feeling of belonging. We chose to replicate the study conducted by Chen, Poon and DeWall (2015). In this study, participants either drank warm or cold water or didn’t get water at all. Participants

in the water conditions received instructions that they had to drink water. After drink, they completed a belonging scale adopted from the Need Satisfaction Index (Williams, 2009) and some unrelated distracting from the purpose of the study tasks. This study enriched the literature about the influence of temperature on social behavior by revealing the link between warmth and belongingness. However, Chen, Poon and DeWall (2015) noted that the results of their study may vary in western population because of cultural differences and habits. Moreover, only this one study (N = 75) observed this effect. Finally, the whole existence of social thermoregulation phenomenon also remains questionable. Considering the present discussion around the replication crisis in social psychology and growing awareness of its need (e.g., Open Science Collaboration, 2015; Anderson & Maxwell, 2016), the theoretical implication for research in this area, we believe in importance of replication of the Chen, Poon and DeWall's study (2015).

This study is also important because we don't know yet the exact mechanisms of social thermoregulation. We assume that we inherited it during evolution, but there is a lot of research about this phenomenon in animals and only a few studies test social thermoregulation on human. IJzerman et al. (2015) stated there was no any other thermoregulation-based model of social cognition before the theory they developed. Furthermore, designs of prior investigations of these phenomena typically included cover stories and manipulations that could not be repeated more than once without attracting participants' attention to temperature changes (e.g., rooms, beverages with different temperatures). The present study includes a new tool (EmbrWave) for temperature manipulation that allows an experimenter to change temperature condition fast and less obviously for participants. Preliminary results suggest the ability of this device to affect human's overall feelings of temperature (Wang et al., 2020). We also use cover story that we are testing the device itself. This deception allows us to conduct studies without drawing

participants' attention to manipulations, since it is important for the occurrence of thermoregulation effects that participants are not aware of them (William & Bargh, 2008).

Using this new technology, we hope to answer the main question of this investigation: does human peripheral temperature influence the feeling of belonging? In accordance with previous research (Chen, Poon, & DeWall, 2015) we predict that participants in warm condition would report more belongingness than participants in cold condition. The results of this study would be useful for a better understanding of the relationships between temperature and belongingness. Going forward that knowledge will help scientists explain underlying mechanisms of social thermoregulation and, moreover, to develop further interventions for personal well-being and social connections improvement. There have been made already promising prospects such as using social thermoregulation theory for relationship therapy or a physiological mobile application for bonding (IJzerman, Heine, Nagel, & Pronk, 2017; Frederiks et al., 2018).

Method

Research Design

To test the hypothesis that participants in warm condition would report more belongingness than participants in cold condition we conducted an experimental study in which participants were asked to fulfill questioners while they were wearing a special wrist-worn device, the EmbrWave, that was created as a “personal thermostat” and capable of heating up and cooling down in order to regulate body temperature. Our cover story for participants implied that we investigated the device itself. This legend allowed us to redirect attention on the EmbrWave and distract participants from our actual purpose of study. It was important for this type of research that participants were not aware of our actual purpose because previous investigations showed that the effects of thermoregulation only occur in these conditions (William & Bargh, 2008). This particular study was a part of a big social

thermoregulation project and included several questioners for several dependent variables (e.g., feelings of nostalgia, brand personality perception) that were randomly presented to participants along with randomly settled levels of warmth and coldness. The study and temperature manipulation were administered by computerized script. The script randomly settled up a temperature level (independent variable) that was supported during the entire questioners for one DV (e.g., feeling of belongingness). There were 4 temperature values available: max cooling, mild cooling, mild heating and moderate heating. After completing questioners for one DV the script changed temperature and presented the next questioner. Each trial began with a 5-second pause during which the EmbrWave reset to neutral (on the screen was written "Please wait"). This was repeated until the last DV was completed. After block with manipulations participants were asked to answer questions that are recommended for all social thermoregulation studies (IJzerman et al., 2019).

Preregistration and Ethical Considerations

The preregistration of the study was provided in research proposal for this work assessed by scientific supervisor Rima-Maria Rahal prior to the beginning of data collection. This study is a part of Social Thermoregulation project that is posted on the Open Science Framework (https://osf.io/eydwm/). The research was approved by Ethics Review Board of Tilburg University (approval number RP1).

Participants

The data from this study was gathered from 3 European Universities: the Paris Descartes University in Paris (92 participants), The Universite Grenoble-Alpes in Grenoble (118 participants) and the University of Warsaw in Warsaw (62 participants), including 216 women and 20 men (Mean age = 21.49, SD = 6.36), others rejected to provide gender-specified information. A statistical power analysis was performed for sample size estimation, based on data from published study by Chen, Poon and DeWall (2015) with the sample size

of 75 people. The effect size (ES) in this study was $\eta_p^2 = 0.1$ considered to be between large and medium using Cohen's (1988) criteria. With an α error probability = .05 and power = 0.80, the projected sample size needed with the effect size = 0.3 (GPower 3.1) is approximately N = 128 for a one-way ANOVA with fixed effects, considering 4 predictors (the levels of temperature of EmbrWave). Thus, our proposed sample size of 272 participants was more than adequate for the main objective of this study.

Procedure

After arrival in the laboratory, participants were led into individual cubicles and were invited to consult informed consent. Then they were presented with a cover story (see Appendix A) and an experimenter attached EmbrWave and checked manipulation of heating/cooling and comfort levels was taken place. After device test participants were presented first DV questions and this manipulation continued until all DVs were presented once. One of the trials devoted to feelings of belonging. We used the same questioner as the original study (Chen, Poon, & DeWall, 2015). Questioner consisted of 5 Likert-scale items (e.g., “I feel I belong” and “I feel disconnected”; 1 = not at all, 5 = extremely, see Appendix B) that were adopted from the Need Satisfaction Index (Williams, 2009). After completing of all DVs participants were asked to answer some control questions about EmbrWave efficacy (e.g., “At this moment, what temperature does the room feel like to you?”). The purpose of these questions was to check if the temperature manipulation actually worked and participants felt differently in every temperature condition. We also included demographics and individual difference questions (e.g., Social Network Index (Cohen et al., 1997), smoking status) and brief funnel debrief (e.g., “What do you think the purpose of the study was?”) in order to find if participants were aware of a connection between temperature manipulation and questioners. William and Bargh (2008) argued that the effects of thermoregulation occur when participants are not aware of it. Therefore, participants who suggested that the study

investigates social thermoregulation should be excluded from further analysis. Finally, participants were thanked for participation, briefly explained about the purpose of the study and asked permission to use their data in the research.

Data Analyses

Preliminary data analysis

After preliminary data analysis we had to exclude 31 participants. 4 participants didn't not want their data to be analyzed. 29 participants indicated they think the EmbrWave changed their answers (e.g. «It influenced my emotions, experience», «The house probably seemed warmer and more comfortable with the hot bracelet», some of them answered that the discomfort from the devise influenced their responses). Among them one participant for the question how it could have changed his answer indicated the follow: «My answers were perhaps influenced by the temperature, I felt it when you asked me the question «What temperature is it in the room?», and since this question was after the block with DV we decided to keep him. Another participant said «I think he didn't change at all», suggested that the purpose of this study was curiosity, and hasn't related the temperature settings to the questions, so it looks like he misplaced the button, and we decided to keep him too; other participants' answers suggested that they were aware of the influence of the EmbrWave device and therefore were excluded.

Then we looked for missing values with Microsoft Excel (Version 16.31) using next filters: EmbrWave level of temperature are "-7", "-5", "5" and "9" (since "0" contains demographic information), and a filter to show empty rows for the answers about belongingness. Then we indicated identification numbers of participants with more than 3 empty rows, put off the filter and manually deleted answers of indicated participants (22 people) since they hadn't provided information enough for the purpose of ours study.

After checking for outliers by analyze of boxplots for general belongingness and perceived temperature and deleting 24 extreme deviations 195 participants were left for further analysis (13 men, 170 women, others preferred not to respond or don't identify themselves as male or female; Mean age = 21.27, SD = 5.89; others preferred not to identify their gender). This and further analysis were run with the SPSS statistics program package (Version 20).

Main data analysis

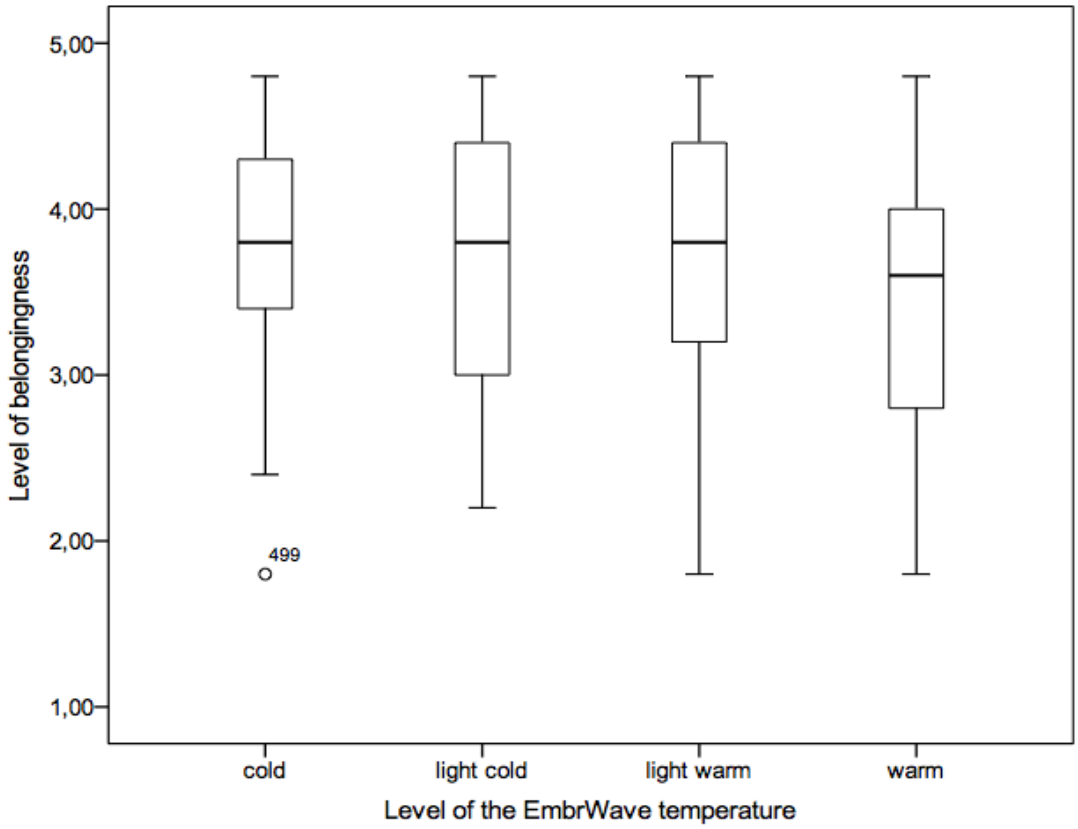
In order to check if the temperature manipulation with EmbrWave worked and participants indeed felt the changes of temperature we conducted the independent-samples Kruskal-Wallis test between the reported temperature in the room and how cold/hot it is in the room on a 7-points Likert scale (1 = very cold; 7 = very hot) since the variables had an abnormal distribution. The test showed that the participants in warmer conditions indeed felt warmer temperature and indicated higher degrees, while people in colder condition reported lower temperatures, and that difference was statistically significant (χ^2 (6) = 15.85, $p < .02$). We also checked if the perceived level of coldness/hotness in the room relates with the actual level of the EmbrWave temperature. The Mann-Whitney test indicated that in warm condition (N = 173, Mdn =246.44) people indicated that they are warmer, and in cold condition (N = 172, Mdn = 99.13) participants indicated that they felt colder; this connection was statistically significant, U = 27583.5, z = 13.91, p = .00. Therefore, we can argue that manipulation was successful, and participants indeed felt changes of temperature during a study.

This study tests the effects of peripheral temperature on the feelings of belongingness. We hypothesized that participants would report more belonginess in hot temperature condition than in cold. 4 condition groups (max cooling, mild cooling, mild heating, moderate heating) is compared on the level of belongingness that was measured by the Need

Satisfaction Index (Williams, 2009). The reverse scores were recoded, and results were averaged to index participants' current feelings of belongingness ($\alpha = .67$). Due to abnormal distribution we can not use one-way ANOVA and will apply Kruskal–Wallis one-way analysis of variance in order to find whether there is a difference in the level of belongingness between participants in different temperature conditions. A one-way analysis of variance failed to reject the null hypothesis that the distribution of belongingness is the same across 4 experimental conditions of the EmbrWave temperature, χ^2 (3) = 5.23, p = .16, with a mean rank belongingness score of 102.18 for max cooling, 100.62 for mild cooling, 107.13 for mild heating and 83.45 for moderate heating (see Figure 1). Therefore, our study didn't provide evidences in support of the hypothesis that warmer temperature causes more belonginess.

Figure 1

Participants' belongingness in different temperature conditions



Discussion

Social thermoregulation theory suggests that with evolutionary development we inherited the dependence on temperature in our social connections and well-being. This theory explains the impact of physical warmth versus coldness on the feelings of belonging as a part of evolution development. Previous research showed that warm temperature is related to more belongingness than cold temperature (Chen, Poon, & DeWall, 2015). This research aimed to provide empirical evidence for the hypothesis that people experience more belongingness when they feel physical warmth.

Unfortunately, our study doesn't confirm these findings. The results of *p*-value in our investigation were larger than the threshold (typically set at .05). It means that our test was unable to reject the null hypothesis. It could've happened due to nonexistence of the effect or because the power of the test wasn't enough to detect a true effect (Aczel et al., 2018; Dienes, 2014, 2016). As Goodman (2008) noted, in some cases even null hypothesis should be kept even with significant *p*-value, while in other events non-significant hypothesis still means that a theory is working. Therefore, more research is required to confirm or reject the hypothesis that participants in warm condition report more belongingness than participants in cold condition.

Our research was presented as a replication study with an application of a new tool, EmbrWave, a hand bracelet that changes temperature and can be used as a personal thermostat. In line with previous investigation (Wang et al., 2020), our study also found that participants were affected by the EmbrWave and felt the difference in peripheral temperature depends on a temperature condition of this device. So, it is doubtful that we couldn't replicate Chen, Poon and DeWall's (2015) findings because of another technology. But, in line with Chen, Poon and DeWall's suggestions regarding the possibility of existing inconsistency in studies with temperature manipulations, we believe the distinction in level of applied

temperature in different investigations may subsequently cause such apparently inconsistent findings.

Another possible explanation, as Chen, Poon and DeWall (2015) also noticed, is cross-cultural aspect. Our sample was gathered from Europe (France and Poland), while Chen, Poon and DeWall studied ethnical Chinese students. Chen, Poon and DeWall argued that Chinese and Asian tend to drink more tea and hot water in everyday life than Western, therefore, they can be more used to the influence of physical warmth but more sensitive to the influence of coldness. Moreover, Western and Eastern culture highly differs in Individualism dimension by 6-D Hofstede's Model (Hofstede, 2011). It is possible that Chinese students themselves feel more belong to others since they are really low in Individualism: 20 points out of 100 for China vs 71 points and 60 points for France and Poland correspondingly (https://www.hofstede-insights.com/product/compare-countries/). In comparison with individualistic cultures, the sense of belonging in members of collectivistic cultures is so strong that they think of the relationship instead of the self as the functional unit of conscious reflection (Markus & Kitayama, 1991). Therefore, further investigation in more homogenous cultures is needed to study the influence of temperature on belongingness and social thermoregulation itself.

We hadn't exactly copied the original study: we used the EmbrWave (vs cups of water) and European sample (vs ethnical Chinese). But we believe these changes are the strengths of this study: we found support for using the new tool for social thermoregulation studies (the EmbrWave showed efficacy in temperature manipulations) and, therefore, improved the method. We also provided evidence for possibility of cultural differences in belongingness estimation under warm and cold temperature.

One of a limitation of this study is climate and season. The investigated data was gathered in the end of autumn, and it is a windy, rainy season in this part of Europe.

Participants could've got wet, frozen or prefer not to take the coat during the study. It could've influenced the experienced temperature and its changes and interfere with results. It can be useful to gather data in different seasons, indicate the weather and analyze these results in different cases, since, for example, winter season in Europe is cold and the difference between outside and inside is huge, so participants come to a laboratory in warm clothes, possibly with perspire, and the adaptation can require a lot of time. Depends on area and season, it can be also rainy, and participants can get caught by rain and get frozen to the bone or feel uncomfortable in wet clothes anyway. In summer the weather is so hot sometimes that cool ventilated laboratory may felt much more comfortable and this can interfere with study results. Another aspect for consideration is the EmbrWave and its comfortability. Some participants indicated they felt inconvenient with the EmbrWave and it also could've influenced their answers and the results of the study (e.g., desire to finish study faster and take of device). As Booker (2007) noticed, feelings of comfort are important for belongingness.

Conclusion

This study didn't confirm the hypothesis about the presence of difference in belongingness level between physical warmth and physical coldness. However, these results are useful for a better understanding of the relationships between temperature and belongingness, since we discovered a possibility of difference in perceived belongingness under warm and cold physical temperature between Eastern and Western cultures. Further research is needed to establish whether people feel more belong when they feel physical warmth than when they feel coldness, and if the social thermoregulation exist. Further studies should also take into account the importance of identification what temperature applied to induce feelings of warm versus coldness and research culturally homogenies sample when it comes to belonging. The results we got should be taken into account by other researchers

when they plan, conduct and analyze investigations of social thermoregulation and related to it concepts.

References

Aczel, B., Palfi, B., Szollosi, A., Kovacs, M., Szaszi, B., Szecsi, P., ... & Wagenmakers, E. J. (2018). Quantifying support for the null hypothesis in psychology: An empirical investigation. Advances in Methods and Practices in Psychological Science, 1(3), 357-366. https://doi.org/10.1177/2515245918773742

Anderson, S. F., & Maxwell, S. E. (2016). There's more than one way to conduct a replication study: Beyond statistical significance. Psychological Methods, 21(1), 1. https://doi.org/10.1037/met0000051

Bargh, J. A., & Shalev, I. (2012). The substitutability of physical and social warmth in daily life. Emotion, 12(1), 154. https://doi.org/10.1037/a0023527

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. Psychological bulletin, 117(3), 497. https://doi.org/10.1037/0033-2909.117.3.497

Baumeister, R. F., DeWall, C. N., Ciarocco, N. J., & Twenge, J. M. (2005). Social exclusion impairs self-regulation. Journal of personality and social psychology, 88(4), 589. https://doi.org/10.1037/0022-3514.88.4.589

Booker, K. C. (2007). Perceptions of classroom belongingness among African American college students. College Student Journal, 41(1), 178-187.

Cacioppo, J. T., & Patrick, W. (2008). Loneliness: Human nature and the need for social connection. WW Norton & Company.

Chen, Z., Poon, K. T., & DeWall, C. N. (2015). Cold thermal temperature threatens belonging: The moderating role of perceived social support. Social Psychological and Personality Science, 6(4), 439-446. https://doi.org/10.1177/1948550614562843

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. Abingdon. England: Routledge.

Cohen, S., Doyle, W. J., Skoner, D. P., Rabin, B. S., & Gwaltney, J. M. (1997). Social ties and susceptibility to the common cold. Jama, 277(24), 1940-1944. https://doi.org/10.1001/jama.1997.03540480040036

DeWall, C. N., Deckman, T., Pond, R. S., & Bonser, I. (2011). Belongingness as a core personality trait: how social exclusion influences social functioning and personality expression. Journal of personality, 79(6), 1281-1314. https://doi.org/10.1111/j.1467-6494.2010.00695.x

Dienes, Z. (2014). Using Bayes to get the most out of nonsignificant results. Frontiers in Psychology, 5, Article 781. https://doi.org/10.3389/fpsyg.2014.00781

Dienes, Z. (2016). How Bayes factors change scientific practice. Journal of Mathematical Psychology, 72, 78-89. https://doi.org/10.1016/j.jmp.2015.10.003

Ebersole, P. (1998). Types and depth of written life meanings. Lawrence Erlbaum Associates Publishers.

Fay, A. J., & Maner, J. K. (2012). Warmth, spatial proximity, and social attachment: The embodied perception of a social metaphor. Journal of Experimental Social Psychology, 48(6), 1369-1372. https://doi.org/10.1016/j.jesp.2012.05.017

Fay, A. J., & Maner, J. K. (2015). Embodied effects are moderated by situational cues: Warmth, threat, and the desire for affiliation. British Journal of Social Psychology, 54(2), 291-305. https://doi.org/10.1111/bjso.12088

Frederiks, K., Sterkenburg, P., Lavner, Y., Cohen, R., Ruinskiy, D., Verbeke, W., & IJzerman, H. (2018). Mobile Social Physiology as the Future of Relationship Research and Therapy: Presentation of the Bio-App for Bonding (BAB). https://doi.org/10.31234/osf.io/xr8ma

Goodman, S. (2008). A dirty dozen: Twelve P-value misconceptions. Seminars in Hematology, 45, 135-140. https://doi.org/10.1053/j.seminhematol.2008.04.003

Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. Online readings in psychology and culture, 2(1), 8. https://doi.org/10.9707/2307-0919.1014

IJzerman, H., & Hogerzeil, L. J. (2017). People as penguins: Thermoregulation as part of the human essence. The Handbook of Human Essence. Oxford University Press. https://doi.org/10.31234/osf.io/zrtg6

IJzerman, H., & Semin, G. R. (2009). The thermometer of social relations: Mapping social proximity on temperature. Psychological science, 20(10), 1214-1220. https://doi.org/10.1111/j.1467-9280.2009.02434.x

IJzerman, H., Coan, J. A., Wagemans, F., Missler, M. A., Beest, I. V., Lindenberg, S., & Tops, M. (2015). A theory of social thermoregulation in human primates. Frontiers in psychology, 6, 464. https://doi.org/10.3389/fpsyg.2015.00464

IJzerman, H., Lindenberg, S., Dalğar, İ., Weissgerber, S. S., Vergara, R. C., Cairo, A. H., ... & Hall, C. (2018). The Human Penguin Project: Climate, social integration, and core body temperature. Collabra: Psychology, 4(1). https://doi.org/10.1525/collabra.165

IJzerman, H., Heine, E. C., Nagel, S. K., & Pronk, T. M. (2017). Modernizing relationship therapy through Social Thermoregulation Theory: Evidence, hypotheses, and explorations. Frontiers in psychology, 8, 635. https://doi.org/10.3389/fpsyg.2017.00635

IJzerman, H., Klein, R. A., Dujols, O., Sparacio, A., & Forscher, P. S. (2019, September 20). Human Social Thermoregulation Study Protocol. Retrieved from osf.io/xf7uk

IJzerman, H., Lindenberg, S., Dalğar, İ., Weissgerber, S. S., Vergara, R. C., Cairo, A. H., ... & Hall, C. (2018). The Human Penguin Project: Climate, social integration, and core body temperature. Collabra: Psychology, 4(1). https://doi.org/10.1525/collabra.165

Inagaki, T. K., & Eisenberger, N. I. (2013). Shared neural mechanisms underlying social warmth and physical warmth. Psychological Science, 24(11), 2272-2280. https://doi.org/10.1177/0956797613492773

Kang, Y., Williams, L. E., Clark, M. S., Gray, J. R., & Bargh, J. A. (2010). Physical temperature effects on trust behavior: the role of insula. Social cognitive and affective neuroscience, 6(4), 507-515. https://doi.org/10.1093/scan/nsq077

Lambert, N. M., Stillman, T. F., Hicks, J. A., Kamble, S., Baumeister, R. F., & Fincham, F. D. (2013). To belong is to matter: Sense of belonging enhances meaning in life. Personality and Social Psychology Bulletin, 39(11), 1418-1427. https://doi.org/10.1177/0146167213499186

Loveland, K. E., Smeesters, D., & Mandel, N. (2010). Still preoccupied with 1995: The need to belong and preference for nostalgic products. Journal of Consumer Research, 37(3), 393-408. https://doi.org/10.1086/653043

Markus, H. R., & Kitayama, S. (1991). Culture and the self: implications for cognition, emotion, and motivation. Psychol. Rev. 98, 224-253. https://doi.org/10.1037/0033-295X.98.2.224

Möller, J., & Herm, S. (2013). Shaping retail brand personality perceptions by bodily experiences. Journal of Retailing, 89(4), 438-446. https://doi.org/10.1016/j.jretai.2013.05.004

Murphy, P. N., & Standing, L. G. (2014). Tactile Warmth Reduces Loneliness, but Visual Warmth Does Not. Psychology Journal, 11(2).

Newman, B. M., Lohman, B. J., & Newman, P. R. (2007). Peer group membership and a sense of belonging: their relationship to adolescent behavior problems. Adolescence, 42(166).

Nie, J., Park, M., Marin, A. L., & Sundar, S. S. (2012, March). Can you hold my hand? Physical warmth in human-robot interaction. In 2012 7th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 201-202). IEEE. https://doi.org/10.1145/2157689.2157755

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. Science, 349(6251), aac4716. https://doi.org/10.1126/science.aac4716

Seehusen, J., Cordaro, F., Wildschut, T., Sedikides, C., Routledge, C., Blackhart, G. C., ... & Vingerhoets, A. J. (2013). Individual differences in nostalgia proneness: The integrating role of the need to belong. Personality and Individual Differences, 55(8), 904-908. https://doi.org/10.1016/j.paid.2013.07.020

Steger, M. F. (2012). Making meaning in life. Psychological Inquiry, 23(4), 381-385. https://doi.org/10.1080/1047840X.2012.720832

Steinmetz, J., & Mussweiler, T. (2011). Breaking the ice: How physical warmth shapes social comparison consequences. Journal of Experimental Social Psychology, 47(5), 1025-1028. https://doi.org/10.1016/j.jesp.2011.03.022

Steinmetz, J., & Posten, A. C. (2017). Physical temperature affects response behavior. Journal of Experimental Social Psychology, 70, 294-300. https://doi.org/10.1016/j.jesp.2016.12.001

Van Acker, B. B., Kerselaers, K., Pantophlet, J., & IJzerman, H. (2016). Homelike thermoregulation: How physical coldness makes an advertised house a home. Journal of Experimental Social Psychology, 67, 20-27. https://doi.org/10.1016/j.jesp.2015.10.008

Wang, Z., Warren, K., Luo, M., He, X., Zhang, H., Arens, E., ... & Liu, S. (2020). Evaluating the comfort of thermally dynamic wearable devices. Building and Environment, 167, 106443. https://doi.org/10.1016/j.buildenv.2019.106443

Wei, W., Ma, J., & Wang, L. (2015). The 'warm'side of coldness: cold promotes interpersonal warmth in negative contexts. British Journal of Social Psychology, 54(4), 712-727. https://doi.org/10.1111/bjso.12108

Williams, K. D. (2009). Ostracism: A temporal need-threat model. Advances in experimental social psychology, 41, 275-314. https://doi.org/10.1016/S0065-2601(08)00406-1

Williams, L. E., & Bargh, J. A. (2008). Experiencing physical warmth promotes interpersonal warmth. Science, 322(5901), 606-607. https://doi.org/10.1126/science.1162548

Zhou, X., Wildschut, T., Sedikides, C., Chen, X., & Vingerhoets, A. J. (2012). Heartwarming memories: Nostalgia maintains physiological comfort. Emotion, 12(4), 678. https://doi.org/10.1037/a0027236

Zhou, Y., Ho, H. N., & Watanabe, J. (2017). Perceptual-semantic congruency facilitates semantic discrimination of thermal qualities. Frontiers in psychology, 8, 2113. https://doi.org/10.3389/fpsyg.2017.02113

Appendix A

Cover story: "We are testing the efficacy of a new consumer product: the EmbrWave, produced by EmbrLabs. The EmbrWave is a device that you wear that can serve as an individualized heater or cooler. We are working with EmbrLabs to test their product for them. We want to test them for this in a situation intended to mimic everyday life, when you might wear the EmbrWave while doing other things. To make full use of your time, we will ask you to wear this product while you complete some surveys for our psychology department. All instructions will be presented on the computer screen. The device will heat and cool at different intervals, but you don't have to pay much attention to it. At the start and end of the session, we will ask you some questions about what you thought of the EmbrWave, whether you would want to purchase it, and whether you would recommend the product to others."

Appendix B

"The Need to Belong" scale (Williams, 2009)

1. I felt "disconnected" (R)
2. I felt rejected (R)
3. I felt like an outsider (R)
4. I felt I belonged to the group
5. I felt the other group members interact with me a lot