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Warmer or cooler: the influence of ambient temperature on complex choices

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Abstract Temperature affects human cognition, emotion, and behavior in important ways, yet exactly how ambient temperature exerts its influences on complex product choices remains largely unknown. In this research, we examine how relatively warm versus cool temperatures, both within a comfortable range and commonly experienced, can affect people's decision quality in complex choices. In a series of three experiments, we demonstrate that warm (vs. cool) temperatures prompt affective processing, which then leads to better performance in complex choices. Consumers and companies need to take ambient temperature into account to create optimal environments for complex decision-making.

Keywords Warm temperature · Cool temperature · Affective processing · Complex choices

1 Introduction

Hitting the shopping mall in summer? It would be a good idea to take a sweater with you, because many stores set their indoor temperatures around 70 °F (~ 21 °C) or even lower (Rosenthal 2011). Yet some trends are changing; government requirements and environmental concerns have prompted some indoor temperatures to rise. For example, China's government requires all public facilities to keep their indoor temperatures at no less than 26 °C/78.8 °F in summer, and nearly 50 malls in

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Hong Kong have raised their indoor temperatures to this same level in an attempt to conserve energy (Cheng 2012).

Such changes in conventional ambient temperatures suggest the need for marketers to investigate whether and how ambient temperatures might influence consumer behaviors. Both practitioners and academics agree that temperature affects human cognition, emotion, and behavior in notable ways (Hancock et al. 2007; Ijzerman and Semin 2009; Williams and Bargh 2008). However, with regard to consumers' cognitive performance, prior research is limited on several dimensions, including its predominant use of simple tasks, such as word memory and figure matching (Ellis 1982; Hocking et al. 2001), and its failure to consider consumption-related decisions, such as product choices. Cheema and Patrick (2012) provide initial insights into the influence of ambient temperature on consumers' cognitive performance and find that warm (vs. cool) temperatures deplete resources and thus increase system I processing, leading to worse performance on relatively simple tasks (e.g., proofreading, gamble with 25 pieces of information). Going beyond simple decisions though (e.g., daily shopping), consumers often must make relatively complex cognitive decisions (e.g., stock investments, purchasing complicated products) that require them to process substantial information that exceeds their working memory and computational capacities. The influence of ambient temperatures on such complex product choices remains largely unknown.

With this study, we seek to address this limitation and advance understanding of the impact of temperature on complex product choices. Building on prior research pertaining to the influence of heat (Hancock and Warm 1989) and thinking styles (Epstein 1994; Mikels et al. 2011), we investigate how relatively warm versus cool temperatures, both within a comfortable range and commonly experienced, might affect people's decision quality in complex product choices. Although warm (vs. cool) temperatures impair performance in simple tasks (Cheema and Patrick 2012), we theorize and find that warm (vs. cool) temperatures can prompt affective processing and induce better decision quality for complex product choices.

2 Theoretical background

Heat produces thermal stress and impairs cognitive resources (Hancock 1986). Prior research establishes that warm (vs. cool) temperatures compete for cognitive resources, leaving people with fewer cognitive resources to devote to focal tasks (Hancock et al. 2007; Ramsey et al. 1983). Yet these different levels of cognitive resources also might prompt alternative thinking styles. According to cognitive–experiential self-theory (Epstein 1994), people's behavior and decisions result from both affect-laden experiential and rational-analytic systems. The former type of system is "automatic, preconscious, holistic, associationistic, primarily nonverbal, and intimately associated with affect," whereas the latter "operates primarily at the conscious level and is intentional, analytic, primarily verbal, and relatively affect free" (Epstein et al. 1996). Extensive research also shows that when people have limited cognitive resources to devote to the focal task, they engage in less cognitive but more affective processing (Finucane et al. 2000; Shiv and Fedorikhin 1999; Slovic et al. 2002). For example, Shiv and Fedorikhin (1999) find that when people have limited versus ample processing resources (e.g., memorizing 7-digit vs. 2-digit numbers while making product choices), they rely more on affective reactions to make their choices. If warm versus cool temperatures lead to a depletion of cognitive resources, then consumers in warm versus cool temperature conditions may be more likely to engage in affective processing. This prediction is supported by Cheema and Patrick's (2012) finding that warm versus cool temperatures deplete resources and encourage system I processing.

Existing research also suggests that cognitive and affective processing styles have unique strengths and weaknesses, so they are well suited to different decision circumstances. Cognitive processing, which usually involves deliberative thinking, is extensive and compensatory, involves explicit trade-offs, and traditionally has been considered the best decision-making mode (Janis and Mann 1977). The comprehensive nature of cognitive processing makes it particularly well suited for simple tasks that require people to process minimal amounts of information. In contrast, affective processing relies on simple, affective heuristics and intuition. Because of its biased aspects and lack of comprehensiveness, affective processing likely produces poorer decisions when the tasks are simple (Gilovich et al. 2002; Kahneman 2003).

A different pattern of results may apply for complex tasks. Decision-makers have limited information processing capacity, including limitations on their working memory and computational capacities. As task complexity increases (i.e., the task requires people to process more information), cognitive processing suffers due to computational errors and limited memory capacity (Bettman et al. 1998), leading to poorer decisions. In contrast, affective processing, which uses an overall impression, relies on less information and is less subject to working capacity constraints. Thus, under affective processing, decision quality is unlikely to drop as task complexity increases. Relatively speaking, as task complexity increases, affective (vs. cognitive) processing should lead to better performance. As Slovic et al. (2002, p. 400) explain, "using an overall, readily available affective impression can be far easier—more efficient—than weighing the pros and cons or retrieving from memory many relevant examples, especially when the required judgment or decision is complex or mental resources are limited."

In support of these notions, Mikels et al. (2011) empirically examine the decision quality of alternative processing styles in both simple and complex tasks. Their results indicate that affective versus cognitive processing leads to better performance in complex decisions that require people to process a large amount of information. However, this beneficial effect of affective processing disappears in simple decisions that require people to process minimal information. On the basis of this theorizing, we hypothesize that warm (vs. cool) temperatures activate affective processing, leading to better performance in complex product choices.

Although there are different ways to define task complexity (e.g., Campbell 1988; Wood et al. 1987), the consensus is that complex (vs. simple) tasks demand consumers to process a greater amount of information before reaching the final decision. Thus, in this paper, we define task complexity as the amount of information a decision-maker needs to process. A task becomes more complex with increasing numbers of alternatives or numbers of dimensions (Payne 1976).

Cheema and Patrick (2012) also reveal a moderating role of task complexity (e.g., general knowledge tests vs. complex cognitive estimation tasks) on the influence of temperature on consumer decisions. They find that because warm (vs. cool) temperatures deplete resources and thus increase system I processing, they lead to worse performance on complex tasks. On the surface, this finding seems to contradict our predictions, but we actually reason otherwise. The apparent difference arises from the calibration of the task complexity variable. The tasks that Cheema and Patrick assign to participants in their studies are "very simple" and "simple," according to the standards we apply for this research, whereas the tasks we employ in this research are "simple" and "complex." That is, the complex task that Cheema and Patrick describe would be categorized as a simple task by our standards. Thus, their finding that warm versus cool temperatures hinder complex (or simple, by our standards) tasks is consistent with our prediction and the findings we report subsequently. In this sense, we extend their research by demonstrating that for complex tasks, warm versus cool temperatures can facilitate cognitive task performance. Our research focus is primarily the effect of temperature on complex task performance. We provide more explanation and additional data to address this point in the General Discussion section.

In the following, we report a series of three studies that provide systematic support for our predictions. Study 1 establishes a basic relationship between temperature and decision quality in complex (vs. simple) decisions. Studies 2 and 3 clarify the underlying mechanism of temperature effects on complex choices.

3 Study 1

3.1 Method and procedure

Study 1 aims to test the basic hypothesis that a warm (cool) temperature facilitates cognitive performance on complex (simple) tasks. The study uses a 2 (temperature: warm vs. cool) × 2 (task complexity: simple vs. complex) between-subjects design. The focal task requires participants to select a lottery from among four options (Payne et al. 2008). For the simple (complex) task, options were defined by payoffs for four (12) equiprobable events, as determined by drawing one of four (12) numbered balls from a bingo cage. For example, in the complex task, if the numbered ball drawn from the lottery is 8 (out of 1–12) and a participant chooses option A, the payoff is $9; if the option choice is D, the payoff would be $6. In the simple task, if the numbered ball drawn from the lottery is 3 (out of 1–4) and a participant chooses option A, the payoff is $9; if the option choice is D, the payoff would be $0. Thus, the complex task requires participants to process a larger amount of information (4 options × 12 events = 48 pieces of information) than the simple task (4 options × 4 events = 16 pieces of information). Among the four options, one has the highest expected value and represents the correct answer (see Appendix 1 for the stimuli).

Eighty-nine undergraduate students from a North American university participated in this study in exchange for $10. Participants completed the study in one of two randomly assigned temperature conditions (warm, 25–26 °C/77–78.8 °F, or cool, 21–22 °C/69.8–71.6 °F; Cheema and Patrick 2012; Ijzerman and Semin 2009; Zwebner et al. 2013). These temperature conditions both fall within the comfortable temperature range (Baker and Cameron 1996; OSHA Technical Manual 2015). The study included no more than four participants per session.

On a computer screen, the instructions first explained that participants would be presented with information about four different lottery options. They had to read the information on each screen, compare the options carefully, and then choose the option they considered best. To encourage them to work diligently on the task, participants learned that after the experiment, the researcher would randomly select five participants, play the lottery options they had chosen, and give them the amount of money they had won. Next, the payoffs of the four options (16 vs. 48 pieces of information) were presented in random order, one at a time for 8 s each, on the computer screen. Participants were not allowed to take notes during the experiment. Following the presentation of the options, participants proceeded to the choice task screen, where they could spend as much time as they liked to deliberate and make their final choice.

After participants made their choices, they indicated their current mood on five items (negative–positive, bad–good, sad–happy, unpleasant–pleasant, in a bad mood–in a good mood), from 1 ("not at all") to 7 ("very much"). We then averaged these items to create an overall mood index ($\alpha = .95$), such that higher numbers indicated a more positive mood. Participants also indicated their current level of arousal on three items (aroused, comfortable, and relaxed), again from 1 ("not at all") to 7 ("very much"). The latter two items were reverse-coded. Their average produced the arousal index ($\alpha = .66$), such that higher numbers indicated greater levels of arousal. As a manipulation check, we also asked participants to indicate how warm/hot they believed the room was, on a scale from 1 ("cool/chilly") to 7 ("warm/hot"). Participants then rated their involvement in the task on five items (enjoyment, motivation, effort, difficulty, interest; $\alpha = .66$). Finally, we asked participants to guess the true purpose of the study and provide some demographic information.

3.2 Results and discussion

Manipulation check Participants in the warm condition reported feeling significantly warmer and hotter ($M_{\text{Warm}} = 5.19$, $SD = 1.19$) than those in the cool condition ($M_{\text{Cool}} = 3.97$, SD = 1.18, $t(87) = 4.88$, $p < .01$).

Lottery choice No one correctly guessed the true purpose of the study. Each person's lottery choice was coded as 1 (correct choice) or 0 (wrong choice). Using this choice measure as the dependent variable and task complexity, temperature, and their interaction term as independent variables, we ran a binary logistic regression. The results revealed significant interactions (*Wald* (1) = 5.78, $p < .05$). For the simple lottery task, a marginally significantly higher percentage of participants in the cool condition than in the warm condition chose the correct option ($M_{\text{Warm}} = 41\%$, $M_{\text{Cool}} = 71\%$; $\chi 2(1) = 2.98$, $p = .08$). For the complex lottery task, however, a marginally significantly higher percentage of individuals in the warm (vs. cool) condition ($M_{\text{Warm}} = 56\%$, $M_{\text{Cool}} = 32\%$; $\chi 2(1) = 3.06$, $p = .08$) made the correct choice, indicating better task performance. Examining the data in a different manner, we found that in the warm condition, task complexity did not affect decision quality ($M_{\text{Simple}} = 41\%$, $M_{\text{Complex}} = 56\%$; $\chi 2(1) = .86$, $p = .35$), whereas in the cool condition, participants revealed better performance for simple versus complex task ($M_{\text{Simple}} = 71\%$, $M_{\text{Complex}} = 32\%$; $\chi 2(1) = 6.286$, $p = .01$).

Mood, arousal, and involvement One-way analyses of variance (ANOVAs) revealed no treatment effects for mood, arousal, or involvement (ps > .27). To provide additional evidence that mood and arousal did not drive the effect, we ran a follow-up study, in which we measured participants' physiological arousal in different temperature conditions. Fifty undergraduate students from the same population as study 1 were randomly assigned to warm versus cool temperature conditions, in which they worked on the same lottery task. The study administrator measured these participants' heart rates and blood pressure. The results from these physiological arousal measures did not differ across the warm and cool temperature conditions (heart rate $M_{\text{Warm}} = 71.06$, $SD_{\text{Warm}} = 11.18$; $M_{\text{Cool}} = 71.14$, $SD_{\text{Cool}} = 10.41$; $p > .43$; diastolic pressure $M_{\text{Warm}} = 76.96$, $SD_{\text{Warm}} = 12.77$; $M_{\text{Cool}} = 79.20$, $SD_{\text{Cool}} = 12.46$; $p > .26$; systolic pressure $M_{\text{Warm}} = 122.32$, $SD_{\text{Warm}} = 21.50$; $M_{\text{Cool}} = 121.36$, $SD_{\text{Cool}} = 16.10$; $p > .47$). Thus, mood, arousal, and involvement do not appear to drive the observed effects.

In study 1, we replicate Cheema and Patrick's (2012) findings that cool (vs. warm) temperatures lead to better performance on simple tasks. More importantly, we extend prior research by showing that warm (vs. cool) temperatures improve performance on complex choices. As our contribution is on the effect of temperature on complex decision quality, we only focus on complex tasks in the subsequent studies.

4 Study 2

4.1 Method and procedure

Study 2 aims to replicate study 1 findings for the complex task and at the same time achieve two additional objectives. First, it tests the proposed underlying mechanism, i.e., warm temperatures prompt affective processing, which enhances performance in complex product choices. Second, it aims to provide further evidence that mood and arousal do not drive the main effect of temperature on complex task performance. Recall in study 1, we measured participants' mood and arousal after they completed the focal task. One could argue that the task might have influenced these measures. Thus, in this study, we take these measures prior to the focal task.

Eighty-seven undergraduate students from an Asian university took part in this study in exchange for $5. Upon entering the laboratory, participants were seated in the room, where the temperature was preset to be either warm or cool (warm, 25–26 °C/77–78.8 °F, or cool, 21–22 °C/69.8–71.6 °F). They were told to wait for a while, after which a research assistant would provide a detailed introduction of the experiment. Before the focal task, participants answered the mood and arousal questions from study 1. After that, the participants had to perform the complex lottery choice task from study 1. We measured their decision time during the task and also asked participants to indicate how confident they were with their decisions after they made their choices.

Next, to assess whether participants employed different modes of processing, we included a popular paradigm to distinguish analytical and affective processing, namely, the ratio-bias paradigm (Avnet et al. 2012). Specifically, participants were asked to play a hypothetical game of chance, under the guise of a purportedly unrelated study, in which they had to choose between two bowls that contained a mix of red and white jelly beans (Avnet et al. 2012; Lee et al. 2015). One jelly bean would be picked at random from the chosen bowl. If a red jelly bean was picked, the participant would earn a \$5 reward; if a white jelly bean was picked, they would not earn anything. One bowl contained 1 red jelly bean and 11 white jelly beans (small bowl), while the other contained 6 red jelly beans and 80 white jelly beans (large bowl). The larger bowl, while containing more jelly beans overall, features a smaller probability of picking a red jelly bean (approximately a 7.0% chance) compared with the small bowl (approximately an 8.3% chance). Epstein and others (e.g., Denes-Raj and Epstein 1994) demonstrate that people who approach this problem with an analytical mindset draw on their knowledge of ratios and probabilities to conclude that the small bowl is the superior choice, whereas people whose choices are guided more by affect tend to focus on frequencies and choose the large bowl instead. We reason that if participants in the warm (vs. cool) temperature condition complete the complex choice task by relying on affective processing, this processing mode will spill over to the jelly bean task and manifest as a tendency to choose the larger bowl. We thus asked participants to indicate their likelihood of choosing the smaller or larger bowl (1 = "definitely choose the smaller bowl," 7 = "definitely choose the larger bowl"). Finally, participants completed the same items related to temperature, involvement, the true study purpose, and demographics as in study 1.

4.2 Results and discussion

Manipulation check Participants in the warm condition reported feeling significantly warmer and hotter ($M_{\mathrm{Warm}} = 3.98$, $SD_{\mathrm{Warm}} = .86$) than those in the cool condition ($M_{\mathrm{Cool}} = 3.42$, $SD_{\mathrm{Cool}} = .74$, $t(85) = 3.24$, $p < .05$).

Mood, arousal, and involvement One-way ANOVAs revealed no treatment effects of mood, arousal, or involvement (ps > .24).

Decision time and decision confidence One-way ANOVAs revealed no treatment effects on decision time ($M_{\mathrm{Warm}} = 49.32$ s, $SD_{\mathrm{Warm}} = 19.97$; $M_{\mathrm{Cool}} = 52.15$ s, $SD_{\mathrm{Cool}} = 19.85$, $t(85) = .66$, $p > .25$) or decision confidence ($M_{\mathrm{Warm}} = 3.30$, $SD_{\mathrm{Warm}} = 1.66$; $M_{\mathrm{Cool}} = 3.39$, $SD_{\mathrm{Cool}} = 1.24$, $t(85) = .27$, $p > .39$) across the different temperature conditions. While prior research suggests that affective-based decision-making tends to be faster, we did not find such a difference in our study. Although we cannot know for sure, we speculate that one possible reason is the experimental setup. In our study, we presented the focal task information (one piece at a time for 8 s) and the final decision on separate pages. As such, participants might be forming their decisions when processing the product information already, thus making the difference of time spent on the last decision screen rather small.

Lottery choice No one correctly guessed the true purpose of the study. Each participant's lottery choice was coded as 1 (correct) or 0 (incorrect). Using this choice measure as the dependent variable and temperature as the independent variable, we ran a binary logistic regression. The results revealed a significant main effect of temperature (*Wald* $(1) = 4.38$, $p < .05$). As predicted, the participants' performance was significantly better in the warm than in the cool condition ($M_{\mathrm{Warm}} = 44\%$, $M_{\mathrm{Cool}} = 23\%$; $\chi 2(1) = 4.51$, $p < .05$).

Mediation effect of affective processing To test whether the effect of temperature on complex product choices is mediated by affective processing, we conducted a mediation analysis using bootstrapping (Hayes 2012). Participants in the warm condition ($M_{\text{Warm}} = 3.58$, $SD_{\text{Warm}} = 1.35$) were significantly more likely to choose the larger bowl of jelly beans than those in the cool condition ($M_{Cool} = 2.86$, $SD_{\text{Cool}} = 1.42$, $t(85) = 2.41$, $p < .05$). The indirect effect through affective processing was significant, with a point estimate of .4519, and the 95% confidence interval excluded 0 (.0600 to 1.1681). Thus, participants in the warm temperature condition presumably applied affective processing, which enhanced their performance on the complex task.

In summary, study 2 replicates the finding in study 1 by showing that a relatively warmer (vs. cooler) temperature enhances performance on complex tasks. It also provides evidence for the proposed underlying process; affective processing induced by warm temperature facilitates complex task performance. Mood, arousal, and involvement levels can be ruled out as alternative explanations.

In the next study, we aim to test the proposed process mechanism further. If warm temperatures induce more affective processing and thus enhance performance for complex choices, it follows that participants in the cool temperature condition should perform equally well on complex choices when they are prompted to engage in affective processing. However, participants in the warm temperature condition should perform poorly on complex choices when they are primed to engage in cognitive instead of affective processing.

5 Study 3

With study 3, we seek to provide further evidence that affective (vs. cognitive) processing underlies the influence of temperature on complex choices. We manipulated the type of processing directly to observe how it interacts with temperature to jointly affect complex task performance.

5.1 Method and procedure

A total of 148 undergraduate students from a large Asian university participated in the study, in exchange for \$5. The study employed a 2 (temperature: warm vs. cool) × 3 (thinking styles: affective vs. cognitive vs. control) between-subjects design. Participants were first escorted to the main lab, where the temperature was set to be either warm or cool (as in previous studies), and they worked on the complex lottery task that we described in study 1. To manipulate processing style, we instructed participants to either "rely on your feelings to guide your decisions" (affective processing condition), to "use your considered, rational analysis to guide your decisions" (cognitive processing condition), or provided no such instructions (control condition; Mikels et al. 2011). As in the previous study, participants selected their preferred option and indicated how much they relied on their feelings versus logical considerations when choosing (1 = "feelings only," 7 = "logic considerations only"; Lee et al. 2015).

5.2 Results

Manipulation check To verify that participants followed the strategy instructions in making their decisions, we applied a 2 (temperature: warm vs. cool) × 3 (thinking styles: affective vs. cognitive vs. control) ANOVAs on the self-reported measure of the extent to which they relied on their feelings or details, which revealed significant main effects of temperature ($p = .008$) and thinking styles ($p = .006$). However, the interaction between temperature and thinking styles was not significant ($p > .27$). As expected, participants in the warm condition reported more reliance on logic when assigned the logic-focus strategy ($M_{\text{Cognitive}} = 3.60$, $SD_{\text{Cognitive}} = 1.44$) rather than the feeling-focus ($M_{\text{Affective}} = 2.77$, $SD_{\text{Affective}} = 1.24$, $t(49) = 2.21$, $p < .05$) or control ($M_{\text{Neutral}} = 2.80$, $SD_{\text{Neutral}} = 1.26$, $t(48) = 2.09$, $p < .05$) strategies, though the latter difference was not significant ($t(49) = .09$, $p > .45$). Participants in the cool condition also reported more reliance on feelings when using the feeling-focus strategy ($M_{\text{Affective}} = 3.08$, $SD_{\text{Affective}} = 1.18$) instead of the logic-focus ($M_{\text{Cognitive}} = 3.96$, $SD_{\text{Cognitive}} = 1.27$, $t(46) = 2.48$, $p < .05$) or control ($M_{\text{Neutral}} = 3.88$, $SD_{\text{Neutral}} = 1.45$, $t(46) = 2.07$, $p < .05$) strategies. In this case, the difference between the logic-focus and control strategies was not significant ($t(46) = .21$, $p > .41$).

Lottery choice Using choice as the dependent variable and thinking style, temperature, and their interactions as independent variables, we ran a binary logistic regression, which revealed a significant interaction of temperature and thinking style (*Wald* $(1) = 5.03$, $p < .05$). To gain further insights, we split the data according to thinking styles. In the control condition, the findings replicate studies 1 and 2: With choice as the dependent variable and temperature as the independent variable, a binary logistic regression reveals a significant main effect of temperature (*Wald* $(1) = 4.67$, $p < .05$). Significantly more people in the warm (vs. cool) condition made the right choice ($M_{\text{Warm}} = 56\%$, $M_{\text{Cool}} = 25\%$; $\chi 2(1) = 4.87$, $p < .05$).

Next, we focused on those in the affective prime condition. Using choice as the dependent variable and temperature as the independent variable, we ran a binary logistic regression. The effect of temperature was not significant (*Wald* $(1) = .32$, $p > .50$). As expected, participants in the cool and warm temperature conditions exhibited comparable levels of performance on complex tasks ($M_{\text{Warm}} = 54\%$, $M_{\text{Cool}} = 46\%$; $\chi 2(1) = .32$, $p > .57$). These results support our prediction that affective processing enhances performance on complex tasks for those in the cool temperature condition. However, for participants in the warm temperature condition, who already had been prompted to engage in affective processing, performance is not affected by the thinking style manipulation.

Similarly, for consumers in the cognitive prime condition, using choice as the dependent variable and temperature as the independent variable, we ran a binary logistic regression. The effect of temperature was not significant (*Wald* $(1) = 1.10$, $p > .29$). As expected, participants in the cool and warm temperature conditions exhibited comparable levels of performance on complex tasks ($M_{\text{Warm}} = 20\%$, $M_{\text{Cool}} = 33\%$; $\chi 2(1) = 1.12$, $p > .29$). These results support our prediction that when consumers in the warm condition are encouraged to use cognitive instead of affective processing, the beneficial effect of warm temperatures no longer arises.

5.3 Discussion

The findings from study 3 provide further evidence in support of our proposed process explanation that affective processing is the source of the beneficial effect of warm temperatures on complex task performance. When people in the cool temperature condition were prompted to engage in affective processing, they performed as well on a complex task as their warm condition counterparts. However, when consumers in the warm condition were prompted to use cognitive instead of affective processing, the beneficial effect of warm temperatures disappeared.

6 General discussion

Across three studies, we have tested the hypothesis that ambient temperature, within a comfortable range, can affect decision quality in complex choices. Specifically, people functioning in relatively warm temperatures perform better than those in relatively cool temperatures on complex product choices. Consistent with our theorizing, a higher percentage of people in the warm temperature condition chose the correct option in the complex lottery (study 1). By measuring and manipulating thinking styles, studies 2 and 3 provide support for the proposed underlying process, namely, that affective processing prompted by warm temperatures helps people perform better in complex choices.

Our findings thus offer several theoretical contributions. First, they add to literature on ambient temperature and consumer decision-making by illustrating how even temperature within a comfortable range can significantly affect consumers' decision quality in comparably complex product choices. As we have mentioned, Cheema and Patrick (2012) also note a moderating role of task complexity in the relationship between temperature and consumer decisions. They find that for complex tasks, warm (vs. cool) temperatures hurt complex task performance, which seems to contradict our results at first glance. However, as we argued earlier, this contradiction actually reflects the calibration of complexity. Their complex task (e.g., in their study 1, participants saw 25 pieces of information in a gamble task) is comparable to our simple task. We thus extend their insights by demonstrating that for more complex tasks (e.g., our study 1 participants processed 48 pieces of information in the gamble task), the warm (vs. cool) temperature can lead to better decisions. According to our theorizing, we would also predict that there should be no temperature effect for really simple tasks. We designed a study to validate this claim. Fifty-six undergraduate students from the same population as all the studies completed this study in either a warm or cool temperature condition. To create the really simple task, we modified the simple lottery task used in study 1. Specifically, the lottery options were defined by payoffs for two equiprobable events, as determined by drawing one of two numbered balls from a bingo cage, so altogether the participants only need to process eight pieces of payoff information (see Appendix 2 for stimuli). After being exposed to the eight pieces of information, participants were required to choose the best option. Results showed that participants in both temperature conditions performed equally well in finding the correct choice ($M_{\text{Warm}} = 79\%$, $M_{\text{Cool}} = 71\%$; $\chi 2(1) = .38$, $p > .25$). It confirms the finding in Cheema and Patrick's paper that warm temperatures do not hamper performance on really simple tasks (i.e., "simple task" in their paper). Taken together, it suggests that warm temperature will have a beneficial effect on complex rather than simple cognitive tasks.

Furthermore, we explain why these effects occur, by providing empirical evidence of the underlying process. Affective processing, prompted by relatively warm (vs. cool) temperatures, underscores the beneficial effects of warm temperature on complex choices.

Prior research also has suggested a link between temperature and aggression (Anderson 1989; Larrick et al. 2011), but these effects mainly arise when temperatures are uncomfortable, such that extreme heat evokes negative affect (e.g., anger) and greater arousal, which prompts higher levels of aggression. In our research, we focus on ambient temperatures in a comfortable range, and these results indicate no significant differences between people in cool and warm temperature conditions in terms of their affect/mood or arousal levels. In this sense, our results extend understanding of the influence of temperature on consumers' behavior in conventional, comfortable ranges.

In turn, these findings have important practical implications for setting optimal temperatures in various contexts. In real life, consumers face decisions with varying degrees of complexity, from simple everyday purchases (e.g., toothpaste) to complex decisions (e.g., investing in stocks). According to prior research, when the focal task is simple and requires high accuracy, cooler temperatures are ideal. However, the findings from our studies indicate that when consumers confront complex tasks, warmer temperatures are more beneficial. If possible, retailers should set temperature levels in their stores according to the complexity of the choices that their consumers make. If retailers want to promote better understanding of fairly complex products, a relatively warm temperature is appropriate. Consumers also might adjust their sense of the temperature by themselves to match different decision types, such by changing clothing in the store or setting optimal room temperatures when shopping online. Retailers thus must be cautious about the complex influence of temperature when selecting optimal temperatures for their stores; they even could consider varying the temperatures at different locations. Note that Cheema and Patrick (2012) also show that depleted cognitive resources leave consumers less motivated to make complex decisions in warm (vs. cool) temperature settings. So on the one hand, warm temperatures may make consumers less likely to make decisions (motivational effect), but on the other hand, it can benefit their performance once those consumers decide to make a choice. As the motivational effect was already examined by Cheema and Patrick, our focal interest was on how temperature affects the ability to make better decisions in complex tasks, and therefore, we did not include the "no choice" option in our studies. However, if we gave consumers a no-choice option, the results may be different, and this is something worthy of future investigation.

Finally, this study offers several avenues for further research. In particular, we define task complexity as the amount of information a decision-maker needs to process. However, other dimensions contribute to task complexity too, such as the level of ambiguity. Additional research could examine whether the results we observe can be extended to other types of complex tasks. Further, consumers under different cultures may have different standards for "normal temperature" (e.g., mall temperatures in China are set at 79 °F; however, typical mall temperatures in the USA are at 72 °F or lower). Future research may want to examine the settings of warm (vs. cool) temperatures in different cultures. These and many other questions await further investigation.

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Appendix 1: Stimuli for study 1

Table 1 Lottery information, simple choice task

Option	Event (number rolled)				Expected value
	1	2	3	4	
A	0	0	9	14	$5.75
B	0	2	7	9	$4.50
C	0	0	7	10	$4.25
D	0	0	0	6	$1.50

Table 2 Lottery information, complex choice task

Option	Event (number rolled)												Expected value
	1	2	3	4	5	6	7	8	9	10	11	12	
A	0	0	0	0	0	0	8	9	10	12	14	16	$5.75
B	0	0	0	2	3	4	5	6	7	8	9	10	$4.50
C	0	0	0	0	0	0	3	5	6	7	14	16	$4.25
D	0	0	0	0	0	0	0	0	0	2	4	12	$1.50

Appendix 2: Stimuli for rather simple lottery choice task

Table 3 Lottery information, rather simple choice task

Option	Event (number rolled)		Expected value
	1	2	
Luxor	5	6	$5.50
Rio	3	5	$4.00
Platinum	3	4	$3.50
Sahara	0	1	$0.05

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