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### Original Article

## The Effects of Temperature Priming on Cooperation in the Iterated Prisoner's Dilemma

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**Abstract:** Based on initial research findings by Williams and Bargh (2008) and Kang, Williams, Clark, Gray and Bargh (2011) on the interaction between interpersonal and physical warmth, theoretical models such as cognitive scaffolding and the importance of evaluations of interpersonal warmth in trust-based decisions, this experiment investigated the effect of temperature priming on 30 pairs of British university students with hot and cold objects on frequency of cooperation in a game of iterated Prisoner's Dilemma. Participants were found to cooperate significantly more frequently when primed with hot objects than with cold objects, supporting the assertion that physical warmth sensation positively affects interpersonal trust evaluation. No support was found for the prediction that male-male pairs would cooperate less than female-female pairs. The implications of these findings to evolutionary and developmental theories of interpersonal warmth are discussed.

**Keywords:** Iterated Prisoner's Dilemma; cooperation; interpersonal warmth.

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### Introduction

The proposition that there is a link between real world temperature sensation and feelings of psychological warmth has found increasing support from neurobiological and developmental studies. Harlow's (1958) study on attachment in infant macaques was the first to show that physical warmth can replace interpersonal warmth, to a certain extent: infant macaques that were reared with a warm cloth-surrogate were less socially damaged by their maternal deprivation than those raised without such warmth (a finding that has parallels with humans; see, for example, Bargh and Shalev, 2012). In their study of 2012 Bargh and Shalev were able to demonstrate that people tend to self-regulate their feelings of interpersonal warmth with applications of physical warmth. This shows that humans can

also use physical warmth to replace interpersonal warmth. It also demonstrates the inter-relatedness of interpersonal and physical warmth.

In addition to behavioural findings, a number of neuroanatomical studies have also lent support to the notion of a link between physical and interpersonal warmth (and similarities here between human and non-human primates). Craig, Chen, Bandy and Reiman, through lesion studies, for example, suggested that temperature sensation is located in the insular cortex, rather than the parietal somatosensory cortices utilized in touch sensation (Craig et al., 2000). This study also posited a link between physical warmth sensation and emotional warmth sensation. Craig et al. suggest that the right anterior insula is “integral to mentally generating the image of one’s physical state that underlies basic emotions”, including interpersonal evaluations (Craig et al., 2000, p. 188). This finding is supported by Stephanie et al.’s (2011) studies on individuals whose insulae were implanted with electrodes. By stimulating the electrodes in this region they were able to isolate several functionalities of different insula regions, finding that stimulating the dorsal posterior insula elicited “a subgroup of warmth...sensations” (Stephanie et al., 2011, p. 137).

In recent years neuroimaging techniques have also been used to add to our knowledge of the relationship between interpersonal and physical warmth. Sanfey, Rilling, Aronson, Nystrom and Cohen (2003) viewed the brains of participants using fMRI during an economics game known as the Ultimatum Game. They found significant activity in the anterior insula during decision-making events in these games, indicating that interpersonal trust evaluations, (previously shown by Winston, Strange, O’Doherty and Dolan (2002) to be heavily based upon “warmth” criteria), may play a part in economic decision making. This finding is supported by van den Bos, van Dijk, Westendberg, Rombouts and Crone’s (2009) research which demonstrated insula cortex activation during games involving trust and reciprocity. Moreover, the existence of a “hard-wired” link between interpersonal warmth and physical warmth is also supported by Meyer-Lindenberg’s (2008) research into borderline personality disorder where abnormal activity in the insula cortex mirrored abnormal patterns of trust in relationships. These findings implicating the insula with both interpersonal warmth evaluation and interpersonal trust evaluation support Williams and Bargh’s (2008, p. 606) suggestion that interpersonal warmth information forms the “first pass” of evaluating interpersonal trust. Thus, manipulating a participant’s evaluation of interpersonal warmth, by controlling their sensation of physical warmth, may conceivably influence an individual’s evaluation of interpersonal trust. This is the premise on which the current study is based.

Kang, Williams, Clark, Gray and Bargh (2011) provide the most persuasive evidence for the dual functionality of the insula in processing interpersonal and physical warmth sensations. Using fMRI scans during economic games, their experiment found that the left-anterior insular region was activated more strongly when making a trust decision when primed with a cold object than with a hot object. In contrast to Williams and Bargh’s (2008) findings that both hot and cold objects alter interpersonal trust, Kang et al. (2011) found that the insula only showed increased activity when participants were primed with the cold object. This might suggest that it is only the cold condition that alters interpersonal warmth evaluation; warm conditions may simply reflect the baseline level, although this

was not investigated further.

This recent neurobiological evidence is supportive of earlier developmental and consequent evolutionary explanations of the connection between physical warmth, interpersonal warmth and cooperation. Asch (1946) found that the presence of the word “warm” or “cold” altered participant’s impressions of an ambiguously described person. Asch (1946) further argued that interpersonal warmth factors are important in the evaluation of trust. Trust evaluations are a fundamental aspect of cooperation and reciprocation, and have been suggested to be fundamental to the evolution of non-kin related cooperative behaviours (Axelrod and Hamilton, 1981). Developmental theorists, such as Mandler (1992) and MacDonald (1992), state that warmth is an important aspect of early childhood experiences of caregivers, necessary for healthy childhood development. It is argued by Williams and Bargh (2008) that these influential early experiences of warmth are associated with other feelings of warmth at a later date. They state that, “[due to] these frequent early life experiences with [a] trustworthy caregiver, a close mental association should develop between the concepts of physical warmth and psychological warmth” (Williams and Bargh, 2008, p. 606). It is further argued that feelings of physical warmth in later life may “activate memories of other feelings associated with warmth [such as trust and comfort]” due to their earlier association with primary caregivers (Williams and Bargh, 2008, p. 606).

Allman (2000) argued that as the brain evolved from a relatively simple organ into an incredibly complex system, pre-existing areas of the brain were co-opted into performing more complex tasks. Thus, the insula may have originated as a module for measuring physical temperature, and later, as complex social structures emerged, became adapted to evaluate “friendliness” and “trustworthiness”, as suggested by Williams, Huang and Bargh (2009). Williams, Huang and Bargh’s (2009) “cognitive scaffolding model” attests that due to having common cognitive media, physical concepts such as temperature, and abstract concepts such as interpersonal warmth, are experienced similarly. They also argue that cognitive scaffolding is an innate, natural process linked to evolutionary mechanisms. Although Wilson (2002) argued that there was little evidence for the scaffolding of abstract constructs, subsequent support for this theoretical model is found in research into numerous abstract psychological concepts; such as time (Boroditsky, 2000), moral disgust (Wheatley and Haidt, 2005) and good and evil (Meier, Hauser, Robinson, Friesen and Schjeldahl, 2007).

Williams and Bargh (2008) predicted that, due to the developmental association between physical and emotional warmth, and the apparent dual function of the insula in processing both physical and emotion warmth information, tactile experiences of warmth should “activate concepts or feelings” associated with interpersonal warmth. In their study, they demonstrated that by priming a participant with a warm or cold object, the participant’s judgment of a fictitious individual’s personality was “warmer” (more generous, trustworthy and friendly) or “colder” (less generous, trustworthy and friendly) respectively. Williams and Bargh (2008) were rigorous in their separation of interpersonal warmth criteria from other, non-warmth related criteria. This allowed them to determine that the effects of temperature priming were solely related to interpersonal warmth, and not merely a mood “halo” effect. However, by their use of criteria semantically linked to

warmth or cold, it is difficult to determine whether their results were actually due to increased feelings of interpersonal warmth, or whether the participants were merely associating the feelings of physical warmth with the wording of the questions. Further research is required to validate their findings.

In addition to testing the effects of temperature priming on interpersonal warmth evaluation, Williams and Bargh (2008) tested its effects on generosity. They found that participants primed with a cold object were more likely to choose a gift framed as a gift for themselves than a gift framed as a gift for a friend. The opposite was found when participants were primed with hot objects. This demonstrates that temperature priming may well have an effect on real-world behaviours, such as generosity.

Kang et al. (2011) also studied the effects of temperature priming on games of economics. They found that participants primed by touching a cold object were less willing to invest with an anonymous partner compared to participants primed with a hot object. This provides evidence of prior temperature affecting cooperation: influencing participants to cooperate less in the cold condition, and vice versa. Furthermore, it demonstrates temperature priming having a tangible effect on real-life choices. In a similar study IJzerman and Semin (2009) also found that when participants were seated in a warm room they felt interpersonally closer to the experimenter than those seated in a cold room, and that this effect was bi-directional: participant's perception of room temperature could be altered by placing them closer to other participants, simulating interpersonal closeness. This provides further evidence that temperature priming affects interpersonal evaluations. It is a fair assumption that these feelings of interpersonal closeness are likely to induce higher levels of cooperation in participants.

However, previous research provides conflicting evidence as to how initial acts of generosity affect decisions later on. Garapin, Llerena and Michel (2011) found that when participants play a game of Prisoner's Dilemma, after playing a donation game, they were less likely to cooperate. This suggests that prior instances of generosity may result in lower levels of generosity at a later date, which may have a significant effect on a repeated measures design. Thus, we can expect participants in a second game to be less cooperative than in their first game. Also, we may expect participants experiencing hot temperature priming first to score lower than participants experiencing cold temperature priming first, as participants may be more cooperative in the first round. Conversely, Axelrod and Hamilton (1981) suggest that prior instances of defection will be punished by further defection. From this, we may predict that in conditions where participants experience cold temperature priming first, cooperation will be less likely in the subsequent hot round than it would have been if the hot round was first due to the predicted higher likelihood of defection in the cold condition.

The research reviewed suggests that there is a close connection between the sensation of physical warmth and the sensation of interpersonal warmth. However, only Kang et al. (2011) have directly studied the effects of temperature priming on cooperation; a study where participants were required to take part in an abstract investment game which may have been somewhat removed from their day-to-day experience of cooperative decision making. In the current study we make use of "iterated prisoner's dilemma", a well-established method of investigating tendencies to cooperate (or defect) within the field of

human behavioural ecology (Workman and Reader, 2008). Given that this game is played by two participants many times with both having the opportunity to reward or penalize their partner for previous decisions it is more likely to mirror real-life cooperative decisions than the task used by Kang et al. In light of the findings of Kang et al., that hot temperature priming influenced participants to be more cooperative than participants who were temperature primed with a cold object, the current study makes use of iterated prisoner's dilemma to examine the inter-relatedness of physical warmth and interpersonal warmth, and its potential to influence trust decisions, by testing the effects of temperature priming on reciprocation between two participants, with tangible rewards for either cooperating or defecting.

## **Materials and Methods**

### *Participants*

The participants comprised of 60, 19-29 year old students from a British university, forming 30 pairs, recruited through opportunity sampling. To counterbalance the experiment, 15 pairs were randomly assigned to the hot-first condition while the remaining 15 pairs were randomly assigned to the cold-first condition. Six pairs were male and 24 were female. These were split evenly between the two conditions to control for the effects that gender may have on cooperation (Kerr and MacCoun, 1985). As Axelrod and Hamilton's (1981) explanation of reciprocation, and the subsequent development of the iterated Prisoner's Dilemma, depend on individuals being capable of reciprocation at a later date, participants were paired with either friends or housemates. This ensured that there was ample opportunity for reciprocation of cooperation at a later date.

### *Materials*

The experiment measured how temperature priming affects the level of cooperation displayed by participants. Participants were temperature primed by holding hot or cold objects during the two conditions of the experiment respectively, forming the two independent variables. The level of cooperation displayed by the participants was measured using the total score obtained by each pair in a game of iterated Prisoner's Dilemma. The apparatus used in the experiment consisted of four cards, two of which had "co-operate" printed on them and two had "defect". One of each was given to each participant so they could cooperate or defect without revealing their answer to their partner beforehand. Gel-chemical hand warmers were used as the hand-held hot objects and freezer packs were used as the cold objects. The game of iterated Prisoner's Dilemma was used to measure levels of reciprocity. This measure was chosen because it has been proposed that it is a model for real-world reciprocation, supported by Axelrod and Hamilton's (1981) research on game-theory.

Incentives, in the form of small chocolates or sweets, were given to persuade participants to engage in the game. These incentives fulfilled the criteria for an iterated Prisoner's Dilemma points system: when both participants finish with equal scores, each participant received two sweets, for a total of four. However, when one participant finished with more points than the other, they received three sweets and their partner received none.

This provides both an incentive to work together and a temptation to defect, and would more accurately represent real-world cooperation. Lönnqvist, Verkasalo, and Walkowitz (2011) found that when a game of Prisoner's Dilemma was incentivized, participants were less generous.

### *Procedure*

Participants were required to complete two consecutive games of iterated Prisoner's Dilemma. During the first game, both participants held either a hot object first (hot-first condition) or a cold object first (cold-first condition). During the second game, their held object was reversed, creating a repeated measures design. Thus, the hot-first condition was run as: hot first, cold second; and vice-versa for the cold-first condition. For each pair in the hot-first condition, another pair was placed in the cold-first condition to counterbalance the design. Whether the participants were placed in the hot-first or cold-first condition was recorded in order to investigate whether prior co-operation had any effect on subsequent decisions. As this experiment sought only to discern whether there is a difference between hot temperature priming and cold temperature priming, not how they change from baseline rates of cooperation, there was no control condition.

To play the iterated Prisoner's Dilemma, participants place a card stating "co-operate" or "defect" onto the table face-down. Once both participants have selected their option, participants were prompted to turn over their card to reveal their decision. This ensured that neither participant knew what the other had chosen prior to making their own decision. The score was recorded after each round. Participants repeated this for a total of five rounds while holding the hot or cold object, depending on whether they are in the hot-first condition or cold-first condition. They then repeated this procedure holding the opposite object from the first game. The number of rounds to be played was not revealed to the participants. Instead, they were told that the number of rounds to be played is random and has been determined beforehand, and that the experimenter will announce when the game has finished. This is necessitated by the condition of the iterated Prisoner's Dilemma that states that if individuals can foresee a distinct end to the game, the most effective strategy changes from one of mutual cooperation to one of constant defection (Axelrod and Hamilton, 1981).

As Russel and Fiske (2008) found that participants judged competing targets as less warm than cooperating targets, care was taken to use neutral language, avoiding language that would suggest the participants were in a competition against each other, or that they were to cooperate with each other. For instance, language such as "you will be playing *against*" was replaced by "you will be playing *with*". The interactions between the experimenter and the participants were scripted to ensure parity across all cases.

Trivers (1971) and Dawkins (1976) suggest that many instances of cooperation between individuals occur through kin-altruism. In this experiment, participants were controlled for degree of relatedness by excluding pairs who are related to one another. Furthermore, Axelrod and Hamilton (1981) suggest that the primary driving force behind cooperation between non-kin is reciprocal altruism. They state that for reciprocal altruism to function, the possibility of future meetings, and future reciprocation, between individuals must be high. To ensure this mechanism functions for participants, they were controlled for

degree of familiarity by pairing participants with friends.

There is a large body of research suggesting that males and females approach cooperation differently, either due to biological factors (Buss 1989; Buss and Schmitt 1993; van Vugt, De Cremer and Janssen, 2007) or to socio-cultural processes (Sell and Kuipers, 2009). Kerr and MacCoun (1985) found that when participants played a cooperation game with male partners, both men and women were less cooperative. In order to control for this effect, participants were controlled for gender by grouping them into same-sex pairs. This also suggests that male-male pairs may be less cooperative than female-female pairs. Provided there are an equal number of male-male pairs in the hot-first condition and the cold-first condition, this will not need to be controlled for.

As IJzerman and Semin (2009) found that the ambient temperature of a room can affect participants' perception of interpersonal warmth, the experiment took place indoors at room temperature. IJzerman and Semin (2009) also found that the distance between participants affected ratings of interpersonal warmth. To control for this, participants were seated a set distance of one meter from each other. This distance was decided upon as it is between the upper and lower limit for conversational distance between friends in the United Kingdom, as discussed in Stratton, Tekippe and Flick (1973). Krauss, Huang and Keltner (2010), found that touching another person can promote cooperation between individuals. In order to prevent this from affecting the data, participants were not allowed to touch each other for the duration of the experiment. Furthermore, participants were not allowed to inform each other of their decisions during the experiment.

#### *Ethical issues*

This experiment was approved by the Ethics Committee of Bath Spa University in accordance with BPS guidelines.

## **Results**

The descriptive data revealed a difference in mean scores across the hot and cold conditions. As shown in Table 1, the mean scores indicate that participants score more highly in terms of cooperation following the hot priming condition.

**Table 1.** Mean pair hot (H) and cold (C) cooperation scores (and standard deviations) over five rounds of iterated Prisoner's Dilemma

	Order	Mean	SD	N
Score H	H-C	16.20	1.42	15
	C-H	15.53	1.85	15
	Total	15.87	1.66	30
Score C	H-C	14.33	1.68	15
	C-H	15.20	2.04	15
	Total	14.77	1.89	30

As the data collected meet the requirements for parametric tests, a repeated measures ANOVA was conducted to investigate the effects of hot and cold temperature

priming on pairs' combined scores over five rounds of the iterated Prisoner's Dilemma. The between factors variable was whether the sequence for pairs was hot followed by cold or cold followed by hot trials. The within factors variable was cooperation scores following hot or cold priming. The scores for the hot condition were significantly higher than the scores for the cold condition ( $F_{1,28} = 8.54$ ;  $p = 0.007$ ) irrespective of whether hot preceded cold or cold preceded hot ( $F_{1,28} = 0.04$ ;  $p = 0.85$ ). Therefore the prediction that hot temperature priming would result in higher frequency of cooperation than cold temperature priming was supported.

#### Breakdown analyses

It was found that male-male pairs did not cooperate to a significantly different degree than female-female pairs, indicating that sex did not have an effect on frequency of cooperation (see Table 3). Further analysis found that practice effects did not significantly affect participant's scores, as the mean for the total pair first round scores of 15.70 and the mean for the total pair second round scores of 14.93 were not significantly different (see Table 4). Also, it was found that whether participants experienced hot temperature priming first or cold temperature priming first did not significantly affect the results. The mean total pair scores of 30.53 for the hot-first condition and 30.73 for the cold-first condition were not significantly different (see Table 5).

After converting the data into binary format, with a higher hot score than cold being represented by 1, and a higher cold score than hot being represented by 0, it was found that twice as many of the participants cooperated more frequently in the hot condition than the cold condition. This is demonstrated in Table 2.

**Table 2.** Frequency of Higher Hot Scores and Higher Cold Scores ( $n = 30$ )

	Frequency
Hot Score Higher	20
Cold Score Higher	10

Both the scores for the hot condition and the cold condition were negatively skewed, with hot scores having a skewness of -0.76 and cold scores a skewness of -0.32. However, these are within the tolerances for parametric analysis. The kurtosis values of the hot score and cold score were 1.84 and -.32, indicating a normal distribution. There was one outlier in the data, with a hot score of 18 and a cold score of 11. However, these scores are both within the existing range of participant's hot scores (11-19) and cold scores (11-18) respectively. Thus, this outlier was not excluded from analysis.

An independent-samples t-test was conducted to compare the total pair scores for male-male pairs and female-female pairs. This test was conducted to evaluate Kerr and MacCoun's (1985) suggestion that individuals are less cooperative when paired with male partners, and its potential effect on the data. Total pair scores were found by combining each participant's score in a pair over both hot and cold conditions and adding it to their partner's. It was found that there was no significant difference between male-male pairs ( $M=32.14$ ,  $SD=2.55$ ) and female-female pairs ( $M = 30.17$ ,  $SD = 2.77$ ),  $t(28) = 1.64$ ,  $p = .105$  (one-tailed) (see Table 3). The magnitude of the differences in the means (mean



difference = 1.97, 95% CI: -.44 to 1.18) was only moderate (eta squared = .09). Thus any variation between males and females is due to chance. This does not support the research prediction that female-female pairs will cooperate more frequently than male-male pairs. This allows us to treat male-male pairs and female-female pairs as equal for comparison between hot scores and cold scores.

**Table 3.** Difference in Means between Male-Male and Female-Female Total Pair Scores ( $n = 30$ )

	Total Pair Score
Male-Male Pairs	32.14 (2.55)
Female-Female Pairs	30.17 (2.77)
<b>Total</b>	<b>30.67 (2.77)</b>

To determine whether practice effects affected participant's frequency of cooperation, a paired-samples  $t$ -test was conducted to compare participants' mean first game scores to participants' mean second game scores, disregarding which condition was in effect. Although the scores for the first game ( $M=15.70$ ,  $SD=1.80$ ) were higher than the scores for the second game ( $M=14.93$ ,  $SD=1.84$ ) (see Table 4), this difference was not significant:  $t(29) = 1.81$ ,  $p = .08$  (two-tailed). The magnitude in the difference of the means (mean difference = .770, 95% CI: -.98 to 1.63) was moderate (eta squared = .10). Thus any variation in first game scores and second game scores is down to chance. Therefore, the prediction that there would be a difference between participant's scores in the first round and second round was not supported. This indicates that practice effects were not a confounding variable in the data.

**Table 4.** Difference in Mean Scores between the First and Second Game Scores ( $n = 30$ )

	Game Score
First Game	15.70 (1.80)
Second Game	14.93 (1.84)
<b>Total</b>	<b>15.32 (1.41)</b>

To determine whether the order in which participants experienced temperature priming affected participants' frequency of cooperation, an independent-samples  $t$ -test was conducted comparing the total pair scores for the hot-first condition to the total pair scores for the cold-first condition. The scores for the hot-first condition were calculated by summing each pair in the hot-first condition's total score over both the hot condition and the cold condition. This gives a total game score for each of the pairs in the hot-first condition. The scores for the cold-first condition were calculated using the same method. It was found that there was no significant difference between the hot-first condition ( $M=30.53$ ,  $SD=2.23$ ) and the cold-first condition ( $M=30.73$ ,  $SD=3.37$ ),  $t(28) = -.192$ ,  $p = .85$  (2-tailed, see Table 5). The magnitude in the difference of the means (mean difference = .200, 95% CI: -2.34 to 1.94) was small (eta squared = .02). Thus any variation in between the hot-first condition and the cold-first condition is down to chance. Therefore, the prediction that there would be a different rate of cooperation in the hot-first condition and

the cold-first condition was not supported and the two conditions may be treated as equal for the final statistical analysis.

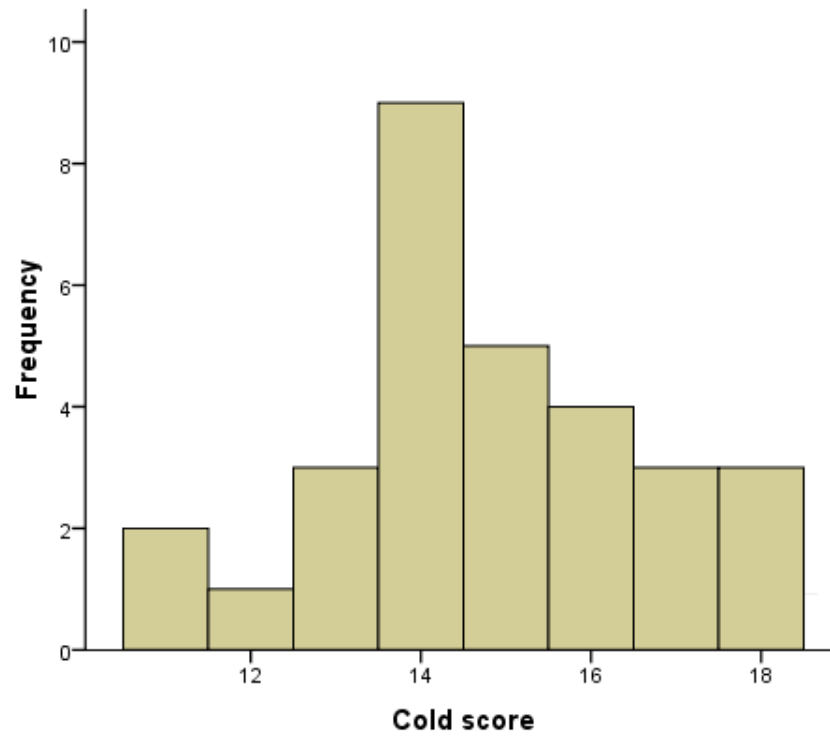
**Table 5.** Difference in Mean Scores between the Hot-First and Cold-First Conditions ( $n = 30$ )

	Total Pair Score
Hot-First Condition	30.53 (2.23)
Cold-First Condition	30.73 (3.37)
<b>Total</b>	30.67 (2.77)

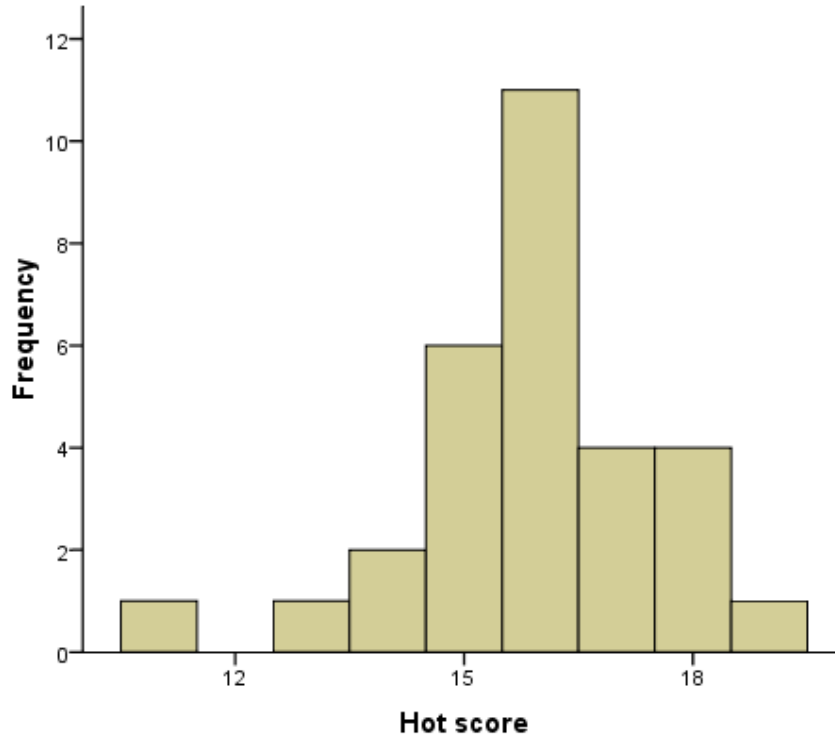
Finally, the “hot score” and “cold score” of the participants were analyzed using a paired-sample t-test. The “hot score” was found by combining each participant’s total score over every round in the hot condition and adding it to their partner’s total. This gives a combined score for each pair in the hot condition. The “cold score” is found using the same procedure in the cold condition. As the hypothesis predicted that the hot condition would result in higher rates of cooperation, a one-tailed test was used to analyze the data.

To assess the normality of the sample, a Kolmogorov-Smirnov test for normality was conducted on the hot scores and cold scores. As the significance of this statistic is  $>.05$  we can assume the sample meets the assumptions of normality required to conduct a paired samples t-test (see Figures 1 and 2). The scores between pairs are independent from one another, as each experiment was conducted consecutively, preventing one pair’s score influencing another’s.

**Figure 1.** Frequency of Cold Scores ( $n = 30$ )



**Figure 2.** Frequency of Hot Scores ( $N = 30$ )



## Discussion

Statistical analysis of the data found that pairs scored significantly higher in the hot condition ( $M = 15.90$ ) than in the cold condition ( $M = 14.77$ ), indicating greater frequency of cooperation. There was no significant difference found between male-male pairs' and female-female pairs' mean scores, although male-male pairs did score slightly higher. This suggests that differences in cooperation between the sexes were due to chance, which allowed male-male pairs and female-female pairs to be treated as equal in the statistical analysis.

Previous research provides conflicting evidence as to which condition would promote higher cooperation, the hot-first condition or the cold-first condition. As discussed earlier, Garapin et al. (2011) suggest that prior instances of generosity may result in lower levels of generosity at a later date, suggesting a lower frequency of cooperation in the hot-first condition than the cold-first condition. However, Axelrod and Hamilton's (1981) research suggests the opposite effect. In order to investigate this, the hot-first and cold-first conditions were analyzed. No support was found for either suggestion as the hot-first condition and cold-first condition did not differ significantly. Furthermore, comparative analysis of the first games and second games found that they were not significantly different, suggesting practice effects did not significantly affect participant's scores either.

These findings support the initial prediction that participants would be more cooperative after being primed with hot objects and less cooperative after being primed with cold objects. This is in keeping with Kang et al.'s (2011) finding that participants were less willing to donate to an anonymous partner in an economics game if they were primed

with cold objects than if they were primed with hot objects. This finding is also supportive of Williams and Bargh's (2008) finding that temperature priming participants with hot objects resulted in more generous behaviour. Hence it is suggested that, as in these previous studies, experiencing physical warmth leads directly to increased feelings of interpersonal warmth and, in turn, to cooperation in the current study. It might however be suggested that there is a simpler explanation. It is possible that the cold priming condition leads to a reduction in the likelihood of acting cooperatively since, during our ancestral past, cold ambient temperatures would have led to an increase in thermoregulatory burden. This second explanation is difficult to refute, but since it is clear that our ancestors would have been dependent on conspecifics during periods of stress and that a lack of cooperation may well have led to the removal from future reciprocal aid relationships (Trivers, 1971; 1985; see also Schilbach et al., in press) we feel that this alternative explanation is a less likely to account for our findings.

The discovered effect of temperature priming on cooperation also provides indirect support to the theory that there is a common neurological medium for the perception of physical warmth and interpersonal warmth in the brain (Allman, 2000). The support is indirect as the experiment did not measure insula activity during the economics trust game, the connection is an assumption based on previous research by Kang et al. (2011) and Stephanie et al. (2011). However, it adds to the body of evidence demonstrating a clear connection between physical warmth sensation and interpersonal warmth evaluation. Furthermore, it demonstrates a connection between physical warmth sensation and interpersonal trust evaluation, which Williams and Bargh (2008) consider is partially dependant on interpersonal warmth evaluation. This experiment's findings also provide indirect support for Mandler (1992) and Williams et al.'s (2009) theory that complex psychological concepts are founded on more primitive concepts, otherwise known as cognitive scaffolding. Again, it does not provide direct support, as the iterated Prisoner's Dilemma does not directly measure interpersonal warmth. Instead, it measures frequency of cooperation, which was used as a proxy for interpersonal warmth evaluation. While this proxy was used by Williams and Bargh (2008) and Kang et al. (2011), future research might benefit from a measure directly studying the effects of interpersonal warmth evaluation.

If, as Trivers' suggests, we have a lengthy evolutionary history of reciprocation and an evolutionary heritage of dependence on conspecifics for our survival (Trivers, 1971; 1985; Schilbach et al., in press) then it is likely that we have evolved a tendency to seek affiliation and rapport. Arguably such affiliation is likely to be based around feelings of interpersonal warmth that develop as individuals engage in mutually cooperative behaviours. Since there is clear aforementioned evidence that the neuroarchitecture underlying interpersonal warmth has "piggybacked" on top of that which underlies physical warmth then perhaps the inclusion of the iterated prisoner's dilemma (with its built in repeated opportunities for affiliation) into behavioural studies of this nature might help to further our knowledge of this relationship.

Future studies of this nature might be conducted within a developmental framework in order to investigate the development of "cognitive structuring". Such a study might help to test Mandler's (1992) assertion that complex psychological concepts develop from

simpler physical sensations in an individual's lifetime, or Allman's (2000) assertion that the connection between physical and interpersonal warmth is an innate evolutionary adaptation, and is present from birth.

In conclusion, it was found that hot temperature priming resulted in a higher frequency of cooperation than cold temperature priming. This is supportive of previous studies into the effects of temperature priming on interpersonal warmth evaluation, interpersonal trust evaluation and performance in economic games. It also provides indirect support for the dual-functionality of the insula, and theoretical models based on this observation. Such findings might have implications for the evolutionary and developmental models of interpersonal warmth in relation to cooperation.

In conclusion, it was found that hot temperature priming resulted in a higher frequency of cooperation than cold temperature priming. This is supportive of previous studies into the effects of temperature priming on interpersonal warmth evaluation, interpersonal trust evaluation and performance in economics games. It also provides indirect support for the dual-functionality of the insula, and theoretical models based on this observation. Such findings might have implications for the evolutionary and developmental models of interpersonal warmth in relation to cooperation.

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