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John A. Bargh and Idit Shalev
Yale University

Classic and contemporary research on person perception has demonstrated the paramount importance of interpersonal warmth. Recent research on embodied cognition has shown that feelings of social warmth or coldness can be induced by experiences of physical warmth or coldness, and vice versa. Here we show that people tend to self-regulate their feelings of social warmth through applications of physical warmth, apparently without explicit awareness of doing so. In Study 1, higher scores on a measure of chronic loneliness (social coldness) were associated with an increased tendency to take warm baths or showers. In Study 2, a physical coldness manipulation significantly increased feelings of loneliness. In Study 3, needs for social affiliation and for emotion regulation, triggered by recall of a past rejection experience, were subsequently eliminated by an interpolated physical warmth experience. Study 4 provided evidence that people are not explicitly aware of the relationship between physical and social warmth (coldness), as they do not consider a target person who often bathes to be any lonelier than one who does not, with all else being equal. Together, these findings suggest that physical and social warmth are to some extent substitutable in daily life and that this substitution reflects an unconscious self-regulatory mechanism.

Keywords: unconscious, self-regulation, embodiment, warmth

Classic as well as contemporary research in social psychology has demonstrated the central importance of interpersonal warmth (vs. coldness) in person perception, both in forming first impressions (Asch, 1946; Kelley, 1951) and as one of two main dimensions of outgroup stereotypes around the world (Fiske, Cuddy, Glick, & Xu, 2002). Fiske, Cuddy, and Glick (2007) concluded from their stereotype-content research that assessing interpersonal warmth versus coldness is the first step taken in forming impressions of any new acquaintance, and it is essentially a "friend-or-foe" judgment. A "warm" individual is considered to be prosocial, cooperative, generous, and trusting, whereas "cold" individuals are viewed as self-centered, competitive, and untrustworthy.

But why exactly do we use the terms "warm" and "cold" to refer to these two basic sorts of individuals (and not the more straightforward "friend" vs. "foe," "cooperative" vs. "competitive," etc.)? The explanation Asch (1958) later offered for the power of the warm-cold dimension in person perception was that abstract psychological concepts such as interpersonal warmth are metaphorically based on concrete physical experiences. Asch thus anticipated Lakoff and Johnson (1980), Barsalou (1999) and modern research on the "embodied grounding" of abstract concepts in physical experience (see Anderson, in press; Haggard, Rossetti, & Kawato, 2008; Semin & Smith, 2008; Williams, Huang, & Bargh, 2009). Concepts concerning the physical world (e.g., distance, size, and temperature) form early in childhood, as they are based on direct concrete experience (Mandler, 1992), and they do not require the language abilities or memory retrieval skills that come online years later. According to one approach, the "conceptual scaffolding" model of Williams et al. (2009), abstract concepts then develop based on (and thus become strongly associated with) these physical concepts to the extent that they are analogous (i.e., share key features). This assumed associative relation helps to explain the fact that we so easily and fluently use physical terms to refer to and describe more abstract phenomena (Lakoff & Johnson, 1980; Mandler, 1992)—especially social and psychological phenomena, as in a "close" relationship, a "warm" smile, and a "higher calling."

As for the underlying reason for the tight connection between physical and social warmth (and coldness), it seems clear how early childhood experiences with caretakers who provide both physical (holding close) and psychological warmth (love, trust, help, and support) could lead to the development of a strong associative connection between the concepts of physical and social warmth. Indeed, the attachment theorist Bowlby (1969) argued that the conjoined needs for both physical and social warmth across evolutionary time periods has resulted in an innate drive for the young of many species, including humans, to maintain close distances to their parents and kin. As discussed below, there is now neuroanatomical evidence that the association between physical and social "temperature" is indeed hardwired in humans. For present purposes, however, both the innate and early experience accounts of the physical-to-social warmth association lead to the prediction that physical warmth (coldness) experiences can produce the same subjective, phenomenal feeling states associated

John A. Bargh, Department of Psychology, Yale University; Idit Shalev, Institute of Social and Policy Studies, Yale University.

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Correspondence concerning this article should be addressed to John A. Bargh, Department of Psychology, Yale University, P.O. Box 208205, New Haven, CT 06520. E-mail: john.bargh@yale.edu

with psychological warmth (coldness). We now turn to evidence bearing on this prediction.

Harlow (1958) first demonstrated the importance of early physical warmth experiences in the social development of infant monkeys raised alone. Those in the "cloth mother" condition, which critically included a 100-W light bulb behind the cloth, did not have nearly the social deficits in adulthood that characterized monkeys raised alone with a cold, wire mother. Thus, Harlow was the first to show how physical warmth could be effectively substituted (in monkeys) for the absent maternal warmth, leading to significantly greater social warmth capacities for the monkeys later in adulthood.

More recently, Williams and Bargh (2008) showed that incidental warmth experiences (such as when holding a cup of hot coffee or taking a warm bath) produce "warm" psychological experiences of trust and behavioral effects on generosity, without the person's awareness. In one experiment, having participants briefly and incidentally hold a paper cup of hot coffee versus iced coffee replicated the effects of the words *warm* or *cold* in Asch's (1946) original impression formation study. In a second study, those first primed with warm physical experience were more selfless and generous regarding the donation of their experimental payment than those who were in the cold prime condition. Following up on this finding, IJzerman and Semin (2009) first seated participants in either a cold or warm room and found that those in the warmer room reported feeling interpersonally closer to the experimenter than those in the colder room. Most recently, Kang, Williams, Clark, Gray, and Bargh (2010, Study 1) showed that warm physical priming produced greater trust in an economics trust game (Delgado, Frank, & Phelps, 2005) compared to cold physical priming. Across all these studies, physical warmth (coldness) led to judgments and behavior that were socially warm (cold).

Reversing the causal direction, Zhong and Leonardelli (2008) showed that after an actual or remembered social-rejection experience (i.e., social coldness), participants reported the room temperature as being colder than those who had just recalled an inclusion experience, and they also showed greater desire for warm food and drinks (but not control food and drinks, such as apples) than those who were not excluded. Notably, the researchers suggested that perhaps "experiencing the warmth of an object could reduce the negative experience of social exclusion". IJzerman and Semin (in press) found that social distance manipulations also produced changes in the perception of room temperature. Being seated relatively close to (versus distant from) other participants in the experimental room produced higher estimations of room temperature, as did manipulations of the similarity of a target person—the more similar the target, the higher the reported temperature. As similarity has long been known to increase attraction and the probability of friendship (i.e., social warmth; Byrne, 1971), together these studies show that experiences of social warmth produce concomitant feelings of physical warmth.

There is growing evidence from social neuroscience research that the association between physical warmth (coldness) and social warmth (coldness) might be hardwired in humans (Meyer-Lindenberg, 2008). The insular cortex is implicated in the processing of both physical temperature (e.g., Craig, Chen, Bandy, & Reiman, 2000; Sung et al., 2007) and the psychosocial version of warmth information: feelings of trust (e.g., Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003; Todorov, Baron, & Oosterhof, 2008), empathy, and social emotions such as embarrassment and guilt (Eisenberger, Lieberman, & Williams, 2003; Kross, Egner, Ochsner, Hirsch, & Downey, 2007). The most recent available evidence suggests that the anterior insula provides the basis for subjective feelings and emotional awareness (see Craig, 2002, 2009, for reviews). Consistent with this hypothesized direct anatomical connection, Kang et al. (2010, Study 2) observed in a recent fMRI investigation that the left anterior insula became more activated following cold versus warm temperature sensation, and it was also more activated following betrayals of trust in the economics game.

Therefore, it seems that the "coldness" of loneliness or rejection could be treated somewhat successfully through the application of physical warmth—that is, physical and social warmth might be substitutable for each other at some level. If so, then the physical-social warmth association may be a boon to the therapeutic treatment of syndromes that are mainly disorders of emotion regulation, such as Borderline Personality Disorder (BPD; see Glenn & Klonsky, 2009). Indeed, in her influential biosocial approach to BPD, Linehan (1993) emphasized the affective intensity and lability of patients and suggested that they could benefit from learning techniques to self-regulate their affective levels (p. 143).

In Studies 1a and 1b we extend the contemporary research on the relationship between physical and social warmth by documenting how people already tend to self-regulate their feelings of social warmth (connectedness to others) with applications of physical warmth (through taking warm baths or showers), yet they apparently do so implicitly, without explicit awareness of the relation. We followed these studies with an experimental test of the coldness-loneliness relation involving physical temperature primes in Study 2. Next, in Study 3 we provided the first experimental test of whether interpolated physical warmth experiences can reduce feelings of social coldness caused by actual or recollected rejection experiences. These studies also expanded on previous research by including chronic, individual difference measures of social connectedness (i.e., the UCLA Loneliness Scale) in addition to temporary manipulations of those feelings (as in the previous research), and showed that these chronic measures produce conceptually similar effects. (The use of the chronic loneliness measure also helped rule out the "semantic priming" alternative interpretation that applies to much metaphor-priming research.)

Studies 1a and 1b focused on the predicted use of physical warmth (specifically, baths or showers) by the general public as a form of self-therapy to restore feelings of social warmth when those feelings are lacking (as when one is feeling lonely). We followed these studies with an experimental test of the coldness-loneliness relation involving physical temperature primes in Study 2. Next, Study 3 directly tested the prediction that physical warmth experiences can effectively substitute for social warmth needs produced by social rejection experiences.

A further goal of the present research was to test for both implicit and explicit levels of awareness of the physical-social warmth relation in our participants, as the implicit knowledge may unconsciously manifest itself in actual behavior (e.g., increased bathing) in the absence of experienced distress or any explicit awareness of the relation (see Wilson & Brekke, 1994). The lack of explicit awareness of the relation was especially surprising given how pervasive the use of the metaphor is in everyday language ("A warm smile", "a cold shoulder"). Clearly, people

easily understand the social meanings of these physical terms and use them to effectively communicate about the personality and behavior of others (see Lakoff & Johnson, 1980). Indeed, there are signs that at the cultural level we have possessed this knowledge for centuries: For example, in the *Inferno* Dante linked the sin of betrayal of trust (i.e., extreme social coldness) with the poetic justice of being physically frozen, indicating that Dante appreciated the metaphorical relationship between physical and social coldness. Yet our experimental participants (as well as those in previous research on this effect) showed no explicit awareness of the physical-social warmth relation in postsession debriefing (Studies 2 and 3), and the direct test of such awareness in Study 4 provided further evidence that people are not aware of the effect at a conscious level.

Study 1a

Studies 1a and 1b were designed to test the hypothesis that people (implicitly) compensate for the lack of social warmth in their lives with increased physical warmth experiences. Specifically, we hypothesized that chronic or "trait" loneliness (the self-perceived deficit in social connectedness; Russell, 1996) of our participants would be positively associated with the frequency, duration, and preferred water temperature of the showers and baths that they take. In this way, it was hypothesized that people self-regulate their deficits in social warmth with applications of physical warmth, thus effectively substituting physical for social warmth.

To test this hypothesis we recruited both a university student sample (Study 1a) and an adult community sample (Study 1b) of participants. Both samples completed a brief survey concerning how frequently they take a shower or bath, what water temperature they prefer while bathing, and also how long their typical bath or shower lasts in minutes. Following this bathing activities survey, participants completed the short version of the UCLA Loneliness Scale (Russell, 1996).

Participants

Fifty-one undergraduates (26 females, and 25 males) were recruited for the study outside of their dining hall in exchange for $2. Their ages ranged from 18 to 45 years of age, with a mean age of 20.11 ($SD = 4.17$).

Method

After giving their informed consent, participants completed two surveys in a random order that purportedly involved lifestyle habits (e.g., "In the past 3 months, how often have you been involved in physical activity?"; "How many meals do you have per day?"), including three key items about their bathing habits: "How often do you usually take a bath?" (on an 8-point scale ranging from *more than 3 times a day* to *less than once a week*), "What temperature water do you use?" (on a 6-point scale ranging from *cold* to *very hot*), and "About how much time do you spend in the bath"? (on a 7-point scale ranging from *less than 2 minutes* to *over 30 minutes*). Next, participants filled out the short version of the UCLA Loneliness Scale (Russell, 1996), which included 10 statements worded in a negative or "lonely" direction. Individuals indicated how often they had feelings that agreed with each statement, ranging from 1 = *never* to 4 = *often*. Finally, participants were debriefed regarding their awareness of the study hypotheses (none of the participants were able to identify the purpose of the study), and they were thanked for their participation.

Results

Pearson product–moment-correlation coefficients were computed to examine the relationship between participants' bathing habits and their degrees of loneliness. As hypothesized, significant positive associations were obtained between loneliness and both frequency of bathing ($r = .48$, $p < .001$, two-tailed) and the typical duration of a bath or shower ($r = .29$, $p < .05$). There was also a trend for loneliness to be related to a preference for warmer water temperature ($r = .26$, $p = .07$). In other words, participants' degrees of loneliness accounted for fully 23% of the variance in how often they took baths or showers. Also, the lonelier the participants were, the warmer they tended to prefer their baths or showers and the longer they spent under the warm water.

We created a summary index variable of the bathing frequency, duration, and preferred-temperature items by standardizing each score and taking the mean: This score can be understood conceptually as "physical warmth extraction" from the bathing activity, as the more often, longer, and warmer the bath was, the greater the total warmth experienced by the participant. This index variable correlated with UCLA Loneliness Scale scores ($r = .57$, $p = .0001$) such that 32.5% of the variation in physical warmth extraction during bathing was explained by how lonely the participant was. Overall, in this student sample, chronic levels of "social coldness" were strongly related to the amount of physical warmth the individual consumed each week in the form of bathing.

Study 1b

Participants

In this replication study, a community sample of participants (16 female, 25 male) was recruited on the town green of a small New England city. This sample was significantly older than the sample in Study 1a, with ages ranging from 19 to 65 and a mean age of 43.60 ($SD = 11.49$).

Method

After providing their informed consent, participants filled out the same lifestyle habits survey and UCLA Loneliness Scale that were used in Study 1a in exchange for $2 compensation. Finally, participants were debriefed regarding their awareness of the hypothesis of the study, thanked for their participation, and dismissed. None of the participants were able to identify the purpose of the study with any accuracy.

Results

As in Study 1a, significant positive associations were obtained between loneliness and (a) the average duration of the participant's bath or shower ($r = .33$, $p < .05$) and (b) the preferred water temperature of the typical bath or shower taken by the participant

($r = .34$, $p < .05$). Unlike Study 1a, however, there was no association obtained between loneliness and the frequency of taking showers or baths ($r = .03$, $p > .25$). Still, as in Study 1a, the overall "physical warmth extraction" index variable was significantly correlated with chronic levels of loneliness ($r = .37$, $p = .017$) such that 14% of the variance in weekly physical warmth extraction through bathing in this more diverse community sample was explained by the degree of chronic loneliness. We suspect that the difference between the two samples on the frequency item was because the bathing habits of the older community sample are likely more routine and regular than in the dormitory-based student sample, so that needs for social warmth are met more by increases in the durations and temperatures of baths or showers than by increases in their frequency. Consistent with this interpretation, the mean water temperature preference of the older community sample was 4.8 ($SD = .83$) on the 1–6 scale, whereas of the mean temperature preference of the mainly student sample was 2.5 ($SD = .88$). However, it was important to our central hypothesis that in both the student and community samples the lonelier the participants were, the warmer they preferred the water temperatures of the baths or showers to be.

Study 2

The Study 1 results supported the hypothesis that people tend to substitute physical warmth experiences for the social warmth that is missing from their lives. According to our model, loneliness is "social coldness", a negative emotional state that can be ameliorated somewhat through applications of physical warmth (as in taking warm baths or showers). The results of Study 1 were consistent with this model by showing that lonely people tended to bathe more often, longer, and that they prefered warmer water temperatures when bathing when compared to less lonely individuals. But since this evidence was correlational in nature, it does not by itself demonstrate an equivalence of physical and social coldness.

Study 2 directly tested our model's prediction that cold physical experiences produce feelings of social coldness by first inducing a warm versus cold (vs. none) physical temperature experience and then administering the UCLA Loneliness Scale to participants. This experiment moved beyond previous research on the physical-social warmth relation in two important ways. First, it tested whether physical warmth (versus cold experiences) produced analogous changes in a trait measure of each participant's feelings of social warmth or coldness—that is, it did not test a fleeting impression of the warmth or prosociality of a single target individual (as in Williams & Bargh, 2008, and IJzerman & Semin, 2009), but instead it provided a report of the experienced chronic warmth or coldness of each participant's longer-term social environment (i.e., the UCLA Loneliness Scale). Second, unlike all previous temperature priming studies (IJzerman & Semin, 2009, in press; Williams & Bargh, 2008; Zhong & Leonardelli, 2008)—with the exception of Kang et al. (2010)—a baseline or control condition was included that did not receive either the warm or cold temperature experience, enabling us to ascertain whether it was the warm or the cold experience (or both) that was mainly driving the effect. Does physical warmth increase prosociality and reduce interpersonal distance, or does physical coldness decrease prosociality and increase interpersonal distance (or both)?

Participants

A total of 75 students (38 females, 37 males) ranging from 18 to 45 years of age with a mean age of 20.17 ($SD = 3.55$) were recruited for the study outside a university dining hall. They first provided their informed consent, and then they participated in exchange for $2.

Method

Following the warm or cold temperature-priming manipulation of Williams and Bargh (2008, Study 2), experimental participants were given a product evaluation task in which they first held a therapeutic pack (260 × 370 × 10 mm, MD Prime Co., Korea) that had just been heated in a microwave oven for 41 s (to produce a pack temperature of 98 °F) or cooled in a freezer for one hour, and then they answered questions concerning their opinions of the product. The experimenter placed the pack on each participant's left palm: After a minute each participant completed a consumer questionnaire with the pack still resting on his or her palm. The questionnaire consisted of three items: 1) was application of the pack pleasant (*yes/no*), 2) was it effective (*yes/no*), and 3) would the participant recommend the product to their friends (*yes/no*). Participants in the control condition were not presented with this task and did not hold the warm or cold pack.

Next, as part of an ostensibly separate study, participants completed the short form of the UCLA Loneliness Scale. We probed participants' suspicions and awareness of the primes using a funneled debriefing procedure (Bargh & Chartrand, 2000). None of the participants were able to identify the purpose of the prime, the connection between the studies, or the experimental hypothesis being tested.

Results

We expected that the cold temperature prime would increase participants' scores on the loneliness scale, as experiences of physical coldness should increase feelings of social coldness (disconnectedness). A one-way ANOVA (cold vs. warm vs. control) ANOVA on loneliness scores revealed the predicted main effect of temperature, $F(2, 74) = 3.80$, $p < .05$, $\eta_p^2 = .096$. Planned comparisons indicated that the cold-pack manipulation significantly increased loneliness scores ($M = 2.52$, $SD = .91$) compared to both the warm-pack, $M = 2.04$, $SD = .64$; $t(49) = 2.12$, $p = .04$, and the neutral-pack, $M = 1.97$, $SD = .68$; $t(48) = 2.55$, $p < .01$, conditions. The mean loneliness score in the warm-pack condition did not significantly differ from the mean in the neutral-pack condition, $t(49) < 1$.

These findings support the interpretation of the positive relationship between loneliness and taking warm baths or showers (observed in Study 1) in that physical warmth-seeking was used to compensate for the feelings of physical coldness associated with social coldness (loneliness). The association between physical and social coldness appears to be bidirectional: Even a brief physical coldness experience (as in present Study 2) significantly increased reported feelings of chronic loneliness (social coldness), and Zhong and Leonardelli (2008) have shown that recalling an episode of past rejection (social coldness) makes one feel physically colder (have lower estimates of room temperature). For many

people, taking a warm bath or shower is at least partly done to experience normal feelings of social warmth.

It was also noteworthy that the mean loneliness score in the warm-pack condition was quite similar to the mean score in the neutral condition, with both means close to the overall scale norm of 2.0 (see Russell, 1996) and significantly lower than they were in the cold-pack condition. Although a floor effect was possible given the normative mean of 2 on a 1–4 scale (in that the warm-priming manipulation had little room to move participants farther in the "not-lonely" direction), other recent studies have also found that cold-priming is stronger than warm-priming. Kang et al. (2010, Study 2) found that cold-priming produced greater activation of the left anterior insula compared to both the warm-priming and control conditions (which were equivalent), and IJzerman and Semin (in press) found that a social distance (coldness) manipulation (reading about a dissimilar target person) had three times the effect on room temperature estimation than a comparable social closeness (warmth) manipulation (reading about a similar target person; Cohen's $d = .97$ vs. .36, respectively).

It seems that the default state or orientation toward other people is mild warmth in that additional physical warmth experiences do not change the default as much as does a physical coldness experience. This "default warmth" interpretation is in harmony with the conclusions of Cacioppo and Gardner (1999) that people have a basic default approach motivation toward the social world but that avoidance motives, when triggered, are generally stronger than approach motivations. It is also consistent with the conclusions reached by Baumeister, Bratslavsky, Finkenauer, and Vohs (2001) in their comprehensive review that "bad is stronger than good" in terms of stimulus effects on judgment and behavior.

Study 3

Although physical warmth experiences may not have a strong effect on feelings of social warmth when a person is already feeling connected to family, friends, and coworkers, we do expect it to have a strong restorative or compensatory effect when the person is not feeling so connected (i.e., lonely). Zhong and Leonardelli (2008) showed that participants who were excluded during a simulated online interaction (the Cyberball game; Williams, Cheung, & Choi, 2000) showed a greater desire for warm food and drinks (but not control food and drinks, such as apples) than those who were not excluded. The researchers suggested that perhaps "experiencing the warmth of an object could reduce the negative experience of social exclusion". Similarly, the present Study 1 showed that the lonelier the individual, the more likely it was that he or she would take warm baths or showers. Thus, feelings of social coldness, whether they are acute following a rejection episode or chronic in the form of general loneliness and social isolation, appear to trigger a compensatory motivation to restore the missing warmth. What remains to be shown is that such applications of physical warmth temporarily reduce or even eliminate feelings of social coldness; in other words, that physical warmth is an effective substitute for social warmth. Study 3 was designed to test this hypothesis that physical warmth experiences can ameliorate the negative "cold" feelings caused by social rejection.

Following the procedure of Park and Maner (2009), participants first asked to recall a time in which they were socially excluded or socially included. In the control condition, participants were asked to recall their most recent meal. Next, they took part in the warm or cold pack product testing task (as in Study 2). Finally, their need to affiliate and also their desire to take part in emotion-improving activities (e.g., going shopping, eating candy) were assessed. We predicted that remembering an exclusion experience would activate a need to affiliate with others (replicating Park & Maner, 2009) and also increase the need to engage in mood-improving activities, and that holding the warm pack following the exclusion experience would help to satisfy, and thus significantly reduce, both needs.

Method

A total of 176 undergraduates (88 females, 88 males) ranging in age from 18 to 25 years with mean of 20.46 ($SD = 2.94$) participated in the study in exchange for $2. After providing their informed consent, participants were randomly assigned to write about a time in which they had felt socially excluded, a time in which they felt socially included, or in the control condition, about their most recent meal. Then, following the same procedure as in Study 2, participants momentarily held a warm pack or cold pack as part of a supposedly unrelated product evaluation task (or in the control group, they were not given this task) after which their momentary need to affiliate was assessed using the five-item measure of Park and Maner (2009), with items such as "Do you want to spend time with a close friend?" and "Do you want to talk on the phone with a friend?". Next, participants responded to several items taken from the emotion-regulation activity survey of Thayer, Newman, and McClain (1994), which asked about their degree of interest in activities such as eating candy, going shopping, exercising, taking a nap, and taking a shower. Finally, participants were debriefed regarding their awareness of the hypotheses (Again, no participant correctly guessed the underlying hypothesis of the study.), thanked, and dismissed.

Results

Need for affiliation. The statements concerning the need for affiliation were averaged to create a composite score, which was then subjected to a 3 (temperature: cold vs. warm vs. neutral) × 3 (social experience: exclusion vs. inclusion vs. neutral) ANOVA. Consistent with the hypotheses, a significant main effect was obtained for temperature, $F(2, 175) = 3.89$, $p < .05$, $\eta_p^2 = .04$, indicating that the participants' overall tendency to affiliate in the cold-pack condition ($M = 4.69$, $SD = 1.04$) was greater than their tendency to affiliate in the no-pack ($M = 4.21$, $SD = 1.23$) or warm-pack ($M = 4.22$, $SD = 1.13$) conditions. Replicating Study 2, the effect of cold temperature experiences to increase feelings of social coldness was found to be stronger than the effect of warm physical experiences to increase feelings of social warmth (compared to the baseline).

The analysis also revealed the predicted Social Experience × Temperature interaction, $F(4, 175) = 3.22$, $p < .01$, $\eta_p^2 = .07$. In the exclusion-followed-by-cold-pack condition, participants showed a higher need for affiliation than participants in the control (describe last meal)/cold-pack condition ($M = 5.08$, $SD = .83$ vs. $M = 4.15$, $SD = 1.21$), $t(36) = 2.73$, $p < .01$. However, as predicted, the warm-pack intervention significantly decreased the need for affiliation provoked by recalling the exclusion experience: Indeed, here participants showed a lower need for affiliation compared to participants in the control/warm-pack condition ($M = 3.85$, $SD = .92$ vs. $M = 4.51$, $SD = .84$), $t(38) = -2.37$, $p < .05$. There was no simple main effect

of temperature condition on the need for affiliation within the inclusion condition, $F(2, 54) = 1.57$, $p > .21$. Thus, warm physical experiences were found to significantly reduce the distress of social exclusion, effectively substituting for needed social warmth experiences and eliminating the need for affiliation triggered by the exclusion event.

Interest in emotion regulation activities. Although the need for affiliation is one consequence of social rejection (Park & Maner, 2009; Williams et al., 2000), it is not the only one: Rejection and other difficulties in social relations also produce negative affective states which require regulation. Thus, we included the additional emotion-improvement items to test the hypothesized effectiveness of an intervening physical warmth experience in reducing the need for emotion regulation, not just the need for affiliation produced by a social rejection experience.

The statements concerning interest in emotion regulation activities were averaged to create composite scores for each participant, which were then subjected to a 3 (social experience: exclusion vs. inclusion vs. neutral) × 3 (temperature: cold vs. warm vs. neutral) ANOVA. This analysis revealed significant main effects for temperature, $F(2, 175) = 3.11$, $p < .05$, $\eta_p^2 = .03$, and for type of social experience recalled, $F(2, 175) = 10.03$, $p < .001$, $\eta_p^2 = .10$. Both of these main effects were qualified by the predicted Temperature × Social Experience interaction, $F(4, 175) = 2.79$, $p < .05$, $\eta_p^2 = .06$. Further analyses of the components of this interaction revealed significantly higher interest in emotion-improvement activities following social exclusion compared to social inclusion in both the cold-pack ($M = 4.86$, $SD = .88$ vs. $M = 3.58$, $SD = 1.35$), $t(34) = 3.40$, $p < .005$, and no-pack ($M = 4.14$, $SD = .21$ vs. $M = 3.04$, $SD = .22$), $t(38) = 3.37$, $p < .005$, conditions. However, in the warm-pack condition interest in emotion regulation activities following social exclusion was reduced and was not greater than the interest following social inclusion ($M = 3.80$, $SD = .23$ vs. $M = 3.76$, $SD = .22$), $t < 1.0$.

Overall the results of Study 3 show that an intervening experience of physical warmth effectively satisfied and "turned off" the needs for affiliation and emotion regulation caused by recalling the exclusion experience. Together with the findings of Studies 1 and 2, this pattern of results suggests that physical warmth experiences can effectively substitute for needed social warmth experiences.

Study 4

Thus far we have shown (correlationally) that people tend to seek out physical warmth experiences when they experience social coldness, and we have shown (experimentally) that this is an effective strategy for reducing those negative feelings of coldness. At the same time, however, neither our participants in the present studies nor those in previous studies on the physical-social warmth relationship showed any explicit awareness of the potential effect of physical temperature experiences on their feelings of social connectedness or vice versa. It appears that people are aware of the relation implicitly, as shown in their actual behavior, yet they lack explicit knowledge of the effect (i.e., it is an unconscious form of self-therapy). Following the procedure of Nisbett and Bellows (1977), Study 4 was designed to provide a test of explicit awareness of the bathing-loneliness relation (see also Nisbett & Wilson, 1977). We conducted a person perception experiment in which participants read vignettes about a day in the life of two cousins that were identical except that in the experimental (but not the control) version the main character took a bath or shower on two occasions. After reading the story, participants rated the loneliness of that character. We hypothesized that the target person who was described as bathing twice would not be considered to be any lonelier than the control target.

Participants

A total of 60 participants (32 females and 28 males) ranging from 18 to 31 years of age with a mean age of 20.40 ($SD = 2.64$) were contacted outside of a university dining hall and participated in exchange for $2.

Procedure

Participants provided their informed consent, and they were told that they would be reading a story written by a previous participant. Placed at the top of the page were the instructions ostensibly given to the previous participant to write about a time when he or she had suddenly remembered an event that he or she had long forgotten. The story was presented in handwritten form to bolster the cover story. It described a woman who helped one of her cousins (Barb) move into her new apartment and how they both ended up going out to eat. The experimental and control versions of the stories (see Appendices A and B) were identical except for several key moments in which Barb takes a shower in one version and performs a mundane activity (e.g., changing her clothes) in the other.

After reading their randomly assigned version of the story, participants were asked to rate Barb's degree of loneliness on the short version of the UCLA Loneliness Scale (Russell, 1996) and her momentary need to affiliate and degree of interest in emotion regulation activities using the same two measures as in Study 3 (Park & Maner, 2009; Thayer et al., 1994). Each activity was scored on a 6-point Likert scale from 1 (*strongly disagree*) to 6 (*strongly agree*). After completing these three measures, participants were debriefed and dismissed; none were able to guess the experimental hypothesis.

Results

An independent-samples *t*-test was conducted to compare the loneliness scores in the bathing versus no-bathing story conditions. Consistent with our hypothesis that there is a lack of explicit awareness of the bathing-loneliness effect, participants did not consider the target person Barb to be any lonelier in the bathing ($M = 1.90$, $SD = .51$) than the no-bathing ($M = 2.23$, $SD = .74$) version of the story, $t(58) = -1.97$, $p < .05$. (If anything, there was a trend for our participants to consider "bathing Barb" to be less lonely.) There were also no significant differences between the two versions of the story in regards to how participants rated Barb's need for affiliation (bathing: $M = 4.60$, $SD = .73$; no-bathing: $M = 4.44$, $SD = .66$), $t(58) < 1$, or her interest in emotion regulation activities (bathing: $M = 3.69$, $SD = .81$; no-bathing: $M = 3.84$, $SD = .99$), $t < 1$.

Although a single study cannot be conclusive on this point, the results of Study 4 are consistent with the hypothesis that people do lack explicit awareness or an accurate theory (Nisbett & Wilson, 1977; Wilson & Brekke, 1994) of the physical-social warmth

relation. Reading about a target person who takes frequent showers within a short time period does not cause social perceivers to consider that person to be any lonelier than a target person who fills the same time with other mundane behaviors. Indeed, if anything our participants tended to consider the frequent bather to be less lonely, perhaps due to a semantic priming effect (bathing being associated with warmth), which is similar to Asch's (1946) original study. Note, however, that this semantic priming effect would be in the opposite direction of the behavioral effects observed in Study 1 in which increased bathing was associated with increased social coldness (loneliness) and not warmth, which provides further evidence that the behavioral effect in Study 1 is not likely due to semantic priming.

Returning to Dante, it appears that people do appreciate the substitutability of physical and social warmth, but they only appreciate it at an implicit level, as they lack an accurate theory of how loneliness and other forms of "social coldness" increase physical warmth-seeking activities. Dante reserved the ninth and deepest circle of Hell for those sinners who had betrayed the trust of others (Satan himself included) and tellingly consigned them to the *contrapasso* (punishment that fits the crime) of being frozen in ice for all of eternity, and in doing so, pointedly overturned the traditional image of a fiery Hell. Contemporary humans also show appreciation of the connection between physical and social temperature in the tendency to self-regulate feelings of loneliness with warm physical sensations, yet the evident lack of explicit awareness of the relation leads us to conclude that this is an unconscious self-regulatory mechanism.

General Discussion

In Studies 1–3, feelings of social coldness and disconnectedness were shown to trigger a need for social warmth that can be satisfied by applications of physical warmth, as in taking warm baths or showers. Extending previous studies (IJzerman & Semin, 2009, in press; Williams & Bargh, 2008; Zhong & Leonardelli, 2008), the present research included a chronic individual difference measure of social coldness (the UCLA Loneliness Scale) as well as experimental manipulations of social coldness (remembering past exclusion experiences) and showed their equivalence in experimental designs. Studies 1a (student sample) and 1b (community sample) showed that chronic loneliness (social coldness) was associated with a greater tendency to experience physical warmth through taking more frequent, longer, and warmer baths and showers. Study 1 thus supported the central hypothesis that people tend to substitute physical warmth for the social warmth that is missing from their lives.

Study 2 showed that a physical coldness manipulation significantly increased feelings of loneliness (social coldness). Thus, just as social coldness influences feelings of physical coldness (reported room temperature; Zhong & Leonardelli, 2008), physical coldness experiences can cause feelings of social coldness (loneliness). Next, Study 3 provided an experimental demonstration of the "self-therapeutic" effect of physical warmth in which feelings of social coldness, caused by recalling an experience of social exclusion, were significantly reduced by an interpolated physical warmth experience. Socially excluded participants who then held the warm pack showed a significant decrease in their need for affiliation and desire for emotion improving activities compared to excluded participants who held the cold pack or who did not hold the cold pack. Finally, Study 4 provided direct evidence that people lack the correct "theory" or explicit awareness regarding the loneliness-bathing effect, suggesting that the tendency to seek physical warmth as a substitute for absent social warmth reflects an unconscious self-regulatory strategy.

Thus, it appears that the "coldness" of loneliness or rejection can be treated somewhat successfully through the application of physical warmth—that is, physical and social warmth might be substitutable for each other to some extent (see also Zhong & Leonardelli, 2008). In harmony with this conclusion, researchers have recently posited associations between physical pain and social pain systems (e.g., Eisenberger et al., 2003; MacDonald & Leary, 2005a, 2005b; Panksepp, 2003, 2005). The neural overlap between physical pain and social pain systems (see Eisenberger et al., 2003; Panksepp, 2003) suggests that potential threats in both goal domains are processed similarly. People who are made to feel rejected while playing a computerized ball-toss game ostensibly with other participants exhibited increased activity in the dorsal anterior cingulated cortex (dACC), an area also implicated in the body's pain response system (Eisenberger et al., 2003).

The therapeutic value of the substitutability of physical and social warmth would seem promising not only for the self-soothing of emotional distress as in Dialectical Behavior Therapy (Linehan, 1993) but also for the treatment of Seasonal Affective Disorder (SAD), in which large fluctuations in ambient external temperature (along with nontemperature influences such as the amount of daylight per day) may well influence fluctuations in one's internal "social" temperature. Moreover, because feelings of loneliness and perceived isolation lead to poorer physical and mental health outcomes among the elderly (e.g., Chappell & Badger, 1989; Larson, Zuzanek, & Mannell, 1985; Tomaka, Thompson, & Palacios, 2006) and do so independently of actual social disconnectedness (Cornwall & Waite, 2009; Tomaka et al., 2006), ameliorating these feelings (through physical warmth) could significantly improve the life quality of the elderly. Again, as with the tendency of lonely individuals to take more warm showers or baths (Study 1), it would seem that the elderly already appreciate the benefits of physical warmth given their traditional preference to retire to warm locations (e.g., Florida and Arizona in the United States). Our findings suggest that they may be seeking out the increased physical warmth for psychosocial and emotional reasons in addition to physical ones (e.g., poorer circulation).

In conclusion, we have shown that people tend to self-regulate their feelings of social connectedness through the use of physical warmth experiences and that this self-regulatory technique appears to be unconscious and implicit, with our participants manifesting no explicit awareness that physical warmth can be substituted for needed social warmth. Our experimental evidence suggests that the substitution of physical for social warmth can reduce needs for affiliation and emotion regulation caused by loneliness and social rejection, needs that characterize several mental and social disorders with major public health significance.

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(*Appendices follow*)

Appendix A

Stories Used in Study 4: "Bathing" Version

In late March or could have been early April last year I was helping one of my cousins move into her new apartment and we were going to head out for some food; I was starving and was ready to head out right away but Barb wanted to take a shower first. While I was waiting I surfed her bookcase for anything interesting to look at and found out she liked Cezanne a whole lot because she had these three really expensive art books about him, and I'd never known she was even interested in art that much; then I felt a little funny like I was snooping around or something so I just flipped through some magazines until she came out again – it seemed like hours but maybe it was because I was so hungry . . . Then at lunch I asked about the Cezanne books and what kind of art she liked and she looked a little sheepish and then told me about this epiphany she had about his paintings, while looking at one of his still lifes at the Metropolitan one day, and then buying all three of those books at the gift shop before going home, which she admitted was pretty extravagant – and then I remembered! and it was weird because I'd completely forgotten about this, but it turns out the day she got those books I had called her about something completely unrelated and she happened to be in the bathtub and she was so excited about the painting she had seen and talking on and on about it and all the time I was worrying about her having that phone near the tub and imaging her dropping it in the tub and ruining it or shocking herself or something – so I guess that distracted me at the time from what she was saying about the painting and the books. Barb still kids me about getting shocked with my phone like when it's raining – well I'd heard about it happening to someone I knew, but ok, ok, I feel silly about it now.

Appendix B

Stories Used in Study 4: "No-bathing" Version

In late March or could have been early April last year I was helping one of my cousins move into her new apartment and we were going to head out for some food; I was starving and was ready to head out right away but Barb wanted to change clothes first. While I was waiting I surfed her bookcase for anything interesting to look at and found out she liked Cezanne a whole lot because she had these three really expensive art books about him, and I'd never known she was even interested in art that much; then I felt a little funny like I was snooping around or something so I just flipped through some magazines until she came out again – it seemed like hours but maybe it was because I was so hungry . . . Then at lunch I asked about the Cezanne books and what kind of art she liked and she looked a little sheepish and then told me about this epiphany she had about his paintings, while looking at one of his still lifes at the Metropolitan one day, and then buying all three of those books at the gift shop before going home, which she admitted was pretty extravagant – and then I remembered! and it was weird because I'd completely forgotten about this, but it turns out the day she got those books I had called her about something completely unrelated and she happened to be walking home from the museum in the pouring rain and she was so excited about the painting she had seen and talking on and on about it, and all the time I was worrying about her talking on her cell phone in the rain and imagining it getting ruined or Barb getting shocked or something – so I guess that distracted me at the time from what she was saying about the painting and the books. Barb still kids me about getting shocked with my phone like when we're near a fountain or drinking fountain – well I'd heard about it happening to someone I knew, but ok, ok, I feel silly about it now.

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