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Don't sweat it: Ambient temperature does not affect social behavior and perception☆

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ABSTRACT

Literature suggests that human perception and behavior vary with physical temperature. We conducted an experiment to study how different ambient temperatures impact social behavior and perception: subjects undertook a series of tasks measuring various aspects of social behavior and perception under three temperature conditions (cold vs. optimal vs. warm). Despite well-established findings on the effects of temperature, our data suggest that ambient temperature has no relevant influence on social behavior and perception. We corroborate our finding of a null effect using equivalence testing and provide a discussion considering recent failed replication attempts in this field of research and related studies on heat and violence.

1. Introduction

Thermoregulation is one of the most important functions of the human body (Charkoudian, 2003). Over time, evolutionary processes have profoundly shaped human behavior and cognition such that many human characteristics have emerged from adjusting to external temperature (Parsons, 2014; Wheeler, 1984). It is argued that humankind regressed hair growth and developed upright walking through evolutionary processes to facilitate the dissipation of excess body heat (Wheeler, 1984). Such adaptations were crucial for survival because a 4 °C rise from normal body temperature is fatal (Bouchama & Knochel, 2002). Consequently, thermoregulation has deeply shaped human nature, society, and culture. Temperature influences primal behavior, such as seeking shadowy areas when it is hot or seeking warmth by huddling with conspecifics (Ebensperger, 2001). Humans consume food, clothe themselves, and build houses to maintain a stable body temperature (Parsons, 2014). Oaktree ring analysis revealed a significant role of temperature changes in the major mass migrations in central Europe in the past 2500 years (Büntgen et al., 2011). Further, thermal stress has always been and still is a relevant factor in military operations (Goldman, 2001).

☆ All materials, including supplementary analyses, oTree scripts, and all the code for running all analyses and generating all figures, are available online in an OSF repository (https://osf.io/utpxf/?view_only=cb821201f50849e18f709108c29893bd).

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Due to their economic relevance, economists have empirically investigated the effects of temperature. Evidence has linked high temperatures to lower stock market returns (Cao & Wei, 2005), lower economic growth (Dell, Jones, & Olken, 2012), less economic production (Burke, Hsiang, & Miguel, 2015b), and hence a higher risk of conflict (Burke, Hsiang, & Miguel, 2015a). Temperature also influences risk preferences (Wang, 2017) and court decisions (Heyes & Saberian, 2019). Finally, the relevance of studying the link between temperature and human behavior is obvious in the light (or shadow) of the predicted climate change leading to a global rise in temperature and a consequent increased frequency and magnitude of heat waves (Intergovernmental Panel on Climate Change, 2022).

There are two seemingly contradictory strands of literature on the influence of temperature on social behavior. On the one hand, the economics literature is predominantly concerned with the negative impact of heat, i.e., a heat-aggression link that connects uncomfortably high temperatures to impaired mood (Baylis, 2020; Keller et al., 2005), increased aggression (Anderson, 1989, 2001; DeWall & Anderson, 2011), increased risk of civil conflict (Burke et al., 2015a) and increased criminal activities (Bruederle, Peters, & Roberts, 2017; Heilmann, Kahn, & Tang, 2021; Mares & Moffett, 2019; Ranson, 2014). On the other hand, there is a psychological literature that considers a positive impact of warm temperatures, a warmth-prosociality link that connects comfortably warm temperatures to increased perception of social closeness (Williams & Bargh, 2008), increased perception of personal warmth (Ijzerman & Semin, 2009) and increased social behavior (Storey & Workman, 2013; Williams & Bargh, 2008).

Concerning the negative impact of heat, the psychological literature has shown that external temperatures strongly influence and shape human psychology and behavior. Aggression and conflict are exacerbated by heat (Anderson, 1989, 2001; DeWall & Anderson, 2011), and high temperatures impair mood (Keller et al., 2005), sleep (Okamoto-Mizuno, Tsuzuki, & Mizuno, 2004), and health (Ormandy & Ezratty, 2012; Parsons, 2014). There is evidence that heat could also lead to more suicidal behavior (Fountoulakis et al., 2016; Holopainen, Helama, Björkenstam, & Partonen, 2013). Multiple broad-based meta-studies have suggested that extremely high and low temperatures negatively affect cognitive performance, indicating that performance follows an inverse U-shaped curve with an optimum at medium temperatures (Hancock, Ross, & Szalma, 2007; Pilcher, Nadler, & Busch, 2002; Yeganeh, Reichard, McCoy, Bulbul, & Jazizadeh, 2018). Recently, economists have suggested multiple mechanisms by which very high temperatures could influence social behavior. These include internal effects on individuals by either directly affecting pro-sociality and aggression (Almås et al., 2019; Blakeslee, Chaurey, Fishman, Malghan, & Malik, 2021; Mukherjee & Sanders, 2021) or indirectly by affecting mental capacities, self-control, risk- and time preferences, taste for violence, etc. Almås et al. (2019), Baysan, Burke, González, Hsiang, and Miguel (2019), Blakeslee et al. (2021) and Heilmann et al. (2021). Heat was also proposed to influence behavior through external effects, for example, resource scarcity, migration, or decreased law enforcement effort (Burke et al., 2015a; Heilmann et al., 2021; Missirian & Schlenker, 2017).

Concerning the positive impact of higher temperatures on social behavior, there is evidence of an association between warmth and prosocial behavior. Asch (1961) claimed that the words "cold" and "warm" dramatically change the impression that individuals form about others. Furthermore, there is evidence that thermal factors also influence social perceptions indicated by specific language use, i.e., idioms such as "showing the cold shoulder" or "having warm feelings for someone" (Ijzerman & Semin, 2009). Such metaphorical phrases appear universal across cultures (Lakoff & Johnson, 1980; Landau, Meier, & Keefer, 2010). Our literature review identified three main constructs positively impacted by warmth: social warmth, social distance, and empathy.

There is extensive psychological research on the connection between temperature and social warmth. Social warmth is a factor of a universal two-factorial person perception model: socially interacting organisms must determine whether an opponent is a "friend" or "foe" and to what extent an opponent could be harmful or helpful (referred to as ability; Abele & Wojciszke, 2007; Fiske, Cuddy, & Glick, 2007). According to the grounded cognition theories (Barsalou, 2008), the touch of warm objects promotes social warmth (often also called affection) and prosocial behavior (Williams & Bargh, 2008). In an experiment, Williams and Bargh (2008) found that participants holding warm beverages perceived a person as socially warmer than when holding cold drinks. In the second experiment, participants were more altruistic, i.e., they tended to prefer rewards for other people rather than for themselves when holding warm objects.

It is assumed that the touch of warmth activates strongly associated concepts of closeness, which are learned in early childhood (e.g., a mother's warmth during nursing; see also Bowlby, 1969; Harlow, 1958). Ijzerman and Semin (2009) replicated the findings of Williams and Bargh (2008) and showed that ambient warmth diminishes social distance (i.e., increases social proximity). "When social distance decreases, an 'other' is no longer some unknown individual from some anonymous crowd but becomes an identifiable victim" (Schelling, 1968, as cited in Bohnet and Frey, 1999; also see Bohnet and Frey, 1999). As a neurophysiological explanation for their findings, Williams and Bargh (2008) and Ijzerman and Semin (2009) identified the involvement of areas of the insular cortex in both temperature sensations and specific social functions. Kang, Williams, Clark, Gray, and Bargh (2011) measured brain activity via functional magnetic resonance imaging of participants playing the Trust Game while exposed to warm and neutral thermal conditions. Individuals exposed to the warm condition trusted more than those in the neutral condition. Activation patterns of the insular implicated a key function of the insular cortex in mediating the influence of warmth on trust. The insular is strongly associated with empathy, the ability to understand and feel the emotions or intentions of others, which is crucial for cooperation and trust (Bird et al., 2010; Jabbi, Swart, & Keysers, 2007; Singer et al., 2004). This evidence highlights a strong relationship between physical warmth and empathy.

Is there a way to reconcile the contradiction between the heat-aggression and the warmth-prosociality link? There are at least three possible avenues of argument. First, the heat-aggression and warmth-prosociality link deal with categorically different temperature regions. The former deals with uncomfortably high temperatures of upwards of 30 °C, at which temperature become a physical stressor, whereas the latter deals with temperatures where increasing the temperature increases comfort and well-being. Thus, there could be a monotonically increasing relationship between temperature and social behavior to a tipping point, from where higher temperatures increase aggression. Second, prosocial behavior and aggression might be independent constructs. There is ample evidence that people who display high social behavior use aggression, i.e., punishment in public goods games, to increase other people's social behavior (e.g., Choi & Ahn, 2013; Fehr & Gächter, 2000, 2002). Third, most of the laboratory and field experiments on the heat-aggression and warmth-prosociality link rely on small sample sizes, are generally underpowered, and are either unincentivized or rely on small incentives (for a recent meta-analysis see Lynott, Corker, Connell, & O'Brien, 2023). Multiple replication attempts of the findings of Williams and Bargh (2008) and Ijzerman and Semin (2009) were not able to support their results (Chabris, Heck, Mandart, Benjamin, & Simons, 2018; Lynott, Corker, Connell, & O'Brien, 2017; Lynott et al., 2014). More generally, social priming studies are under scrutiny (Vadillo, Konstantinidis, & Shanks, 2016). In light of the replication crisis in the social sciences (see Schultze, Huber, Kirchler, & Mojzisch, 2019), the field of social priming has been called "the poster child for doubts about the integrity of psychological research" (Kahneman, 2012).

Doubts about the psychological literature on the warmth-prosociality link raise the question relevant to this study: Does ambient temperature influence social perception and behavior? Specifically, does ambient temperature, rather than social primes such as holding cold/warm objects, suffice to influence social perception, and does ambient temperature affect social behavior when adequately measured using incentivized methods from behavioral economics? While the latter question contributes to a larger discussion between psychologists and economists on what extent behavior differs under real and hypothetical incentives (for an overview, see Camerer & Mobbs, 2017), the former is relevant considering the predicted climate change in the next decades. Moreover, it appears as a more natural method for studying the effects of temperature on behavior.

We experimentally investigate social decision-making and perception under different temperature conditions to address our research questions. Indoor thermal sensation primarily depends on ambient temperature, relative humidity, and clothing[1] (Parsons, 2014). There is no general agreement about understanding thermal perceptive categories, such as "warm" or "cold". Evidence suggests that the optimal performance level is at ambient temperatures of 21–22 °C (Hancock et al., 2007; Pilcher et al., 2002; Seppänen, Fisk, & Lei, 2006; Yeganeh et al., 2018). Ijzerman and Semin (2009) found the effects of ambient temperature on social distance in 15–18 °C and 22–24 °C rooms. Kunkel and Kontonasiou (2015) identified that 27 °C is broadly considered warm for eight European countries but still a potentially comfortable range of temperature (see also Givoni, 1992; Yang, Yan, & Lam, 2014). Thus, we examined social decision-making and perception in 18 °C (as cold), 22 °C (as optimal), and 27 °C (as warm) environments. Furthermore, we controlled relative humidity and clothing. Humidity affects perceived temperature under extreme temperature conditions. Cold (hot) environments are perceived as less comfortable and colder (hotter) when relative humidity is below 30% (over 50%; Parsons, 2014). Therefore, we held relative humidity between 30% and 40% in all temperature conditions. In a between-subject design manipulating the ambient room temperature (cold vs. optimal vs. hot), we measure multiple facets of social behavior within the same subject using methods from both psychology and behavioral economics.

Our behavioral economics measures included standardized versions of the Dictator Game, Public Goods Game, Trust Game, Ultimatum Game, and Lying Game (Fehr & Camerer, 2004). Our psychological measures are established concepts related to measurements of social warmth, social distance, and empathy. Our findings suggest that ambient temperature has no relevant influence on social decision-making and perception. We corroborate our finding of a null effect using equivalence testing.

2. Hypotheses

In this paper, we investigate the relationship between moderate temperatures (18 °C – 27 °C) and social perception and behavior. We measure multiple components of prosocial behavior, such as altruism, fairness, cooperation, trust, and honesty. Focusing on the comfortable range of temperatures and social behavior measures instead of aggression or anti-sociality measures means we aim to investigate the warmth-prosociality link. The psychological literature on the warmth-prosociality link claims that temperature has a sustained effect on human nature and culture (Ebensperger, 2001; Wheeler, 1984), as well as on human physiology (Parsons, 2014), psychology (Pilcher et al., 2002), and behavior (Burke et al., 2015a, 2015b). Particularly, we could identify three psychological constructs which are claimed to be positively influenced by temperature: First, Williams and Bargh (2008) showed that the touch of warm objects promotes social warmth. Second, Ijzerman and Semin (2009) found similar results by altering social distance through ambient warmth. Finally, neuropsychological studies showed a strong relationship between temperature sensation and empathy because of shared neural structures (Bird et al., 2010; Jabbi et al., 2007; Kang et al., 2011; Singer et al., 2004). We designed our study to conceptually replicate these results by measuring the perceived social warmth of one's partner, the perceived social distance (or proximity) to one's partner, and one's report of empathy. Based on the previous findings, we predict that social perception constructs, such as perceived social warmth, perceived social proximity, and empathy, increase as the ambient temperature increases. This increasing relationship is monotonic for the moderate temperatures of our study design. As our predictions are based on studies with small samples and of dubious quality, and these studies typically only considered differences between warm vs. cold temperatures, we must be agnostic about the exact form of the monotonic relationship between temperature and social perception.

Hypothesis$_1^{\text{Social perception}}$: *For moderate temperature, social perception constructs, i.e., perceived social warmth, perceived social proximity, and empathy, increase monotonically as the ambient temperature increases.*

Next, we consider the implications on social behavior and examine whether an ambient room temperature manipulation is strong enough to influence incentivized decisions. The literature suggests that physical and social warmth, less social distance, and more

[1] Additional relevant factors for thermal reception are thermal radiation (sunshine), wind chill, and skin wetness (sweat). These factors were irrelevant to this experiment because all measurements were made indoors.

empathy have positive effects on cooperation and social norm compliance: Williams and Bargh (2008) showed that individuals in a warm condition chose a socially warmer and altruistic option: Participants briefly holding warm objects more often chose a gift for a friend than for themselves. Similarly, Storey and Workman (2013) found higher cooperation of individuals holding warm objects in an iterated prisoner's dilemma. The literature on interactions between the psychological constructs (social warmth, social distance, and empathy) mentioned earlier and social behavior is even larger (Bird et al., 2010; Dimant, 2019; Ijzerman & Semin, 2009; Jabbi et al., 2007; Kang et al., 2011; Singer et al., 2004; Williams & Bargh, 2008). This motivated our second hypothesis, which considers the effects of ambient room temperature on behavior across a series of established behavioral economics paradigms related to altruism, fairness, trust, cooperation, and social norm compliance. As previous studies could not differentiate whether changes in behavior in these tasks were driven by changes in preferences or beliefs (e.g., about the motives and intentions of one's partner), we are also eliciting incentivized beliefs, where appropriate. Just as for the relationship between the ambient temperature and social perception, we predict a monotonically increasing relationship between our social behavior measures and the ambient temperature.

Hypothesis$_2^{\text{Social behavior}}$: *For moderate temperature, social behavior, i.e., altruism, fairness, cooperation, trust, and honesty, increase monotonically as the ambient temperature increases.*

3. Methods

Subjects. We recruited 144 women and 84 men (M_{age} = 22.87 years, SD_{age} = 4.05, N = 228) from a student subject pool at the University of Mainz using ORSEE - a software platform for organizing and managing experiments (Greiner, 2009). All participants gave written informed consent, participated voluntarily, and were completely made aware of the study's procedures. A joint ethics committee formed by the Economics & Management Faculties of the Universities of Mainz and Frankfurt approved this study.

Procedure. Each subject was asked to change into a t-shirt that was provided on arrival to control clothing. Gender-separated changing rooms were available. Participants were then led to their randomly assigned and isolated experimental booths in the climate-controlled computer laboratory. The room temperature was set to different levels for three experimental groups (M_{cold} = 18.36 °C, SD_{cold} = 0.58; $M_{optimal}$ = 22.13 °C, $SD_{optimal}$ = 0.28; M_{warm} = 27.71 °C, SD_{warm} = 0.39). Relative humidity was held in a comfortable range between 30% and 40% ($M_{humidity|cold}$ = 40.86%, $SD_{humidity|cold}$ = 0.53; $M_{humidity|optimal}$ = 36.77%, $SD_{humidity|optimal}$ = 0.51; $M_{humidity|warm}$ = 32.11%, $SD_{humidity|warm}$ = 0.41), but the relative humidity could not be equalized across treatments. Before starting the test, there was a 30-min manipulation period. The participants stayed in the room for 10 min to get accustomed to the ambient temperature before they executed a 20-min survey on sustainable consumption (Lasarov, Mai, Krause, Schmidt, & Hoffmann, 2021). The 30-min manipulation period was intended for the participants to feel the constant effects of the increased or decreased temperature, i.e., feel cold or warm, and to ensure that the participants do not just react to an initial temperature shock. Before beginning the series of economic tasks and social perception measurements, the participants were randomly and anonymously paired with a partner. The experimental setup is displayed in Fig. 1. At the end of the experiment, the participants individually left the laboratory, their body temperature was measured in a neighboring room, and payments were received.

Payment. The participants received a 6 EUR show-up fee. One task from the series of tasks was randomly chosen for payment. The average earnings were 17.42 EUR for approximately 90 min.

3.1. Measuring social behavior

To measure social preferences, we conducted a series of tasks consisting of a Dictator Game, an Ultimatum Game, a Public Goods Game, a Trust Game, and a Lying Game, which are well-established in the field of behavioral economics (for an overview, see Camerer, 2011). Next, we briefly summarize our specifications of these games and refer to the supplementary appendix for screenshots (original and translated) of the instructions and decision screens.

Public Goods Game. To measure cooperation and reciprocity, we used a Public Goods Game (Marwell & Ames, 1979). In the Public Goods Game, two players are endowed with 10 EUR and are asked to decide on their contribution to a communal project. The players can contribute any natural number between 0 EUR and 10 EUR to the communal project, which generates additional income for the players. Specifically, the combined amount contributed by both players is multiplied by 1.5 and equally distributed among the two players. This marginal per capita return of 0.75 makes the game a Prisoner's Dilemma (Kahneman, Knetsch, & Thaler, 1986). The participants make two decisions. The first contribution decision is made without knowledge of the partner's investment. As a second decision, participants state their contribution as a reaction to each possible investment decision by the partner (Fischbacher, Gächter, & Fehr, 2001).

Trust Game. We measured trust in the partner and trustworthiness using a Trust Game (Berg, Dickhaut, & McCabe, 1995). In this game, one subject, the trustor, is asked to send any amount between 0 and 10 EUR to the other subject, the trustee, who receives the tripled amount. The trustee then decides on what share of the tripled amount to send back to the trustor. We used the strategy method, so trustees stated their decision as a reaction to each possible decision of the trustor (Charness & Rabin, 2002).

Dictator Game. To measure sharing and altruistic behavior, a Dictator Game was conducted. In this game, the participants divide 20 EUR between themselves and a partner (Kahneman et al., 1986). The dictator can give any natural number between 0 and 20 EUR to their partner, who has no decision to make. To substantiate the external validity, we observed donation behavior: Participants

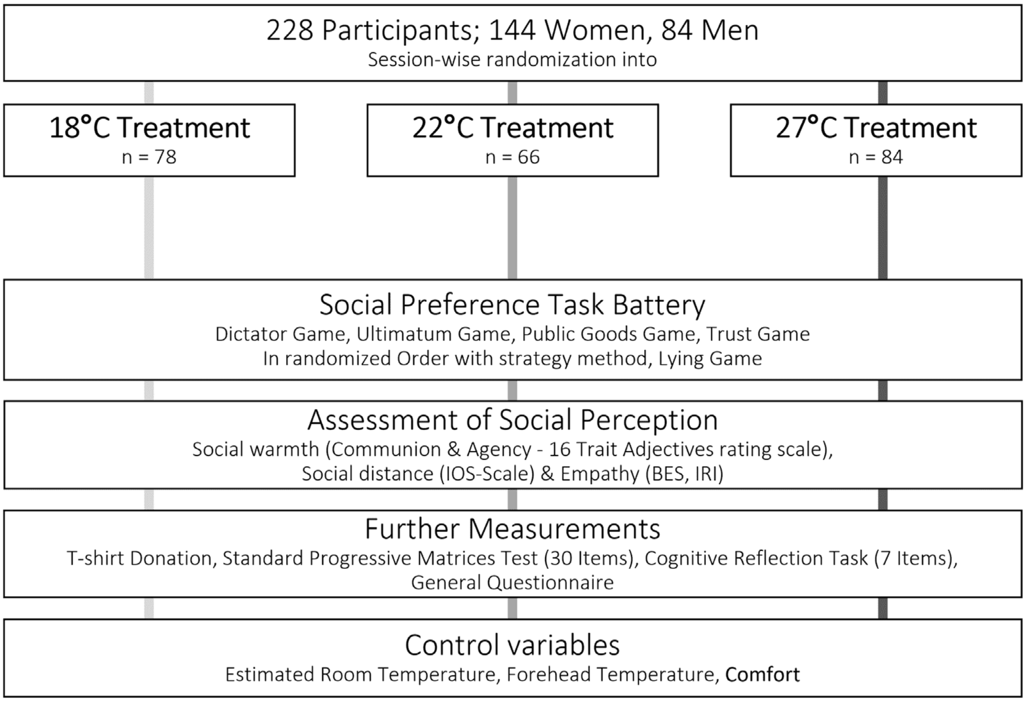

Fig. 1. Experimental setup.

were given a choice to keep the provided t-shirt or to take it back to their assigned booth, where it would be collected and donated to the German Red Cross.

Ultimatum Game. Furthermore, we used the Ultimatum Game, a take-it or leave-it bargaining game (Fehr & Camerer, 2004; Güth, Schmittberger, & Schwarze, 1982). One participant, the proposer, offers a share of 20 EUR to a partner, the responder. The proposer can offer any natural number between 0 EUR and 20 EUR. The responder can then accept or reject the offer, resulting in both participants earning 0 EUR. The responder's choice is elicited indirectly, i.e., they have to state their minimum acceptable offer (MAO), i.e., the smallest amount of money they would be willing to accept.

Lying Game. To measure honesty and lying behavior, we conducted a Lying Game (Fischbacher & Föllmi-Heusi, 2013). In this game, the participants were instructed to roll a die privately. Subjects were informed that their payoff resulted from the reported roll multiplied by factor 3 when rolling 1 to 5. For rolling a six, the payout was zero. Cheating could not be identified on an individual level in this design.

Beliefs. For measuring the beliefs about other players' behavior, the participants were asked to state their assessment of their partners' contribution in the Public Goods Game and the amount sent in the Trust Game, respectively. To incentivize the correct estimations, participants could earn one additional Euro for every correct answer.

Partner matching, interaction and randomization. At the beginning of the experiment, every subject was randomly matched with a partner. Throughout the experiment, any interaction between the partners was indirect, and every subject only learned about their partners' choices at the end of the experiment. In each task, participants played both roles and completed each task as a one-shot game. In the two tasks with interaction, i.e., the second stages of the Public Goods Game and the Ultimatum Game, the strategy method was used. Thus, the subjects had to state their reaction to any possible choice of their partner in the first stage of the game. The participants only learned about their partners' choices and the resulting payoffs at the end of the experiments. The order of tasks was randomized, and one task was randomly chosen to determine the payoffs of each group.

3.2. Measuring social perception

Social warmth. Social warmth is a factor of a universal two-factorial person perception model (Fiske et al., 2007). Such dichotomous models have been postulated under several names and substantially agreed on the same factors (see Abele & Wojciszke, 2014, pp. 199 for an extensive complication). Abele and Wojciszke (2014) integrated these models into the two factors "communion" (warmth, morality) and "agency" (competence, assertiveness; Abele & Wojciszke, 2007; Hauke & Abele, 2020; Wiggins, 1991). The communion and agency dimensions are considered the Big Two of judgment of self and others in personality psychology (Abele & Wojciszke, 2018; Helm, Abele, Müller-Kalthoff, & Möller, 2017) and were recently considered in economics (Aaker, Vohs, & Mogilner, 2010; Jeong, Minson, Yeomans, & Gino, 2019; Krings, Sczesny, & Kluge, 2011). For assessing communion and agency in the context of temperature exposure, we used a multi-item rating scale taken from Abele, Uchronski, Suitner, and Wojciszke (2008), which consists of 16 trait adjectives. These 16 items were validated in five countries: the United States, Belgium, Italy, Poland, and Germany. The items consist of eight communal and eight agentic adjectives each. The participants made judgments on four rating targets on a 7-point Likert scale. Besides rating their assigned partners, the participants were asked to rate one female and one male student, each portrayed on screen. Furthermore, they were asked to imagine and rate a typical student from their university.

Social distance. To assess social distance (in the sense of interconnectedness), we used the Inclusion of Others in Self Scale (IOS Scale; Aron, Aron, & Smollan, 1992; Gächter, Starmer, & Tufano, 2015). The IOS Scale is a one-item language-free measurement. Participants choose from seven pairs of increasingly overlapping circles, i.e., the one best describing the relationship with their partner, the students in the pictures, and the imagined typical student.

Empathy. As empathy is conceptualized in many ways (Cuff, Brown, Taylor, & Howat, 2016), we examined empathy in a multidimensional approach. Recognizing empathy as both a cognitive (ability to understand the emotions of another; Bryant, 1982) and an affective (ability to experience the emotions of others; Hogan, 1969) construct, we used the Basic Empathy Scale (BES; Jolliffe & Farrington, 2006, for German version see: Heynen, Van der Helm, Stams, and Korebrits, 2016), which measures these two facets. For a further differentiated assessment, we used the Davis Interpersonal Reactivity Index (IRI; Davis, 1983, for the German version, see: Paulus, 2009), which distinguishes between four distinct components: empathic concern (feeling emotional concern for others), perspective-taking (cognitively taking the perspective of another), fantasy (emotional identification with characters in books, films, etc.), and personal distress (negative feelings in response to the distress of others; Davis, 1983; Pulos, Elison, & Lennon, 2004).

Control variables. We implemented a cognitive ability test, a 7-item cognitive reflection task, and assessed the participants' socioeconomic status. See the supplementary appendix for a complete list of variables.

Power analysis. As there is no literature on the effects of ambient temperature on economic outcomes, we determined the sample size for this study based on two approaches. First, we consider the effect sizes of related psychological outcomes. Specifically, we proposed that economic outcomes are manipulated via social distance and social warmth mechanisms. As the most closely related study, we chose a sample size that allows us to detect Ijzerman and Semin (2009) effect sizes of 0.78–0.79 on the IOS Scale with a power of 0.9. s, we choose our sample size such that we are able to detect medium-sized effects (Cohens-d and Cohens-f^2) for the economic outcomes in all pairwise parametric and nonparametric tests and regressions with a power of 0.9. Consequently, using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007), we determined a sample size of 73 subjects per treatment and invited 270 participants, anticipating dropouts. Our result section will show that we do not find medium-sized or larger effect sizes. Even though our study is underpowered to detect negligible effect sizes, we will present an equivalence test approach to argue against the existence of meaningful effects in the next section.

Manipulation checks. At the end of the experiment and to check the success of the temperature manipulation, the participants were asked for their estimates of room temperature ("*Please estimate the room temperature in degrees Celsius.*") and comfort ("*With regards to the room temperature, did you feel comfortable during the experiment?*"). Comfort was rated on a 7-point Likert scale from "*unequivocally no*" to "*unequivocally yes*". Additionally, body temperatures were measured on subjects' foreheads via infrared thermometers immediately after leaving the computer laboratory.

3.3. Transparency and openness

Data and Materials' Availability. All materials, including supplementary analyses, oTree scripts, and all the code for running all analyses and generating all figures, are available online in an OSF repository (https://osf.io/utpxf/?view_only=cb821201f50849e18f709108c29893bd).

Preregistration. This study's design and its analysis were not pre-registered.

Software. The statistical analysis was performed with R in RStudio (RStudio Team, 2020). We used the following R packages: BayesFactor (Morey & Rouder, 2022), data.table (Dowle & Srinivasan, 2021), lmtest (Hothorn, Zeileis, Farebrother, & Cummins, 2022), readxl (Wickham & Bryan, 2019), rsvg (Ooms, 2022), stargazer (Hlavac, 2022), svglite (Wickham, Henry, Pedersen, Luciani, & Lise, 2022), TOSTER (Lakens & Caldwell, 2022). The experiment was programmed in the open-source Python-based framework oTree (Chen, Schonger, & Wickens, 2016).

4. Results

4.1. Manipulation checks

To check whether the temperature manipulation was successful, we present the results of the participants' room temperature estimates, body temperature, and comfort (Fig. 2). Participants' temperature estimates (Fig. 2a) were significantly different among

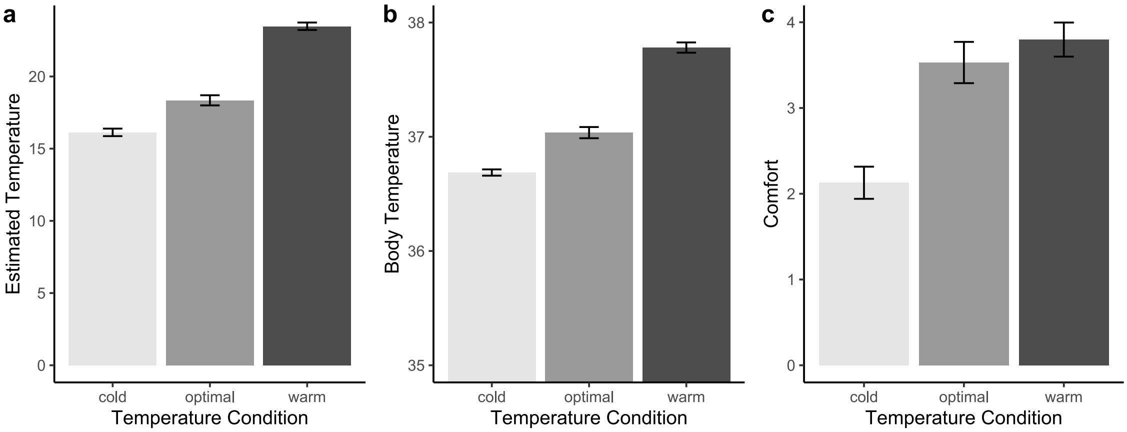

Fig. 2. Estimated temperature, body temperature and comfort ratings by treatment. Error bars represent standard errors of the means.

all three groups (M_c = 16.13, SD_c = 2.30; M_o = 18.35, SD_o = 2.85; M_w = 23.48, SD_w = 2.37; H = 146.69, $p < 0.001$, $n = 228$, Kruskal–Wallis test by Ranks [KWTR][2]); moreover, these estimates were increasing in temperature and were pairwise significantly different (z_{o-c} = 3.834, $p_{o-c} < 0.001$, z_{o-w} = 11.900, $p_{o-w} < 0.001$, z_{c-w} = 7.478, $p_{c-w} < 0.001$, $n = 228$, post-hoc Kruskal–Dunn test [PKDT]).

Body temperature (Fig. 2b) differed significantly among temperature conditions (M_c = 36.69, SD_c = 0.24; M_o = 37.04, SD_o = 0.40; M_w = 37.78, SD_w = 0.41; H = 146.37, $p < 0.001$, $n = 228$, KWTR), was increasing in temperature and was pairwise significantly different ($z_{o-c} = 4.413$, $p_{o-c} < 0.001$, $z_{o-w} = 11.987$, $p_{o-w} < 0.001$, $z_{c-w} = 6.972$, $p_{c-w} < 0.001$, $n = 228$, PKDT).

Self-reported comfort (Fig. 2c) differed significantly (M_c = 2.13, SD_c = 1.65; M_o = 3.53, SD_o = 1.96; M_w = 3.8, SD_w = 1.82; H = 38.22, $p < 0.001$, $n = 228$, KWTR). Pairwise comparisons showed significant differences between cold and optimal as well as between cold and warm conditions but not between optimal and warm conditions (z_{o-c} = 4.547, $p_{o-c} < 0.001$, z_{o-w} = 0.991, $p_{o-w} < 0.322$, $z_{c-w} = 5.873$, $p_{c-w} < 0.001$, $n = 228$, PKDT). We conclude that the temperature manipulation was successful.

4.2. Overall strategy

Although the temperature manipulation was successful, we did not find any significant effects of temperature on social behavior and perception. However, absence of evidence does not imply evidence of absence. To corroborate the conclusion of a null effect, we provide the results of nonparametric k-sample tests for equivalence (WWEG; Koh & Cribbie, 2013; Wellek, 2010). Equivalence testing is a well-established tool in the fields of medical science and psychology and is increasingly recognized in economics (Kim & Robinson, 2019). In this context, "equivalence" means equality, except for practically irrelevant differences. Hence, in this sense, proof of equivalence means excluding any medium or high effects (Wellek, 2010).[3] A k-sample tests approach cannot be taken for every outcome measure. Specifically, second-stage behavior in the Public Goods Game and the Trust Game involves multiple decisions per subject. Simply running the k-sample tests on the pooled data ignores the statistical dependencies in the data. Therefore, we have to treat the answers for those two measures as continuous while interpreting the temperature as a categorical variable and run regression models that allow us to control for the dependence structure in the data. To test whether these regression coefficients are negligible, we conduct two one-sided t-tests (TOST-β). Statistical equivalence can be deduced if the constructed confidence interval around the point estimate is entirely contained in the defined region of practical irrelevance. However, when testing regression coefficients, equivalence bounds cannot be inferred from effect sizes and should be defined by careful and practical considerations to extract the smallest difference of interest (Dixon & Pechmann, 2005; Lakens, Scheel, & Isager, 2018). We consider changes of 5% in the outcome variables between treatments (i.e., a change of ca. 5 °C) as negligible. For instance, in a 10-EUR Dictator Game, subjects commonly share 3 EUR on average. Treatment differences of less than 0.15 EUR would be considered practically irrelevant.

To keep the presentation of the null effects concise, we present the results of all hypothesis tests and equivalence tests in Table 1. Only the equivalence tests of regression coefficients and outcomes, for which equivalence cannot be established are presented separately in the following section.

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[2] Throughout, we report two-tailed test results.

[3] ϵ is a bound for the sum of squared nonparametric distances of the k sample distributions. Throughout the text, we only report the results for $\epsilon = 0.4$, and different equivalence bounds can be found in the online appendix.

Table 1
Descriptive statistics and hypothesis and equivalence tests.

		Variables	Descriptive statistics Median (Mean; Std)			Hypothesis test p-value (H-statistic)	Equivalence test p-value (F-statistic)
			Cold	Optimal	Warm	KWTR	WEGG
Economic test series	Dictator Game	Sharing	10 (8.81; 3.92)	10 (8.11; 3.30)	10 (7.42; 3.71)	0.134 (4.020)	0.110 (0.076)
	Prosocial behavior	T-Shirt donation	1 (0.62; 0.49)	1 (0.67; 0.48)	1 (0.68; 0.47)	0.677 (0.781)	0.002 (0.010)
	Ultimatum Game	Offer	10 (9.14; 2.34)	10 (9.51; 1.31)	10 (9.40; 1.56)	0.349 (2.110)	0.007 (0.021)
		MAO	7 (6.58; 3.32)	7 (6.75; 2.93)	8 (7.24; 3.10)	0.353 (2.081)	0.010 (0.026)
	Public Goods Game	Contribution	5 (5.58; 3.30)	5 (5.79; 3.34)	5 (5.35; 3.40)	0.837 (0.360)	0.001 (0.009)
		Beliefs	5 (5.79; 2.92)	5 (5.36; 2.94)	5 (4.96; 3.25)	0.248 (2.787)	0.025 (0.039)
	Trust Game	Trust	5 (6.28; 3.12)	6 (6.30; 3.12)	6 (6.32; 3.04)	0.989 (0.023)	<0.001 (0.000)
		Beliefs	7 (8.07; 5.60)	7 (8.11; 5.25)	7 (8.33; 6.20)	0.990 (0.011)	<0.001 (0.001)
Social perception measures	Communion	Partner	33 (34.45; 3.82)	33 (34.95; 4.76)	32 (33.45; 3.32)	0.187 (3.353)	0.010 (0.075)
	Agency	Partner	36 (36.46; 4.07)	36.5 (36.76; 4.08)	36.5 (36.04; 4.95)	0.555 (1.177)	0.003 (0.013)
	Social distance	Partner	3 (3.06; 1.51)	3 (2.94; 1.67)	2 (2.62; 1.47)	0.131 (4.066)	0.037 (0.047)
	Empathy	BES	25 (25.12; 2.30)	25 (25.2; 2.36)	25.5 (25.39; 1.95)	0.586 (1.070)	0.002 (0.009)
		IRI	43 (43.03; 6.22)	44 (43.06; 5.21)	43 (42.82; 6.18)	0.964 (0.074)	0.001 (0.001)

Note: KWTR = Kruskal–Wallis test by Ranks, WEGG = Wellek–Welch equivalence test for k-groups, $n = 228$.

4.3. Social perception

Communion and agency. There was no significant effect of temperature on communion or agency scale ratings for any of the targets. The results for the targets other than one's partner are reported in the online appendix. While the equivalence test for communion was not, any potential effect would be contrary to the hypothesis, i.e., communion would be decreasing in temperature.

Social distance and empathy. Empathy measures and ratings on the IOS Scale for any targets were significantly equivalent.

4.4. Social behavior

Dictator Game. A comparison of the shared amounts in the Dictator Game (Fig. 3) showed no significant difference between the three groups. However, mean comparisons revealed a tendency contrary to our hypothesis, i.e., participants give slightly less in warmer conditions. Equivalence testing yielded no significance, but any effect, if existing, would be contrary to the hypothesis that increases in temperature lead to increased social behavior. Additionally, we observed t-shirt donation decisions to assess the external validity of altruistic behavior. Participants' donations were equivalent under any temperature conditions.

Ultimatum Game. In the Ultimatum Game, the proposers' offered amounts and MAOs (Fig. 3) were significantly equivalent.

Public Goods Game. To assess the effect of temperature on cooperation without strategic uncertainty, we report the results from the conditional contributions in the Public Goods Game. A Random Effects Regression (RER) of the conditional contributions on the partner's contribution and temperature indicated no significant effect of temperature in the Public Goods Game (RER, $\beta_{temp} = -0.114$, $SE = 0.154$, $p = 0.442$, Table 2). To test whether the coefficient β was negligible, a two one-sided t-test of β (TOST-β; Dixon & Pechmann, 2005) was conducted. The measurements were made on a scale from 0.00 to 10.00 EUR. In the absence of strategic uncertainty, changes of less than 0.50 EUR between treatments are defined as practically irrelevant. Thus, equivalence margins were set accordingly ($b_1 = 0.5$, $b_2 = -0.5$). We found β to be significantly equivalent to zero ($\beta = -0.114$, $SE = 0.154$, $p = 0.005$, TOST-β). A β_{temp} coefficient of -0.114 signifies a decrease (increase) of 0.11 EUR between the optimal and warm (cold) treatment, which can be considered irrelevant. Furthermore, any negative effect would be contrary to our hypothesis.

The unconditional contributions depend on the beliefs about the partner's conditional contribution (Falk & Fischbacher, 2006; Fischbacher & Gächter, 2010; Kelley & Stahelski, 1970). Unconditional contributions in the Public Goods Game and beliefs about the partner's unconditional choice were equivalent between groups.

Trust Game. To assess the effect of temperature on trustworthiness without strategic uncertainty, we report the results on trustworthiness, i.e., the amount sent back conditional on the amount sent by the trustor. A RER of trustworthiness on temperature

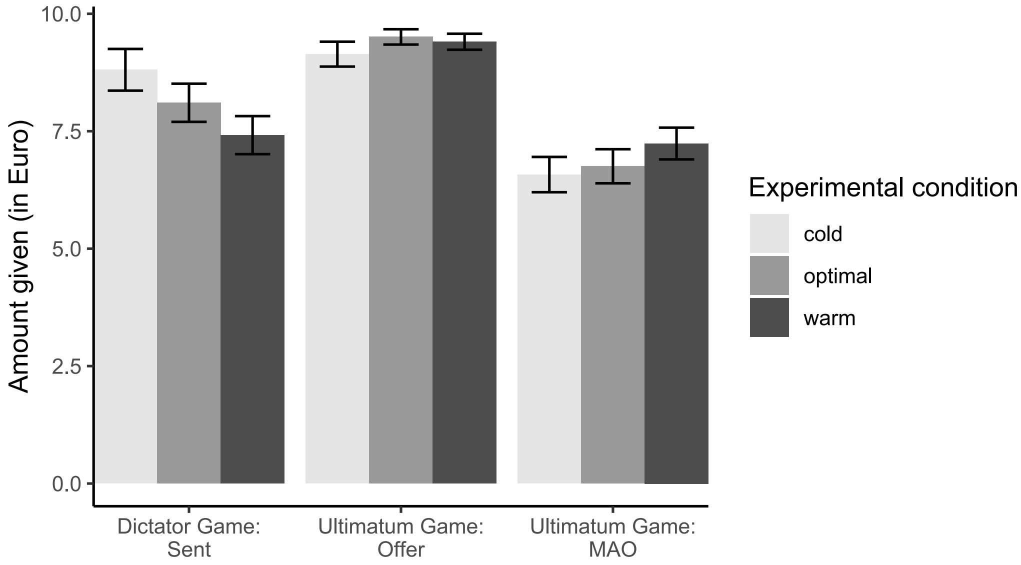

Fig. 3. Mean sent amounts in the Dictator Game, mean offers in the Ultimatum game, and mean minimal acceptable offers (MAO) in the Ultimatum Game by treatment. Error bars represent standard errors of the means.

Table 2
Second stage behavior in the Public Goods and Trust Game.

	Public Goods Game: Conditional contribution (1)	Trust Game: Return (2)
Temperature	−0.114	0.209
	(0.154)	(0.179)
Amount	0.692***	1.354***
	(0.026)	(0.034)
Constant	0.590***	−1.333***
	(0.115)	(0.115)
Obs.	2508	2280
Cluster	228	228
R^2	0.452	0.648

Note: Random Effects Regressions with robust standard errors (clustered by subject). In model (1), amount indicates the contribution by the partner. In model (2), it indicates the amount sent by the partner. Temperature is effect-coded with −1, 0, and 1 for the cold, optimal, and warm treatments respectively. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

was not significant ($\beta_{temp} = 0.209$, $SE = 0.177$, $p = 0.200$, Table 2). We tested for negligibility of β_{temp}. Equivalence margins were set to $b_1 = 0.5$ and $b_2 = -0.5$. This corresponds to a change of less than 2% between treatments (i.e., measurements were made on a scale from 0.00 to 30.00 EUR. The results were significant ($\beta_{temp} = 0.209$, $SE = 0.177$, $p = 0.045$, TOST-β), and the implied change of 0.21 EUR between treatments can be considered practically irrelevant.

Beliefs about the unconditional choice of the partner and the amounts sent by the trustor were significantly equivalent.

Lying Game. Fig. 4 shows the distributions of reported outcomes in the three experimental conditions. Lying behavior could be observed under all temperature conditions. The proportions of the reported numbers differed significantly from the expected value of 16.7% (1/6) in each experimental group (χ^2-goodness-of-fit test, $\chi^2_c = 30.154$, $p_c < 0.000$; $\chi^2_o = 47.455$, $p_o < 0.000$; $\chi^2_w = 49.571$, $p_w < 0.000$). To assess in which group lying was more frequent, an Epps–Singleton test (EST; Epps & Singleton, 1986) was conducted. The EST is a distribution test for determining whether two samples have been drawn from the same population. In most cases, its power is greater than the Kolmogorov–Smirnov test, and it considers the ordinal nature of the data (Goerg & Kaiser, 2009). We found no significant differences in lying across temperature conditions ($W_{2,o-c} = 2.07$, $p_{o-c} = 0.722$; $W_{2,o-w} = 0.69$, $p_{o-w} = 0.95$; $W_{2,c-w} = 2.03$, $p_{c-w} = 0.73$, EST).

Gender effects. In Tables 3 and 4, we show the results of OLS regressions of all manipulation checks, social perception, and social behavior measures on temperature, gender, and their interaction. The temperature coefficient in each model captures the effect of temperature on the perception and behavior of the female participants in the sample. The results for female participants do not differ

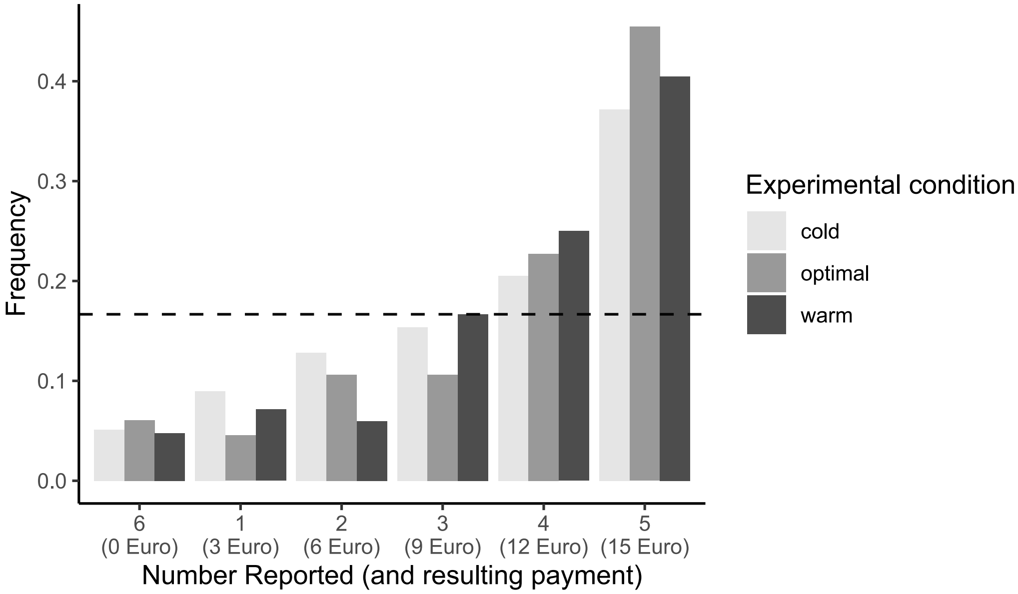

Fig. 4. Frequencies of reported numbers (and resulting payment) in the Lying Game.

from those of the overall sample reported above. A significant interaction coefficient could identify a possibly different effect of the temperature on male subjects. None of the interaction coefficients in models (4) through (8) of Table 3, i.e., the social perception measures, and none of the interaction coefficients in Table 4, i.e., the social behavior measures, are significantly different from 0. We find some gender differences in average behavior in the social perception and behavior measures. When drawing conclusions from these results, one should keep in mind that the subsample of men and women in every temperature treatment is rather small. A gender difference can be found in two of the manipulation check measures — forehead temperature and comfort. Model (2) Table 3 shows that the forehead temperatures of male participants were slightly higher than those of female participants. Model (3) in Table 3 shows that the stated comfort of female participants increases significantly with the ambient temperature. Male participants report a significantly larger comfort which does not depend on the ambient temperature. For the social perception and behavior measures, male participants score significantly lower on both empathy questionnaires, give less in the dictator game and behave differently than female participants in the Trust Game. Specifically, male participants send more of their endowment to their partners and expect higher returns, while at the same time sending back lower amounts to their partner in the second phase.

Supplementary analyses. We found no significant differences in any measurement of social behavior and perception. To further corroborate this result, we report additional tests for the absence of the effect in the supplementary appendix. These include equivalence tests for different margins, a Bayesian approach based on the Bayes ratio, and parametric alternatives to the non-parametric test reported here.

5. Discussion

In this study, we test whether ambient warmth influences social perception and behavior. We seek to answer two questions: First, does ambient temperature, rather than holding cold/warm objects, suffice to influence social perception, i.e., perception of social warmth, social proximity, and empathy? Second, does ambient temperature affect social behavior when adequately measured by incentivized methods from behavioral economics? Both of these have to be answered in the negative, although we demonstrated that the temperature manipulation was successful in changing body temperature and temperature perception.

We control for relevant factors of thermoreception and use standardized economic methods to rigorously investigate multiple facets of prosocial behavior, specifically cooperation, trust, trustworthiness, altruism, sharing, bargaining, and lying. We find that ambient warmth does not affect incentivized decision-making or beliefs about one's partner's decisions. Contrary to Ijzerman and Semin (2009), ambient warmth does not affect social distance judgments. Moreover, we find no difference between measurements of communion and empathy across temperature conditions. To corroborate our findings of a null effect, we used multigroup equivalence testing. We concluded that all measurements in the Public Goods Game, Trust Game, and Ultimatum Game, as well as in social perception, measurements are equivalent with respect to an ex-ante specified bound. The results of this study indicate that subtle cueing (Bargh, 2002) through ambient warmth is not strong enough to have a relevant impact on economic behavior.

There exists well-covered literature on gender differences in indoor temperature, i.e., the "battle for the thermostat", which finds that women woman are less satisfied with room temperatures than men and prefer higher ambient temperatures than men (Karjalainen, 2007; Yang et al., 2021). Recent evidence on cognitive performance and temperature finds that women perform

Table 3
Random effects regression of trustworthiness in the trust game.

	Manipulation checks			Social perception				
	Est. Temp. (1)	Forehead Temp. (2)	Comfort (3)	Communion (4)	Agency (5)	IOS (6)	BES (7)	IRI (8)
Temperature	3.530*** (0.234)	0.543*** (0.028)	1.300*** (0.158)	−0.230 (0.358)	0.100 (0.462)	−0.210 (0.150)	0.150 (0.200)	0.040 (0.485)
Male	0.339 (0.349)	0.131* (0.052)	0.591* (0.248)	0.028 (0.561)	−0.587 (0.598)	0.272 (0.207)	−0.771* (0.311)	−3.775*** (0.851)
Temperature:Male	0.397 (0.397)	0.008 (0.059)	−1.270*** (0.279)	−0.732 (0.589)	−0.797 (0.725)	−0.052 (0.242)	0.019 (0.349)	−0.144 (1.046)
Constant	19.250*** (0.224)	37.128*** (0.027)	2.931*** (0.139)	34.243*** (0.325)	36.625*** (0.374)	2.771*** (0.133)	25.521*** (0.170)	44.354*** (0.400)
Observations	228	228	228	228	228	228	228	228
R^2	0.600	0.625	0.218	0.017	0.012	0.022	0.032	0.096

Note: OLS Regressions with robust standard errors (clustered by subject). Male is a binary variable taking the value 1 for male participants and 0 otherwise. Temperature is effect-coded with −1, 0, and 1 for the cold, optimal, and warm treatments respectively. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 4
Effects of gender on social behavior measures.

	Dictator Game	Ultimatum Game		Public Goods Game			Trust Game		
	Giving (1)	Proposition (2)	MAO (3)	Contribution (4)	Belief (5)	Conditional contribution (6)	Sent (7)	Belief (8)	Return (9)
Temperature	−0.250 (0.293)	−0.070 (0.155)	0.200 (0.305)	−0.110 (0.312)	−0.390 (0.302)	−0.100 (0.177)	−0.160 (0.271)	0.050 (0.601)	0.273 (0.226)
Male	−1.351* (0.558)	−0.371 (0.293)	−0.272 (0.452)	0.456 (0.488)	0.893* (0.424)	0.223 (0.269)	0.954* (0.450)	2.295** (0.794)	−0.633** (0.239)
Temperature:Male	−1.083 (0.684)	0.544 (0.370)	0.363 (0.540)	−0.052 (0.571)	−0.120 (0.505)	−0.038 (0.338)	0.412 (0.532)	0.102 (0.967)	−0.129 (0.368)
Amount						0.708*** (0.032)			1.354*** (0.043)
Amount:Male						−0.043 (0.055)			−0.0004 (0.070)
Constant	8.625*** (0.246)	9.469*** (0.120)	6.958*** (0.248)	5.389*** (0.254)	5.049*** (0.243)	0.509*** (0.120)	5.944*** (0.231)	7.371*** (0.478)	−1.098*** (0.141)
Obs.	228	228	228	228	228	2508	228	228	2280
Cluster						228			228
R^2	0.073	0.028	0.012	0.005	0.033	0.452	0.026	0.038	0.652

Note: OLS Regressions with robust standard errors (clustered by subject). In model (6), Amount indicates the contribution by the partner. In model (9), it indicates the amount sent by the partner. Male is a binary variable taking the value 1 for male participants and 0 otherwise. Temperature is effect-coded with −1, 0, and 1 for the cold, optimal, and warm treatments respectively. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

better at higher temperatures while men's performance decreases (Chang & Kajackaite, 2019). We controlled for potentially different treatment effects by gender and found none, except for an effect on stated comfort. In line with previous findings, we find that the female participants feel more comfortable at higher temperatures. Furthermore, we only find small gender effects on average behavior in the social behavior measures. This is in line with the conclusions of a recent meta-analysis that finds, at most, very small gender effects in social preferences measures such as Dictator Games (Bilén, Dreber, & Johannesson, 2021), Public Goods Games (Balliet, Li, Macfarlan, & Van Vugt, 2011), or Trust Games (van den Akker, van Assen, van Vugt, & Wicherts, 2020).

There are two seemingly contradictory lines of argument for the influence of temperature on human behavior. On the one hand, studies indicate that uncomfortably high temperatures impair mood (Keller et al., 2005), promote aggression (Anderson, 1989, 2001; DeWall & Anderson, 2011), and enhance the risk of conflict (Burke et al., 2015a, see also Van Lange, Rinderu, and Bushman, 2017). On the other hand, Ijzerman and Semin (2009) and Williams and Bargh (2008) provide evidence for a connection between comfortable warmth and prosociality. Each argument builds on a well-established theoretical foundation. Nevertheless, we neither find negative effects on social behavior, as predicted by the heat–aggression link, nor any positive effects on social behavior, as predicted by the warmth–prosociality link.

A recent study by Almås et al. (2019) on the heat–aggression link in economic games discusses two pathways by which temperature might affect aggressive behavior and conflict. Heat might have a direct effect on aggression and conflicts or an indirect effect by influencing external factors that directly or indirectly affect individuals and their experiences, emotions, and behavior. Heat, for example, might influence behavior by the fact that increased temperatures can lead to water shortages, which in turn can lead to poorer harvests. Resource scarcity then leads to a higher risk of intergroup conflict (i.e., aggression; Burke et al., 2015a), migration (Missirian & Schlenker, 2017), and decreased economic production (Burke et al., 2015b). Recreating these indirect effects by external factors in a laboratory setting is difficult. Besides, Anderson, Anderson, Dorr, DeNeve, and Flanagan (2000) found inconclusive results in experimental temperature studies. More recently, a meta-analysis by Lynott et al. (2023) found no evidence in favor of a direct effect of heat on aggression in laboratory and field experiments.

However, direct effects can be explained by changing preferences in hot visceral states, such as hunger, thirst, sexual desire, moods, emotions, drug cravings, physical pain, and fervent emotions (Loewenstein, 1996). There is ample evidence for a meaningful influence of visceral states on economic behavior. Sleep-deprived participants tend to trust less (Anderson & Dickinson, 2010), sexually aroused men are more willing to engage in risky sexual behavior than men who are not sexually aroused (Ariely & Loewenstein, 2006), and hungry individuals become more rational (Krause, Baumann, & Schmidt, 2023). Heat stress could be considered a visceral state with a meaningful influence on economic behavior.

Almås et al. (2019) investigated the effect of temperatures between 22 °C and 30 °C, i.e., temperatures comparable to our optimal (22 °C) and warm (27 °C) conditions, on social preferences and destructive behavior. Similar to this study, Almås et al. (2019) found no influence of temperature on social preferences. They exclusively found that heat increases destructive behavior in a punishment task. These results suggest that violence and social behavior should not be understood as extremes on a common dimension but rather as independent factors. Interestingly, Almås et al. (2019) found more destructive behavior in an environment of political insecurity (Kenya) as opposed to Berkeley, indicating the importance of external factors on the heat–aggression link.

Concerning the warmth–prosociality link, Williams and Bargh (2008) claimed that in social interactions, comfortably warm temperatures act as a subtle and unconscious cue that affects thought and behavior (Bargh, 2002). This is often referred to as social priming (Molden, 2014). There are several studies in support of a link between physical warmth and prosociality. For example, evidence from neuropsychology shows that temperature perception and social functions, such as empathy and trust, share the same neurological structures (Bird et al., 2010; Jabbi et al., 2007; Kang et al., 2011; Singer et al., 2004). Experimental evidence suggests that subjects with higher body temperatures feel more socially connected to others (Inagaki & Human, 2020). Correlational evidence implies that the physical-to-social warmth link is bidirectional. Zhong and Leonardelli (2008) showed that exclusion could literally feel cold, and lonely people tend to self-regulate their feelings through an increased tendency to take warm baths (Bargh & Shalev, 2012). However, social priming studies are under scrutiny (Vadillo et al., 2016), and the relationship between temperature and prosociality has been challenged by several failed replication attempts that have been published recently. Neither a high-powered direct replication in three independent locations (Chabris et al., 2018) nor a replication in the field (Lynott et al., 2014) could find a promoting effect of warm objects on prosocial behavior. Matching their field data with weather data, Lynott et al. (2017) aimed to control for the influence of ambient temperature and were not able to establish conclusive results. These failed replication attempts are predictive of the replication crisis in the social sciences (see Schultze et al., 2019). Our results agree with these failed replication attempts of social priming, i.e., the less subtle effects of haptic warmth on prosociality.

Furthermore, all studies on the effect of temperature on prosocial behavior relied on costless or hypothetical behavior. We provide an experimental investigation of prosociality as a trade-off between egoistic concerns and concerns for a partner using monetary incentives. Incentivization reduces possible “presentation effects” (i.e., generosity; Camerer & Hogarth, 1999), which is crucial for gauging the practical relevancy of an effect. Any effect on social behavior that is of practical relevance to economists should have a common cause and be present when the stakes are real.

The field of social priming has been called “the poster child for doubts about the integrity of psychological research” (Kahneman, 2012). Notoriously, social priming effects are subtle and highly sensitive to experimental context and the subject pool (Casari, 2014; Yu, Abrams, & Zacks, 2014). Yet, Bargh (2014) argued that “unconscious influences [of social priming] on judgment, emotion, behavior, and motivation are of practical importance both to society as a whole and the everyday lives of its members”. Our findings represent a strong contradiction of this claim, at least regarding temperature effects. We showed that several facets of social behavior and perception are statistically equivalent across temperature conditions.

If there was a temperature effect of adequate size, but our study design was inadequate to measure it as priming effects occur only under unique circumstances, then these situations would probably be too rare to be considered practically relevant. There are many known artifacts confounding experimental research, such as experimenter demand effects (Zizzo, 2010), demographic effects (Casari, Ham, & Kagel, 2007), incentive size effects (Slonim & Roth, 1998), framing (Kahneman & Tversky, 1982), and priming effects (Cohn & Maréchal, 2016). Our results suggest that ambient temperature will likely not confound social preference experiments, i.e., if the treatment assignment accidentally covaries with the room temperature, the ambient temperature will likely not drive observed differences in behavior. This implies that to the extent that temperature is in a range between 17 °C and 28 °C, a temperature-controlled environment is not necessary for incentivized social behavior experiments, and experiments should be comparable across different temperature regions.

The implications of this study are to be taken cautiously, minding the limitations of this study. First, our study design implies limited power to detect the negligible effects we argue for. Based on previous, often underpowered, studies, we chose a sample size that allows us to detect medium-size effects with high power. This is especially unfortunate, as this study was not preregistered. We believe that our statistical approach, based on equivalence tests and the consistency of our results across all perception and behavioral measures, helps to mitigate these limitations. Nevertheless, a future preregistered large-scale study on temperature effects on social behavior would be desirable. Second, while we took great care in meeting the temperature conditions, we were not able to keep the relative humidity constant across treatments. As was to be expected, the relative humidity decreased monotonically with the ambient temperature. Nevertheless, our manipulation successfully changed the apparent temperature in the room, which, in the absence of wind chill and radiation, is captured by the heat index (Steadman, 1984). Our temperature treatments corresponded to apparent temperatures of 17 °C, 21 °C, and 27 °C. Lastly, for economic reasons, we randomized treatment assignments at the session level, which could potentially introduce confounding influences. With only a small number of sessions for each treatment, we cannot rule out that sampling error introduced unknown confounding influences, such as groups of friends signing up for one session. Nevertheless, we took great care in standardizing the lab procedures and had very stable weather conditions throughout the data collection. As the weather outside the lab might be the most natural potential confound, we include a summary of the weather conditions in the supplementary appendix.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.joep.2023.102657.

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