Warmth in Affective Mediated Interaction

Exploring the Effects of Physical Warmth on Interpersonal Warmth

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***Abstract*—Recent research suggests that physical warmth activates perceptions of metaphorical interpersonal warmth and closeness, and increases pro-social behavior. These effects are grounded in our earliest intimate experiences: being held by our loving caregivers. These findings provide reasons to incorporate warmth in devices for distant affective communication, which could simulate one's body heat. An experiment was carried out to gain a better understanding of the implications of physical warmth for mediated social interaction. Moreover, we aimed at disentangling effects of social warmth (body temperature) from effects of non-social warmth (artificial heat sources and ambient temperature). Except for an increase in perceptions of metaphorical warmth as a consequence of higher ambient temperature, no effects were found. We use our study to pinpoint the caveats and challenges that research into warmth in affective mediated interaction faces.**

Keywords—Temperature; Computer Mediated Communication; Mediated Social Touch; Body Heat; Attribution

I. INTRODUCTION

When people describe social relationships, they often apply metaphors such as "she is a cold person" or "I am holding warm feelings towards him". These 'social temperature' metaphors conveniently explain one's perceptions of a relationship, and show a strong similarity across languages [1]. Based on Asch' early work [2], Fiske and colleagues describe the cold-warm dimension as one of two main dimensions on which one's first impression of someone else is based [3]. When someone is perceived as being a warm person, several traits related to perceived intent (e.g., friendliness, helpfulness, sincerity, trustworthiness, and morality) are attributed to this person. Lakoff and Johnson proposed that abstract metaphors, for instance metaphorical warmth and affection, are actually grounded in concrete physical experiences [4]. Our earliest intimate experiences consist of being held by our loving caregivers and perceiving the accompanying body heat. It is argued that these experiences are associated with the metaphorical warmth perceived in another person, and with interpersonal closeness. Based on this premise, different studies have been carried out recently, in which it is suggested that subtle manipulations of physical (i.e., non-social) temperature can activate and affect social concepts such as interpersonal closeness and perceived metaphorical warmth, and pro-social behavior [5]. Moreover, whereas temperature perception traditionally is related to the somatosensory cortex (as being a sub-modality of the sense of touch), recent neurobiological research provides evidence that the insular cortex – which is also responsible for feelings of trust, empathy, and social emotions of guilt and embarrassment – is involved in the processing of temperature as well [6]. In addition, both metaphorical and physical warmth are processed in the insular cortex area, and can activate each other [7], [8].

Oftentimes, impressions related to metaphorical warmth are established during face-to-face interaction in which people – both verbally and non-verbally – disclose personal information and emotions [9]. Since our social interactions are increasingly mediated by technology, the question arises whether – and if so, how – Computer Mediated Communication (CMC) can afford the same affective characteristics as real life interactions. On this note, recent efforts have been put in mediated social touch research [10], in which it is investigated to what extent haptic technology can induce social responses similar to those of intimate human touch. Considering the relationship that has been found between physical warmth and metaphorical warmth, and its origins in intimate touch, it seems sensible to incorporate warmth in technologies for affective communication; for instance in mediated touch interfaces, as temperature is considered a significant physical parameter of a social touch [11]. Warm interfaces may thus facilitate the conveyance of affective feelings, but also affect one's socio-emotional behavior. However, research is necessary in order to identify whether, and if so how, physical warmth can be applied in affective CMC. In this study, we aim at gaining a more thorough understanding of the effects of additional physical warmth (as compared with the regular room temperature) on perceived metaphorical warmth and pro-social behavior during social interactions. Moreover, we differentiate between the effects of two types of non-social warmth (attributed to inanimate technology and to the ambient temperature), and social warmth (attributed to another human being). We do so, in order to better understand the implications of warmth for affective CMC. The knowledge gained from the current experiment can serve as starting point for further investigations on (body) heat in CMC, and contributes to the body of knowledge in the physical-metaphorical warmth link.

II. RELATED WORK

A. Physical and Metaphorical Warmth

In a period of relative helplessness, young children (and also other mammals) have to rely on their caregivers to survive. One of the key elements of this survival is physical contact and the accompanying warmth (allegedly even more important than food [12]). During these early interactions we learn how to interact and form relationships with other people on a higher order cognitive level; our so-called attachment

styles are formed. As a consequence, a close association between physical and metaphorical interpersonal warmth is developed. Moreover, for body temperature to be perceived, the two interactants need to be in close proximity of each other, which inherently is intimate. Abstract concepts like social closeness and intimacy therefore seem to be derived from the physical proximity during early child-mother interactions [4]. Recent research demonstrated that non-social, physical warmth – either provided by ambient temperature, or inanimate warm objects – can activate pro-social behavior and associations with abstract concepts such as interpersonal warmth, closeness, and social presence [13]. After being primed with holding a warm drink (versus an iced drink), people tend to assess another person higher on personality traits that are related to metaphorical warmth, but not on traits that are unrelated to this cold-warm dimension. Moreover, the same authors found that people, after holding a warm therapeutic pad (contrary to a cold one), behave more altruistically when having to choose between giving a small present away, or keeping it. During a similar economic game, children were more willing to share stickers in relatively warm ambient conditions than in a colder environment [5]. With regard to effects of warmth on perceived interpersonal closeness, IJzerman and Semin demonstrated that increases in the ambient temperature result in greater social proximity, make people use more relational oriented words, and realize an increased focus on relational aspects [14]. People also felt a closer physical proximity to a warm object than to a cold object, after briefly holding this object. Moreover, an increased need for affiliation when sitting on a heated, rather than on a cooled chair, was found [15]. Since early experiences of infants with their caregivers can differ considerably, the strength of the physical-metaphorical warmth link is not equal amongst people. The effects on pro-social behavior, as well as on perceived closeness in the studies [5] and [15], were mediated by the attachment style of the participant: Only the behavior of securely attached people was affected by warmth. It therefore seems appropriate to take this personal characteristic into account during research on the physical-metaphorical warmth link, and the potential of warmth in mediated social interaction.

It is important to note that research on the relation between physical and metaphorical warmth still is in its infancy. In the majority of the studies, beneficial social effects of increases in physical temperature are suggested, but it may also be the case that priming with coldness negatively affects social behavior. The latter is supported by another study utilizing an economic trust game, in which it was found that people invested less with an anonymous partner when perceiving colder temperatures [16]. This suggests that priming with coldness decreases interpersonal trust, rather than priming with warmth increasing it. More important, accompanying fMRI studies demonstrated that coldness – contrary to warmth – activates specific brain regions associated with trust.

B. Temperature in Affective Mediated Communication

Interpersonal affective CMC plays an increasingly important role in our social interactions. One of the related research areas currently under investigation is the field of mediated social touch (see [10] for an overview). Research on this topic aims at investigating whether and how (social) response similarities – such as the communication of emotions or an increase in affective feelings [17], [18] – between a real human touch and a touch that is simulated by haptic technology can be achieved. The few empirical studies conducted in this field provide initial evidence that response similarities between co-located and mediated touch can be achieved. With relatively simple technologies such as a small rotating disk to the fingertip [19], or force feedback joysticks [20], different emotions can be communicated above chance level. Moreover, people feel more connected with, and more intimacy towards the other during mediated touch interaction [21], and demonstrated more helping behavior after receiving a mediated touch [22]. A human touch is a complex composition of physical parameters and qualities [11], of which temperature is a prominent one. It is nearly impossible to fully recreate a human touch, but different haptic technologies provide the opportunity to disentangle several touch parameters and to scrutinize their effects in isolation. The investigation of temperature in CMC – either presented as parameter of a simulated touch, or as purely non-social heat – seems a valuable additional line of research. The reason for this is that temperature seems to affect perceptions of others, pro-social behavior, and perceived interpersonal closeness; i.e., social cognitions that are important in affective communication.

Several mediated social touch devices that include warmth have been developed, for instance: “The Hug” [23], which is an anthropomorphic cushion that communicates hugs by means of vibro-tactile and warm thermal feedback, “YourGloves”, “HotHands”, and “HotMits” [24], which support the feeling of holding hands over a distance, and “Huggy Pajama” [25], which is a pajama that can reproduce hugs by means of inflatable air pockets and heating elements. However, no studies concerning potential social effects were carried out with these conceptual devices. With regard to the affective qualities of warmth in affective CMC, only initial steps have been made, focusing on the perception of thermal stimuli. Salminen and colleagues applied two methods of presenting thermal stimuli to the hand (i.e., pre-adjusted or dynamically changing) and varied the temperature change relative to the baseline temperature of the hand. They found – based on self-reports and skin conductance responses – that warmer stimuli induced more arousal and higher dominance ratings, and concluded that hedonic qualities of warmth (i.e., pleasantness and comfort) were more affected by presentation method than by the absolute intensity [26], [27]; pre-adjusted stimuli were perceived as more pleasant. Other studies demonstrated that warm thermal stimuli in conjunction with other media such as emotionally charged music and visuals [28], or images of food [29], resulted in increased experienced arousal and a positive effect on perceived valence of the images and music, and higher deliciousness ratings of the food. Although not explicitly mentioned in the articles referred to, the results mentioned point in the direction of the aforementioned interaction between physical warmth and affective behavior.

The latter studies mostly focused on the perception of thermal stimuli as such, but did not yet investigate the possible role of attributing the perceived warmth to another person. Lee and Lim included warmth in a mediated communication

system and evaluated its potential in a focus group setting and a field study [30], [31]. They concluded that the real potential of heat communication devices – with temperature, duration, and rate of change as parameters – is within the communication of emotionally charged messages. This suggestion was put into practice in an empirical investigation of the social effects of warmth in mediated interpersonal interaction. Warmth (i.e., a 'thermal hug') seems to enhance feelings of social presence (i.e., the sense of 'being there' with the other) [32]. Pairs in either intimate relationships or close friendships collaborated over distance by means of instant messaging. In the condition in which one person of the dyad could send 'thermal hugs' to the other, the perceived social presence was higher than in a condition where no such hugs could be sent. In two studies in which the perceived warmth could directly be attributed to an embodied agent (rather than to a human being), some social effects were found as well. Participants experienced a higher level of friendship with a robotic animal when its skin was warmer [33]. In another study, participants were holding the hand of a robot while watching a horror movie. They felt more trust and friendship towards the robot when its hands were warm, rather than cold [34]. Moreover, the robot with warm hands was perceived as more human-like. Regarding the latter studies, it remains unclear whether the social effects found are a result of the thermal stimuli as such, or the attribution of the heat to another entity. This requires further investigation.

Earlier research on affective interpersonal communication by means of physiological signals – i.e., auditory heartbeats – [35] suggested that the attribution of these signals to real-time measurements in another person, rather than to an audio excerpt from a movie, enhanced the associated social effects; an increase in perceived interpersonal intimacy. A parallel between heartbeats and social warmth (i.e., body heat) can be drawn, as both can only be perceived when being in someone's pericutaneous space. Since this inherently is intimate, one may expect that attributing warmth to another person, rather than to a non-social source, also increases affective feelings.

C. The Current Experiment

With the current study, we aim at broadening the knowledge with regard to the presumed relations between physical warmth and social cognitions and behavior (i.e., perceived metaphorical warmth in an another person, social closeness, social presence, and pro-social behavior). To do so, we manipulate warmth, by bringing participants in direct physical contact with a heated (or unheated) object (a chair in this case). We particularly focus on the question to what extent a differentiation between social (attributed to the other participant) and non-social (attributed to technology) affects the social cognitions. Moreover, the role of the (also non-social) ambient temperature is investigated. We focus on comparisons between warm stimuli and stimuli at common room temperature; no particularly cold stimuli are included in this study. Based on the literature as discussed, we hypothesize the following effects:

H1: Direct physical contact with warmth increases the positive valence of social cognitions and behavior, as compared with contact with neutral temperature.

H2: The effect of H1 is stronger when the warmth is perceived as being social warmth and thus attributed to another person, rather than to non-social technology.

H3: Residing in a higher ambient temperature also results in increases in the positive valence of social cognitions and behavior.

Moreover, we will explore to what extent the anticipated effects of direct physical contact with warmth and ambient temperature are interchangeable. We also expect that the anticipated effects are stronger for participants with a secure attachment style. For practical reasons, attachment style was included as a covariate, instead of an independent variable.

III. Methods

A. Design

A 2x3 between-subjects experiment was prepared in which the ambient temperature was manipulated (relatively warm or neutral room temperature), as was the warmth (and accompanying attribution) that was presented directly to the participant (no warmth, warmth attributed to technology, and warmth attributed to another person). As a cover story, participants were asked to form an impression of an unknown interaction partner solely based on a textual instant messaging conversation; first as an interviewer and second – in an adjacent room, with another partner – as interviewee. Unbeknown to the participant, the experiment leader was the interaction partner. After the first conversation the participant was brought to the adjacent (warm or neutral) room, in which he or she was asked to complete a questionnaire regarding the impressions formed of the fictitious interaction partner (who ostensibly just left). The chair on which the participant was sitting was either unheated (*Control Condition; C)* or heated. Half of the participants on the heated chair were told they were partaking in an unrelated pilot experiment regarding an adaptive office chair *(Artificial Heat Condition; AH)*, whereas it was emphasized to the other half that their interaction partner was just sitting there *(Body Heat Condition; BH)*. The warmth was not explicitly mentioned in the heated conditions.

B. Participants

In total, 85 people participated in the experiment, of which 1 did not finish the experiment due to technical problems and 8 were omitted from analysis as they indicated to be aware of the absence of an actual interaction partner. This resulted in 48 participants in the warm environment (C: 13, AH: 16, BH: 19), and 28 in the cold environment (C: 9, AH: 9, BH: 10). The mean age of the participants was 22.1 (*SD*=4.3, range:18-40), 25 of them (32.9%) were female, and 32 (42.1%) had a secure attachment style. All participants were (PhD-)students, unaware of the actual purpose of the study.

C. Materials

Google Hangouts software was used for the textual instant messaging. A semi-scripted approach, with pre-defined questions and answers similar to [36], was applied, in which the participants were asked to formulate the questions in their

own words. The answers were aimed at creating a believable, yet ambiguous personality. With this setup, we aimed at a seemingly natural interaction without variances in personal or emotional self-disclosure of the participant, and without variances in the responses of the "interaction partner", as these are closely related to perceived intimacy [9] and could thus bias the results. For the experimental manipulation, an office chair was discretely equipped with 'Waeco Magic Heat' (MSH-45, 12V, 3A maximum) car seat heaters: one pad in the seat and one in the backrest. The seat was pre-heated to approximately 32°C since a person's skin temperature typically remains between 32-35°C [37]. When the participant would sit down, the heaters were switched off. This resulted in a slow decrease of temperature of the seat, resembling the temperature changes of a chair where someone actually sat before. Different ambient room temperatures were achieved by turning the heating installation on or off; temperatures were recorded with an iButton on the desk. The average temperature in the warmer environment was 23.8°C (*SD* = 0.59, range: 22.4°C – 24.6°C), whereas the neutral environment was 20.2°C on average (*SD* = 1.09, range: 17.2°C - 21.9°C).

D. Measures

To actually measure perceived interpersonal warmth, closeness, social presence, and pro-social behavior, participants were asked to answer several questions. We applied the ten bipolar 7-point scales as used by Williams and Bargh [8] in their experiment to investigate the participant's perceptions of the interaction partner as a person. Of these ten personality traits (as initially defined by [2]), five are related to the cold-warm dimension. With regard to the perceived closeness and intimacy towards the other, we applied two scales: the Inclusion of Other in Self (IOS) scale [38] and the Subjective Closeness Index (SCI) [39]. In two IOS questions, the participant was asked to indicate which of seven overlapping circle-pairs best represented the perceived relationship with, and perceived intimacy towards the other person respectively. From the SCI, two items were applied: "Relative to all your other relationships (both same and opposite-sex), how would you characterize your relationship with the other participant?" and "Relative to what you know about other people's close relationships, how would you characterize your relationship with the other participant?". These items were answered on a 7-point scale ranging from "not at all close" to "very close". As a measure for social presence, the nine item 7-point bipolar Semantic Differentials scale [40] (also applied to measure social presence [32]) was used. To investigate the effects on pro-social behavior, the participants were asked to divide 10 credits over themselves and their interaction partners. Each credit would increase the chance of winning 25 Euros in a raffle. This implementation of the dictator game paradigm was derived from [41], who applied it in their study on the effects of a social touch on pro-social behavior. Since earlier studies suggest that effects of warmth on social cognitions are moderated by one's attachment style, we determined whether the participant was either securely or insecurely (dismissing, pre-occupied, or fearful) attached, by means of four short descriptive paragraphs [42], and included this as a covariate. To investigate potential negative connotations of a warm chair in BH, participants were asked how nasty they perceived the chair (7-point likert scale). Moreover, gender, age, and the participant's ideas about the actual purpose of the experiment, potential remarkable aspects, and perceptions of the chair temperature and attribution (manipulation check) were collected.

E. Procedure

The participant was invited in the 'interviewer-room' and provided with instructions about the ostensible purpose and procedure of the experiment. After signing an informed consent form, the participant was asked to fill out a questionnaire containing demographics and the attachment style questions. During this, the experiment leader left the room to "check whether the interaction partner was ready" and returned shortly after. Upon notification of the experiment leader, the participant could start the conversation and ask the 13 pre-determined questions in his or her own words. The experiment leader – present in the same room – discretely answered by copying and pasting the pre-defined answer that best fitted the formulation of the question. To increase the participant's belief of chatting with someone else, the experiment leader left the room shortly before the end of the conversation to "already explain some things to the interaction partner". In reality, the experiment leader answered the final questions from the PC in the adjacent room. Next, the participant was invited into the adjacent room, asked to sit down on the chair, and both verbally and textually instructed – according to the experimental condition – to fill out the questionnaire containing the remainder of the experimental measures. The instructions for the C and BH conditions entailed an emphasis on the presence of the interaction partner in the chair, shortly before the participant, whereas the AH instructions explained that the participant was now – as a part of an unrelated pilot experiment – sitting on an adaptive office chair, about which some questions would be asked afterwards. After instructing the participant, the experiment leader left to "prepare the other room for the next participant". When the participant finished the questionnaire, the experiment leader returned, and debriefed and thanked the participant. As part of the debrief, the participant was asked with whom he thought he actually was having the chat conversation.

IV. Results

Data were recoded such that higher scores represent more positively valenced perceptions and behavior. A univariate ANOVA demonstrated that perceptions of nastiness of the chair did not differ per condition (C, AH, BH): $F(2, 73) = 0.049$, $p = .952$, partial $\eta^2 = .001$. Therefore, feelings of disgust are not further included in the analyses. To investigate the effect of the independent variables on the several dependent variables, a 2 (ambient temperature) x 3 (condition) MANCOVA was carried out, including all dependent variables (i.e., relational IOS, intimacy IOS, SCI, social presence, pro-social behavior, personality trait scores on the warm-cold dimension, and unrelated personality trait scores), and attachment style as covariate. Table I shows the mean scores and standard deviations per experimental condition for each of the dependent variables.

TABLE I. MEAN SCORES (AND SD) PER CONDITION

Dependent variable	Ambient temp.	Control Condition	Artificial Heat	Body Heat
IOS (relation)	Neutral	3.11 (1.17)	3.33 (1.58)	2.8 (1.55)
	Warm	2.54 (1.33)	2.56 (1.21)	2.47 (0.91)
IOS (intimate)	Neutral	2.78 (1.64)	3.67 (1.41)	2.9 (1.66)
	Warm	2.77 (1.09)	2.62 (1.46)	2.84 (1.34)
SCI	Neutral	2.61 (0.99)	3.39 (1.58)	2.15 (0.88)
	Warm	2.12 (0.92)	2.38 (1.3)	2.71 (1.26)
Social presence	Neutral	4.4 (1.02)	4.86 (0.54)	4.46 (0.89)
	Warm	4.98 (0.48)	4.36 (0.87)	4.51 (0.97)
Pro-social behavior[a]	Neutral	0.33 (0.71)	0.22 (0.44)	0.0 (0.47)
	Warm	0.85 (1.57)	-0.19 (1.56)	0.11 (1.05)
Warm-Cold traits	Neutral	5.42 (0.47)	5.42 (0.61)	5.26 (0.52)
	Warm	5.8 (0.4)	5.71 (0.56)	5.76 (0.63)
Unrelated traits[b]	Neutral	5.0 (0.59)	5.49 (0.48)	5.12 (0.51)
	Warm	5.29 (0.57)	4.94 (0.81)	5.17 (0.57)

[a.] Scale ranged from -5 to 5.

[b.] No social effects of warmth on this dependent variable were expected.

No significant main effect of experimental condition (i.e., C, AH, or BH) was found (Wilks' $\lambda = .862$, $F(14, 126) = 0.694$, $p = .777$, partial $\eta^2 = .072$), suggesting there is no statistical difference in scores between warmth attributed to technology and warmth attributed to another person with regard to any of the dependent variables. A subsequent custom hypothesis test, combining both heated chair conditions and contrasting these scores with the control condition, did not result in any significant effects either ($p > .067$ for all dependent variables). With regard to the ambient temperature, a statistically significant main effect was found (Wilks' $\lambda = .738$, $F(7, 63) = 3.196$, $p = .006$, partial $\eta^2 = .262$). Closer inspection of the ANCOVAs revealed that a higher ambient temperature significantly increased personality trait scores on the warm-cold dimension: $F(1, 69) = 8.87$, $p = .004$, partial $\eta^2 = .114$. No effects were found for the remainder of the dependent variables: $p > .098$. No interaction effect between ambient temperature and experimental condition was found (Wilks' $\lambda = .791$, $F(14, 126) = 0.791$, $p = .347$, partial $\eta^2 = .111$). Moreover, the influence of attachment style as a covariate turned out to be non-significant as well: (Wilks' $\lambda = .915$, $F(7, 63) = 0.834$, $p = .563$, partial $\eta^2 = .085$).

V. DISCUSSION

Several hypotheses were defined with regard to the social effects of physical warmth – attributed to both social and non-social heat sources – in interpersonal interaction. The overarching hypotheses as well as the individual dependent variables are discussed in order to highlight several caveats and challenges concerning research on warmth in social interaction.

According to the first hypothesis, sitting on a warm chair should result in higher social perceptions and pro-social behavior with regard to the interaction partner, as compared with sitting on an unheated chair. No support for this hypothesis was found. Moreover, no social effect of attribution of the warmth in the chair – either to technology or to the interaction partner – was found. The results thus do not provide support for H2 either. A possible explanation for the latter could be that attributing warmth to a social heat source does simply not have an added value over attribution to non-social heat sources. However, this does not explain the absence of effects of warmth presented directly to the participant. Ambient room temperature was also expected to affect social cognitions (H3); a warm environment was expected to increase the different social cognitions. The results of the current study provide support for this hypothesis, albeit not for all dependent variables. Residing in a warm environment resulted in higher scores on personality traits related to the (metaphorical) warm-cold dimension as compared with an environment of neutral temperature. A warmer personality was thus attributed to the fictitious interaction partner. Moreover, personality traits unrelated to the warm-cold dimension were not affected by warmth. Both findings are in line with the claim that physical warmth activates and increases perceptions of warmth in another person [8]. Contrary to expectations, the remainder of the dependent variables were not affected by ambient temperature. A test on a possible interaction effect between the three conditions and the ambient temperature did not sort a significant result. The absence of such (interaction) effects prevents us from deriving practical implications for warmth in affective CMC devices; for instance to what extent effects of ambient temperature may add up to, or attenuate effects of direct physical stimuli (such as the heated chair, or an affective interface). However, a possible explanation for the absence of many of the anticipated effects could be that the ambient temperatures in both conditions were relatively high; in particular in comparison with other studies that utilize ambient temperature as heat manipulation [5], [15]. In these studies, the difference in temperature between the warm and the cold conditions typically is larger than the difference between the warm and less warm (i.e., neutral, not cold) condition in our study. This could explain why only an effect of ambient temperature was found for one of the dependent variables. Moreover, the fact that no differences were found between the heated and unheated chair may have been caused by the relatively high ambient temperatures as well. The ambient temperature may have attenuated the possible effect of heating in the chair. This however is very speculative. To conclude the discussion of the hypotheses in general, we did not find any influence on the results of attachment style as covariate. According to earlier research, attachment style modulates the strength of social effects of physical warmth, but since hardly any effects of physical warmth were found in this study, it is hard to draw conclusions.

When zooming in on the different dependent variables and comparing these data with the results of related studies, interesting conclusions can be drawn. It is for instance interesting to note that the average score of personality traits on the warm-cold dimension was relatively high (5.59 on a 7 point scale, in the heated chair conditions), as compared with 4.71 after priming with warmth in the original study [8]. Since chair heating did not sort effects, the reason for these scores being high could be that – despite the ambiguous answers – the "interaction partner" was presented as a very warm person.

This could have resulted in a ceiling effect, nullifying possible effects of the physical warmth. Another (perhaps additional) explanation could be the, as mentioned, relatively high ambient temperatures in both conditions. The current study partially confirms the claims made in earlier experiments, stating that higher ambient temperatures increase social perceptions [5], [14]. However, when the latter would be the case, one would expect different IOS and SCI scores to be on the higher ends of the scales as well; in particular in the warmer environment. Interestingly, the average scores of these three dependent variables were all below three, on a seven-point scale, implying seemingly low social closeness and perceived intimacy. A closer look at the results that were found in earlier research [14] reveals that scores were higher when the participants were to determine interpersonal closeness to someone of their own choice (5.12 in the warm and 4.13 in the cold environment; study 1) as compared with perceived interpersonal closeness towards the experiment leader in the subsequent study (i.e., 2.63 and 2.08 in warm and cold respectively). The latter scores are comparable with the scores in the current study. This difference could be explained by the way the thermal manipulation was carried out. Priming with a warm drink could have stronger effects than residing in a relatively warm environment. However, the relation between the participant and the person to whom the perceived closeness was determined could be an influential factor as well. It seems plausible that people chose someone with whom they already had a pre-existing (possibly intimate) relationship, while people in the follow-up experiment were not familiar with the experiment leader. Following this argument, the unfamiliarity with the unknown interaction partner could explain the low scores on perceived closeness and intimacy; it however cannot explain the lack of significant differences between high and neutral temperatures. Nonetheless, relationship also appears to play a role in pro-social behavior as an effect of physical warmth; children were more willing to share with friends than with strangers [5]. Moreover, Gooch and Watts also take the position that social effects of warmth in mediated settings are partly determined by the relationship between interactants [32]. The absence of significant effects with regard to pro-social behavior and social presence in the current study may also be a consequence of the unfamiliarity with the fictitious interaction partner. When assuming that a pre-existing relationship is a prerequisite for warmth to have effects, this could also explain the lack of influence of attachment style.

Until this point, the discussion of the results was based on the premise that physical warmth indeed positively affects social cognitions and behavior. However, we need to acknowledge that the research on the physical-social warmth link is also still in its infancy; only a handful studies has been carried out in this specific area, in which oftentimes a comparison is made between priming with warmth (e.g., coffee cup, heat pads, or warm ambient rooms (21-26°C)) and coldness (e.g., iced drinks, cool pads, or cold rooms (14-18°C); e.g., [5], [8], [16], [14], [15]. This difference in paradigm could be the overarching reason why the effects found earlier could not be replicated. As mentioned in the related work section, a negative effect of coldness could also be the case. This idea is for instance supported by neurobiological research [16] suggesting that coldness – contrary to warmth – activates the same areas in the brain as those that are related to trust, resulting in less willingness to invest with an anonymous interaction partner. When looking more closely at earlier research on pro-social behavior [8], we see that after priming with warmth, the division between altruistic and egoistic behavior is around chance level (i.e., 54% is pro-social), but participants are far less pro-social after being primed with coldness (only 25% demonstrated altruistic behavior). Moreover, only little evidence is available that suggests that warmth has positive social effects when compared with neutral temperatures (e.g., [7]). Other studies also claim a positive effect of a warm mediated hug on social presence [32], or of holding a warm robot hand on perceived friendliness [34], as compared with neutral temperatures. It is however unclear whether these effects are subject to the warmth as such, or possible mediating factors such as human-likeness of the robot, or having an additional channel of communication.

The current experiment had several limitations, of which the implicitness of the attribution was the most prominent. We anticipated that spoken and written implicit references to the heat source would be sufficient for attribution of the perceived warmth. However, the manipulation check questions indicated that many people attributed the warmth to a heat source different than the condition they were in. Another footnote to be placed is that participants in our study were presented with the warmth after the actual interaction, whereas related studies presented the warmth either before or during the task. Perhaps participants already formed their impressions of the other, and were not susceptible to the thermal stimuli anymore.

VI. Conclusions and Future Work

The number of studies on the link between physical warmth and social warmth is still relatively small, and thus more investigations are required to form a more solid body of knowledge. At first glance, the inclusion of warmth in affective CMC such as mediated social touch seems a promising idea, as warmth can be applied to convey affect, but also has influence on social cognitions and behavior. However, the current study did provide neither additional support for these claims, nor insights in the effect of attribution of the heat source. Based on the results of our study, caveats were pinpointed with regard to earlier research. From this, we conclude that including thermal stimuli in affective CMC is all but trivial; just adding warmth does not seem to do the trick. If we indeed are to integrate warmth in for instance mediated touch applications in order to activate certain feelings or behaviors, more thorough insights are required in the actual social effects of warm (and cold (!)) stimuli and accompanying socio-psychological theories, attribution of the warmth (comparing social and non-social heat effects, implicit and explicit references to the heat source, and interpersonal relationships), interactions with other communication channels such as audiovisual and touch, and the prerequisites for successful implementation of warmth as an affective medium in terms of personal and environmental characteristics. Moreover, advancements with regard to research paradigms and measures are necessary. When advancements in these areas are made, affective CMC with thermal stimuli may eventually become a hot (or cool) topic.

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