Make It Hot? How Food Temperature (Mis)Guides Product Judgments

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Despite being a basic food property, food temperature has been largely neglected by consumer research thus far. This research proposes that consumers spontaneously infer that warm foods contain more calories, an unexplored lay belief we named the "warm is calorie-rich" intuition. Eight studies reveal that this deep-seated intuition has powerful implications in terms of guiding (and often biasing) product judgments and consumption decisions. Temperature-induced calorie inferences are rooted in perceptions that warm foods are more filling and tastier than cold ones, which enhance warm foods' desirability and affect consumer choices. The preference for warm products is mitigated when food energy does not provide utility to consumers though, such as when consumers have a health goal active, and it reverses when consumers purposefully aim to reduce their calorie intake. The "warm is calorie-rich" intuition is important for marketers and managers because warm food temperatures can increase willingness to pay (by 25%) and amount served (+27%), as well as influence consumer preferences. This intuition also has important public policy implications: consumers tend to underestimate the nutritional value of cold foods, resulting in increased consumption of calories (+31%) and fat (+37%).

Keywords: product judgment, temperature, willingness to pay, attribute inferences, intuitive judgments, lay beliefs

In 2012, Starbucks partnered with Le Boulanger and began offering a new line of sandwiches and breakfast pastries, served warm. The initiative improved overall food sales by 20%, at a restaurant primarily known for its coffee (Kell 2016). This raises the question of why the strategic decision to include warm options was so successful. We posit that one potential reason for the success is that consumers judge and consume food items differently if they are served warm instead of cold. Food temperature is a central aspect of human nutrition, often stressed in marketing communication (e.g., cold vs. hot starters, depictions of steam in advertisements or on packaging). Yet despite the importance of food temperature from historical, nutritional, and marketing standpoints, research has been surprisingly silent on the impact of food temperature for the marketing of food products and related services.

In response, this research aims to examine how associations with food temperature might shape product evaluations and consumption decisions. We propose that people have internalized a food temperature intuition that manifests spontaneously when they evaluate or choose food products—the "warm is calorie-rich" intuition. This inferential belief that warm foods are more calorie-rich than

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cold ones is rooted in perceptions that warm food is more filling and tastier. Because humans digest cooked food better than raw food, such that they extract more energy from cooked foods (Carmody and Wrangham 2009; Clifford 1930; Kingman and Englyst 1994), the consumption of warm foods for main meals is a common, cross-cultural practice (Wrangham and Conklin-Brittain 2003). Such learned experiences with food temperature prompt people to perceive warm foods as more filling and make related assumptions about their nutritional value and calorie content. Warmer temperatures also physiologically improve food tastiness perceptions (Cruz and Green 2000), which could be linked to calorie richness too (Raghunathan, Naylor, and Hoyer 2006). These core dimensions of food judgments—perceptions of how filling and tasty a food is—in turn evoke a "warm is calorie-rich" intuition and potentially augment the desirability of warm products, with important implications for consumers' choices, consumption, and willingness to pay.

With eight studies using different samples (i.e., MTurk workers, Prolific workers, undergraduate students, and consumers), including two studies measuring actual behavior, we establish that consumers hold a deep-seated, heuristic belief that warm food products contain more calories than cold ones. Also, we show that this intuition affects their consumption behavior and can bias their consumption decisions. For example, consumers may underestimate the food energy available in cold food options, resulting in increased consumption of calories, fat, and carbohydrates. Although the "warm is calorie-rich" intuition is widely prevalent and independent of other food beliefs, its consequences depend on whether food energy (calories) provides utility to consumers. That is, the temperature effect on product choice may be mitigated or even reversed if a health or a dieting goal is active during consumers' judgment.

These findings provide several contributions to theory and practice. First, we contribute to the literature on lay beliefs (Haws, Reczek, and Sample 2016; Mai and Hoffmann 2015) by introducing a powerful, widely ignored intuition about food temperature, which is a basic element of human nutrition. Second, we present multifaceted consequences of the "warm is calorie-rich" intuition and its managerial relevance. Managers can use product temperature strategically to enhance product desirability and consumers' willingness to pay (by adding warm cues or changing a product's temperature). Third, from a public policy perspective, the intuition can be closely linked to the fight against obesity, in that it can misguide consumers to believe that cold foods contain fewer calories than warm ones, resulting in additional and increased calorie consumption (Chernev 2011; Scott et al. 2008). Furthermore, this intuition could be leveraged to optimize perceptions of healthy food, such as by adding a warm component to a usually cold product (e.g., salad) to increase its appeal.

CONCEPTUAL BACKGROUND

When judging products and forming decisions, consumers often resort to commonsense explanations to simplify their thinking (Haws et al. 2016; Luchs et al. 2010; Raghunathan et al. 2006). Such heuristic judgments are grounded in previous experiences, knowledge, or intuitive beliefs about the world. Intuitions can be generated internally through personal experience, such as physical or physiological body reactions (Raghunathan et al. 2006; Ross and Nisbett 2011), or externally, from environmental cues and formed habits (Morris, Menon, and Ames 2001). This research proposes that both internal and external sources may underlie the "warm is calorie-rich" intuition, due to the basic objectives of food intake: the fundamental needs to satisfy hunger (eating and drinking are metabolic requirements for human survival) and to achieve sensory pleasure in the form of taste experiences (Glanz et al. 1998; Lowe and Butryn 2007).

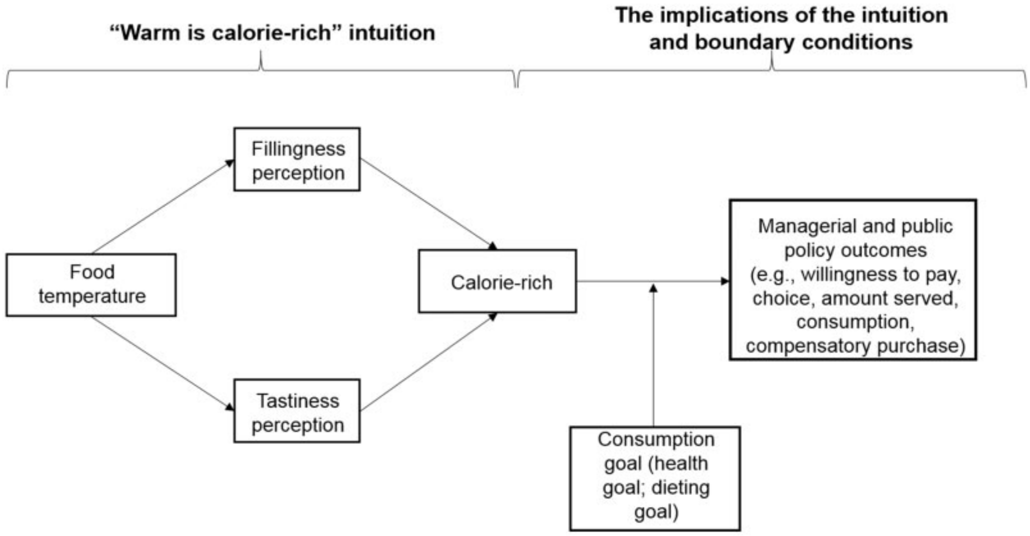
Specifically, we propose that consumers judge warm foods as more calorie rich because they consider warm foods more filling and/or tastier than cold ones. Our theory builds on previous interdisciplinary research that provides accumulative, coherent evidence of the physiological and social impact of heating food on humans' food habits. First, humans extract more energy from heated foods than from raw foods, which is reflected in eating habits and social behaviors. The main meals in most cultures include warm components, whereas cold items are generally associated with snacks, starters, or light meals (Andersson et al. 2003; Jaeger, Marshall, and Dawson 2009; Richter et al. 2012; Roos and Prättälä 1997). Second, food temperature physiologically alters sensory perceptions, such that people perceive warm foods as more palatable than cold ones (Bartoshuk et al. 1982; Cruz and Green 2000; Guest et al. 2007; Rolls 2010; Talavera et al. 2005). Accordingly, we propose that the temperature-induced inferences are based on two distinct mechanisms; each of which contributes incrementally to the development of the "warm is calorie-rich" intuition (figure 1). Next, we discuss the theoretical mechanism of the proposed association between food temperature and calorie content rooted in both tastiness and fillingness perceptions (i.e., how filling a food is perceived to be).

Warm Food Is More Filling than Cold Food

The process of food preparation, and in particular cooking (i.e., the act of applying heat to food to transform it), is an essential element of the human diet. The capacity to heat and cook food was one of the key consequences of the discovery of fire and represented a significant turning point in human development. From a historical perspective, paleontologists claim that more than 250,000 years ago, heat allowed hunters to defrost meat, which helped ensure

FIGURE 1

CONCEPTUAL FRAMEWORK



human survival (Brace 1995). Accumulated evidence from interdisciplinary research also demonstrates that the capacity to heat food offers significant nutritional advantages to consumers. Cooking food can denature proteins, break proteins' complex chains, and increase the speed of digestion (Bax et al. 2012). Because it breaks down food fibers and amino acids, heating increases the variety of foods that humans can digest (Wrangham et al. 1999), such as vegetables or meat, which in their raw state can have a suboptimal consistency or contain too much fiber, making them difficult to digest (Clifford 1930; Stahl et al. 1984). Accordingly, heating food improves the absorption of food nutrients and augments the amount of energy obtained (e.g., by up to 35% for starch; Carmody and Wrangham 2009).

Presumably for these reasons, food preparation and particularly cooking are core elements of eating habits and prevalent social behaviors, shared cross-culturally (Wrangham and Conklin-Brittain 2003; Wrangham et al. 1999). Although today fewer people eat three main meals daily, as was common prior to the Industrial Revolution (Douglas and Nicod 1974), the habit of eating warm meals has persisted, even if reduced to one or two meals per day. Warm main meals combined with snacks remain a dominant eating habit in many countries (Andersson et al. 2003; Jaeger et al. 2009), and most people have at least one main meal with warm components as their most substantial and filling meal of the day (Richter et al. 2012; Roos and Prättälä 1997). Warm ingredients, thus, tend to be associated with main meals, such as dinner and lunch (Bugge and Døving 2000; Jaeger et al. 2009). Considering the essential role of such eating habits in social life and the fact that most meals eaten with the purpose of achieving satiety are warm across cultures, we anticipate that strong associative links between food temperature and its capacity to provide fullness (i.e., filling properties) are anchored in human minds. Beyond the ability to satisfy hunger, we expect that food temperature affects the sensory experience of tastiness, which is also closely linked to calorie content.

Warm Food Is Tastier than Cold Food

Research in multiple disciplines shows that food temperature elicits direct physiological and sensory responses. Even if other food traits (e.g., texture, mouthfeel) remain unchanged, cooked food is preferred over raw food (Wobber, Hare, and Wrangham 2008) and this preference relates to consumers' experience of warm foods' sensory properties. Food temperature thus affects consumers' taste perceptions (Bartoshuk et al. 1982; Cruz and Green 2000; Talavera et al. 2005). Warm liquids, for example, activate the insular taste cortex (identified by glucose taste stimuli), improving pleasantness perceptions (Rolls 2010). For coffee, warmer temperatures alter its sensory properties and product perceptions (Adhikari, Chambers, and Koopel 2019). Cooking also increases the availability of glutamate, responsible for taste preferences (Sasaki, Motoyama, and Mitsumoto 2007), and this intra-oral pleasantness evoked by warm food is represented in brain activity (Guest et al. 2007). These complementary lines of evidence indicate that the act of heating alters food properties and their sensory experience, in ways that tend to make warm food appear tastier and more enjoyable than cold food. These physiological reactions may have psychological consequences, anchoring generalized beliefs about the tastiness of warm food in consumers' minds. Given that both fillingness and tastiness perceptions of warm foods are deeply rooted and are activated spontaneously, we propose that they also may prompt thoughts about less concrete properties that are difficult for humans to form, such as naive assumptions about calorie richness.

The "Warm Is Calorie-Rich" Intuition

Consumers often rely on intuition and subjective judgments to facilitate their product evaluations or infer hidden or missing attributes of services or products, especially in food consumption contexts (Dijksterhuis et al. 2005; Haws et al. 2016; Zlatevska, Dubelaar, and Holden 2014). For example, when calorie information is unavailable or consumers are not motivated to search for it, they might resort to inferential beliefs about the nutritional advantage of heated foods. Concrete (experience) properties, such as taste, are processed faster than more abstract (credence) qualities that need to be inferred (Sullivan et al. 2015). It is thus natural that humans' initial reactions relate to tastiness and fillingness expectations (i.e., how filling a food is expected to be), which in turn influence subsequent impressions of a product's calorie content—a food property that humans have a hard time detecting or sensing (Chernev and Gal 2010; Oakes 2005).

The notion that these initial impressions serve as bases for temperature-induced calorie inferences aligns with observations that both tastiness (Raghunathan et al. 2006) and fillingness (Suher, Raghunathan, and Hoyer 2016) perceptions are associatively linked with product healthiness and, therefore, calorie judgments. Due to these naive perceptions that warm food is more filling and/or tastier than cold food, consumers likely assume that warm foods are also more calorie-rich than cold ones and make decisions accordingly. We refer to this intuitive belief as the "warm is calorie-rich" intuition. Our theory proposes that the mere fact of serving or labeling a product as warm (vs. cold) may lead consumers to assume it is more calorie-rich.

> **H1:** Food products that are warm (vs. cold) are inferred to be more calorie-rich.

Downstream Consequences of the Intuition

As with all heuristics, this intuition can be valid, but it also can misguide consumers and lead to errors. Notably, heating food improves human digestion and alters sensory properties, but serving an item warm or cold does not change its actual calorie content. Consumers thus may erroneously rely on the product serving temperature or temperature labels as heuristic cues of foods' calorie content, which would produce biased conclusions. Therefore, we investigate the implications of temperature cues for consumers' downstream decisions.

This research is particularly interested in the managerial consequences of the "warm is calorie-rich" intuition, which extend beyond calorie inferences and may guide consumption behaviors. More specifically, we posit that calorie inferences will shape managerial outcomes, such as willingness to pay, choice, and amount served or consumed. Temperature is a key property of the offerings provided by restaurants and supermarkets, so the intuition likely influences many daily consumption decisions. Prompted by the "warm is calorie-rich" intuition, initial assessments of a warm or cold product likely shape the perceived utility and value of consumption.

From a nutritional perspective, calories contribute the energy needed for survival and daily activities (Koebnick et al. 1999). Eating behaviors are motivated by the positive-incentive value of food (Bolles 1990; Hetherington and Rolls 1996; Toates 1981), and humans show a natural liking for foods that are rich in energy (Pinel, Assanand, and Lehman 2000). This innate preference develops early in life; newborns value calorie-rich foods that help ensure their survival (Ventura and Worobey 2013). Likewise, many consumers perceive calorie-rich items as intrinsically more valuable than calorie-poor ones (Laran and Salerno 2013) and associatively link calorie richness with resourcefulness in their minds (Salerno and Sevilla 2019), even if they live in wealthier societies where higher calories also appear somehow "sinful" (e.g., obesity associated). For example, Chandon and Wansink (2007) demonstrate that when consumers receive a low-calorie main dish, they often purchase additional side items in a form of calorie compensation, leading to greater overall calorie intake. Therefore, we predict that temperature-induced perceptions of a product's nutritional value (in the form of calorie inferences) guide downstream decision-making. Temperature-induced calorie inferences can prime overall product desirability and determine whether consumers prefer a particular food, as well as how much they value it, and thus how much they buy and pay for it.

Consumers' willingness to pay is driven by the perceived utility of consumption (Van Doorn and Verhoef 2011), which in this case derives from the product's inherent capability to provide energy. Prompted by perceptions that warm foods are tastier and more filling, assumptions about a product's calorie richness should be associated with being a "richer product" in terms of nutritional value and thus of greater consumption utility to consumers. Our theory proposes that the increased nutritional value inferred from product temperature translates into perceived monetary value (temperature → nutritional value → monetary value). Because consumers infer that warm foods provide more energy (higher calorie content), they should favor warm options and pay more for them, compared with the same food served cold.

> **H2a–c:** Temperature-induced calorie inferences lead consumers to (a) be willing to pay more, (b) serve themselves more, and (c) favor warm food relative to cold food.

Boundary Conditions of the Intuition's Consequences

From a marketing perspective, we seek to define conditions in which the "warm is calorie-rich" intuition has the greatest impact. Although this intuition may be widespread and generally internalized, its consequences affect consumers in various ways, particularly depending on whether they derive more value from greater food energy (i.e., more calories). For some consumers, more calories and greater food energy does not entail greater value. Approximately 50% of Americans were on a diet at some time in the last few years (Ducharme 2018), and for these consumers, greater nutritional value and extra calories do not provide utility. Instead, they purposefully search for products with reduced energy (i.e., low calories; Kozup, Creyer, and Burton 2003; Scott et al. 2008) and the "warm is calorie-rich" intuition would not improve product desirability. Therefore, the consequences of the intuition (though not the intuition itself) may be moderated by people's consumption motivation.

Decision-making depends on the goals being pursued through consumption (Dhar and Wertenbroch 2000; Gould 1988; Hirschman and Holbrook 1982), especially in food contexts (Okada 2005; Raghunathan et al. 2006; Scott et al. 2008; Shiv and Fedorikhin 1999). The implications of the "warm is calorie-rich" intuition thus might be offset if calories do not provide utility for consumers' goal pursuit. When consumers pursue health or dieting goals, greater nutritional value implies extra calories and does not provide utility or help them achieve their goals. At the limit, warm temperatures may even appear unfavorable, because the inferred increase in calories is counterproductive to goal pursuit (Johnson, Pratt, and Wardle 2012). We propose that consumers pursuing health or dieting goals still hold and use temperature-related inferences, but they do so differently (Michaelidou and Hassan 2008). The "warm is calorie-rich" intuition can still be misleading if consumers underestimate the calories of cold foods and, thus, engage in unintentional increased calorie consumption (Chandon and Wansink 2007; Chernev 2011; Scott et al. 2008).

> **H3a, b:** The positive effect of warm (vs. cold) food temperature on product choice is mitigated (or reversed) when (a) health or (b) dieting goals are active during consumption judgments.

OVERVIEW OF STUDIES

We test our predictions with eight studies (table 1). Two pilot studies (studies 1A and 1B) consider whether consumers have internalized the "warm is calorie-rich" intuition. Study 2 shows that the fillingness and tastiness perceptions of warm products lead to calorie inferences, which influence willingness to pay. In study 3, we explore another downstream consequence of food temperature, namely, the amount served. As tests of the boundary conditions, studies 4A and 4B reveal that preferences for warm food are mitigated and even inverted when health or diet goals are active. In study 5, we rule out alternative explanations for the temperature effect on calorie inferences and willingness to pay. Finally, in study 6, we illustrate some public policy consequences of the "warm is calorie-rich" intuition. Specifically, the intuition can provoke an increase in consumption. We show that the consumption of a cold fish (inferred to provide less energy) may nudge consumers to choose more side options, leading to more overall calories purchased. Two of our studies were preregistered at the Open Science Framework (i.e., studies 1B and 4B, see the web appendix for further details and additional studies).

PILOT STUDY 1A: THE WARM IS CALORIE-RICH IMPLICIT ASSOCIATION

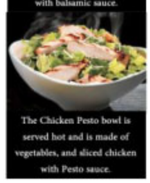
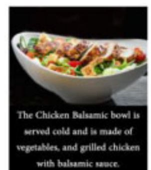
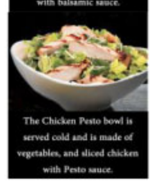
Study 1A aims to establish the implicit association between food temperature and calorie expectations. We assess the extent to which people subscribe to the "warm is calorie-rich" intuition with a computer-based reaction time test, the implicit association test (IAT, Greenwald, McGhee, and Schwartz 1998). The IAT is grounded in the notion that it is easier for people to sort stimuli into categories that are closely associated in their minds than categories that are weakly associated. Faster pairings (i.e., faster response times) imply that the concepts are more closely associated. We expect that participants react faster when "warm" and "calorie-rich" concepts are paired rather than when "cold" and "calorie-rich" are paired. This study also aims to show that the intuition holds across consumer segments (e.g., different health orientations).

Participants and Procedure

Four hundred sixty-seven Amazon Mechanical Turk workers (M_{age} = 41.9 years, SD = 12.9, 59.5% females) participated in this study for monetary compensation. To measure the strength of consumers' associations between target concepts and attributes, the IAT requested that participants categorize stimuli that represent the target concepts, of warm (e.g., words *fire*, *warm*, *heat*) and cold (e.g., *ice*, *snow*, *cool*), as well as pictures representing calorie-rich (e.g., ice cream, cola) and calorie-poor (e.g., fruits,

TABLE 1

OVERVIEW OF THE STUDIES OBJECTIVES AND STIMULI

	Objective	Method	Product	Warm condition	Cold condition
Establishing the "warm is calorie-rich" intuition					
Pilot 1A	Automaticity of the intuition	Implicit Association Test[a]	—		
Pilot 1B	Fillingness and tastiness perceptions as the source	Experiment: temperature label (cold vs. warm)[a]	Food bowl	*A product made of layers of potato, mushrooms, and vegetables served HOT*	*A product made of layers of potato, mushrooms, and vegetables served COLD*
The managerial consequences of the intuition					
Study 2	Impact on willingness to pay	Experiment: actual food temperature (cold vs. warm)[b]	Bread		
Study 3	Impact on product consumption (amount served)	Experiment: actual food temperature + label (cold vs. warm)[c]	Popcorn	 Please be careful because the tray might be hot and heavy	 Please be careful because the tray might be cold and heavy
Boundary conditions offsetting the intuition's consequences					
Study 4A	Reliance on the intuition for a product choice	Experiment in the field: 2 (health goal: active vs. not active) × 2 (temperature: cold vs. warm)[c]	Snack		
Study 4B	Dieting goal as a boundary condition	Experiment: 2 (dieting goal: active vs. not active) × 2 (temperature: cold vs. warm)[a]	Salad bowl dish	 	 
Exclusion of alternative accounts and public policy implications					
Study 5	Potential alternative explanations for the temperature effect	Experiment: temperature cue (present vs. absent)[a]	Main dish		
Study 6	Temperature-elicited side effect on increased calorie consumption	Experiment: temperature cue (present vs. absent)[a]	Main dish		

[a]Data collected in United States.
[b]Data collected in Brazil.
[c]Data collected in France.

water) foods. Purposefully, two of the product stimuli in both calorie-rich and calorie-poor categories are foods typically served warm, while the others are typically served cold (see appendix A for details). To sort the stimuli (words or pictures) into categories, which appeared on the left and right sides of the screen, participants pushed one of the two keys (right I, left E).

The IAT measures implicit associations across seven blocks of sorting tasks. In the first two tasks, participants practiced categorizing the stimuli into target concepts (warm vs. cold) and attributes (calorie-rich vs. calorie-poor) separately. Blocks 3 and 4 were the first critical blocks for the analysis, in which participants had to sort the target concepts and attributes simultaneously, such as the labels *cold* and *calorie-rich* together on the left-hand side, with *warm* and *calorie-poor* together on the right. In the fifth block, the positions of the labels switched (i.e., *cold* on the right, *warm* on the left) and participants practiced the sorting. For blocks 6 and 7, participants again categorized the stimuli into their categories, but this time, the labels presented compatible concept–attribute combinations (e.g., *warm* and *calorie-rich* on the same side). The order of compatible and incompatible blocks was counterbalanced across participants. We measured the reaction times for the compatible and incompatible tasks and calculated their differences (i.e., the *D*-score) to indicate the strength of the implicit association. The instructions asked participants to do the sorting as fast as they could, so the instrument taps intuitive modes of thinking and measures automatic associations held at implicit levels.

To test our proposition that the "warm is calorie-rich" intuition is deeply grounded and held independently of other beliefs about food, we gathered additional information from participants, after the IAT task, about their health consciousness (four items; e.g., "I reflect about my health a lot," Cronbach's $\alpha = .91$), food involvement (three items; e.g., "I think much about food each day," $\alpha = .78$), and warm food consumption habits (two items; e.g., "I often eat warm food as my main meal," $r = .80$), using 7-point scales. We also measured their level of dietary restraint (five items, 5-point scale; e.g., "How often are you dieting?," $\alpha = .74$), their explicit belief in the association between food temperature and calorie content (four items, 7-point scale; e.g., "Warm food is more calorie-rich than cold food," $\alpha = .93$), and sociodemographic traits. Appendix B contains the full measures.

Results and Discussion

To avoid potential biases associated with personal error, we followed common procedures (e.g., Fiedler and Bluemke 2005; Maison, Greenwald, and Bruin 2004) and excluded 28 participants whose error rates exceeded 30%, leaving a sample of 439 participants ($M_{\text{age}} = 42.5$ years, SD = 12.95, 60.1% females). The results revealed that response times for the compatible block (warm and calorie-rich) were shorter ($M = 1{,}071.2$ milliseconds) than for the incompatible block ($M = 1{,}230.7$ milliseconds, $p < .001$). The IAT *D*-score (Greenwald, Nosek, and Banaji 2003) thus indicates a significant "warm is calorie-rich" intuition ($M_{D\text{-score}} = 0.33$, SD = 0.50; $t(438) = 13.62$, $p < .001$), in support of hypothesis 1.

When assessing the pervasiveness of the intuition according to participants' characteristics, we observed that it was consistently significant, across all four quartiles of health consciousness (all $D > .31$, $p < .001$), food involvement (all $D > .24$, $p < .003$), warm food consumption habits (all $D > .26$, $p <. 001$), dietary restraint (all $D > .27$, $p < .001$), and gender (all $D > .31$, $p < .001$). Congruent with prior literature that indicates explicit and implicit subscriptions to an intuition can diverge (Mai and Hoffmann 2015), we found that the implicit intuition was also present for participants who explicitly denied believing in it (i.e., scored < 3 on the 7-point reported intuition belief scale; all $D > .27$, $p < .001$; see web appendix A). That is, consumers hold the "warm is calorie-rich" intuition implicitly even when they are not aware of or explicitly reject it. In summary, the "warm is calorie-rich" intuition is widespread among individuals and sometimes unrecognized.

PILOT STUDY 1B: EVIDENCE OF TWO DISTINCT MECHANISMS

Study 1B tests whether consumers rely on temperature cues to draw conclusions about the calorie content of a product, as well as whether calorie inferences are rooted in tastiness and fillingness perceptions. As indicated by our conceptual framework, we expect that consumers perceive warm food as more filling and tastier, and therefore more calorie-rich, than cold food.

Participants and Procedure

Five hundred two MTurk workers located in the United States participated in a one-factor, two-level (warm vs. cold) between-subjects experiment. In this and all following studies, we purposefully selected ambiguous products (e.g., bread, bowl with vegetables) that can be consumed both warm and cold. Consumers reviewed and evaluated food products offered on a restaurant menu. To lend credibility to the cover story, consumers judged two filler products before being exposed to the target product, called Nalabowl. We unobtrusively manipulated the temperature of the food by informing participants that the food bowl was served hot or cold, along with some other information (table 1). Participants then assessed the product's calorie content with three measures: an open question (i.e., "How many calories do you believe this dish has?") and two bipolar items ("This dish is" not at all calorie-rich–very calorie-rich" and "In my opinion, the amount of calories in the dish I saw is" low–high; seven-point scales). Because of their different formats, we standardized the three items and averaged them to form a single calorie-rich score ($\alpha = .80$). Participants also provided their perceptions of whether the bowl was filling (i.e., "I would rate this dish as" not at all filling–very filling; not at all satiating–very satiating; not at all nourishing–very nourishing; $\alpha = .76$) and tasty (i.e., "I believe this dish is" not at all tasty–very tasty; not at all pleasurable–very pleasurable; not at all delicious–very delicious; $\alpha = .97$) all measured with 7-point scales. Next, participants answered the temperature manipulation check question (i.e., "The dish I saw was" cold–warm). The questionnaire featured attention check questions, and we excluded 10 inattentive participants who failed one of the attention checks, as well as four participants identified as outliers (Mahalanobis distance >16.3), leaving a final sample of 488 participants (M_{age} = 39.86 years, SD = 12.81, 53.7% females).

Results and Discussion

A *t*-test confirmed that the temperature manipulation was successful. Participants in the warm condition judged the product as warmer than those in the cold condition ($M_{warm} = 6.47$ vs. $M_{cold} = 1.52$; $t(486) = 45.67$, $p < .001$). Regarding calorie inferences, another *t*-test revealed that consumers inferred the product to be more calorie-rich in the warm condition than in the cold one (standardized score: $M_{warm} = 0.078$ vs. $M_{cold} = -0.075$; $t(486) = 2.01$, $p = .045$), again supporting the existence of the "warm is calorie-rich" intuition.

Regarding the sources of this inference, participants judged the warm product to be tastier ($M_{warm} = 5.49$ vs. $M_{cold} = 4.46$; $t(486) = 7.62$, $p < .001$) and more filling ($M_{warm} = 5.64$ vs. $M_{cold} = 5.13$; $t(486) = 5.35$, $p < .001$) than the cold one. To test our proposition that calorie inferences are rooted in fillingness and tastiness perceptions, we ran a parallel mediation model (10,000 samples, Hayes 2018) with the temperature manipulation as the independent variable and fillingness and tastiness perceptions as mediators predicting calorie inferences. We found significant mediating effects of both fillingness (ab = 0.051, confidence interval $[CI]_{95\%}$: 0.003; 0.108) and tastiness (ab = 0.056, $CI_{90\%}$: 0.002; 0.112) perceptions on calorie inferences. That is, the "warm is calorie-rich" intuition was driven by both fillingness and tastiness perceptions and the two mechanisms were incremental and unique (i.e., additive in nature). Note that the correlation between both constructs in all our studies is rather weak ($r = .436$), supporting the distinctiveness of the two mechanisms. A follow-up study (web appendix B) supports our theory that temperature-driven calorie inferences are automatically activated by showing that the extent to which people rely on a temperature cue to infer calorie content depends on their subscription to the "warm is calorie-rich" intuition, as assessed in pilot study 1A.

STUDY 2: THE IMPACT OF TEMPERATURE-INDUCED INFERENCES ON WILLINGNESS TO PAY

Study 2 extends the "warm is calorie-rich" intuition investigation to actual product temperatures in the field. We again expect participants to judge the same product (here, bread) as more calorie-rich when it is served warm (vs. cold), and these inferences should translate into greater willingness to pay.

Participants and Procedure

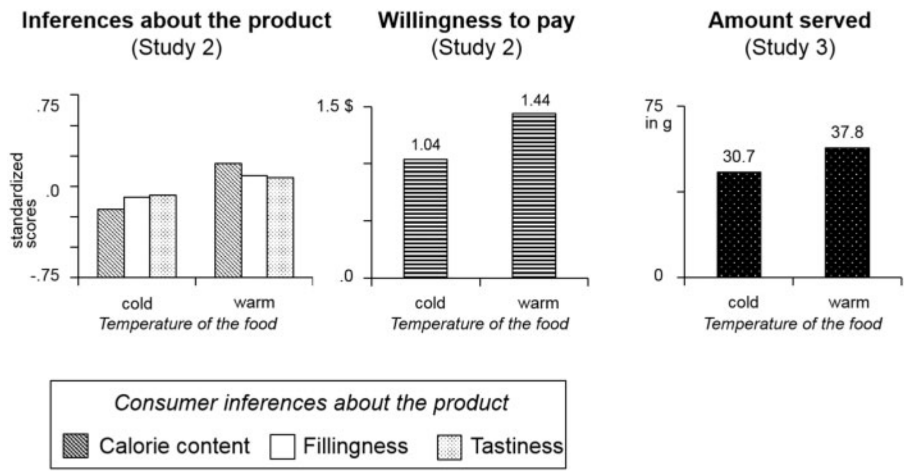
One hundred seven customers of a hair salon (M_{age} = 26.81 years, SD = 9.64, 77% females) participated in a two-level (warm vs. cold) between-subjects experiment. During the 4 days of the data collection in Brazil, all customers in the salon were invited by the researcher to participate in a market test for a food product. Those who accepted were invited to a second room, where an assistant gave them a product to taste. We selected a slice of bread as the focal product, because it is ambiguous regarding temperature, and bread is commonly eaten at both temperatures. We manipulated food temperature by heating (vs. not heating) the bread on a clean, nonstick griller before offering it to the participant with a napkin (table 1). Before tasting it, participants evaluated the product in terms of calorie content, using the three-item measure from pilot study 1B ($\alpha = .72$). They also provided their fillingness ("I would rate this bread as" not at all filling–very filling; not at all satiating–very satiating; $r = .74$) and tastiness ("I believe this bread is" not at all tasty–very tasty; not at all pleasurable–very pleasurable; $r = .70$) perceptions on 7-point scales. Participants also indicated their willingness to pay for the product (i.e., If you had the opportunity to purchase this bread, how much would you pay for it?). Finally, participants completed the 7-point temperature manipulation check question ("The bread I evaluated is" cold–warm) and provided sociodemographic data. Each participant was asked not to talk about the study with other patrons in the salon.

Results and Discussion

Our manipulation of (actual) product temperature was successful (note that temperature was not mentioned until the manipulation check question, at the end of the questionnaire). Participants in the warm condition perceived the bread as warmer than those in the cold condition (M_{warm} = 5.15 vs. $M_{cold} = 3.91$; $t(105) = 4.53$, $p < .001$). We again observed a temperature effect on calorie inferences (standardized score: $M_{warm} = 0.20$ vs. $M_{cold} = -0.20$; $t(105) = 2.67$, $p = .009$), in support of hypothesis 1. Consumers

FIGURE 2

TEMPERATURE EFFECT ON FOOD EVALUATION, WILLINGNESS TO PAY, AND AMOUNT SERVED (STUDIES 2 AND 3)



inferred that the warm product was more filling (M_{warm} = 4.68 vs. M_{cold} = 4.25; $t(105) = 2.19$, $p = .031$) and tastier (M_{warm} = 4.95 vs. M_{cold} = 4.42; $t(105) = 2.23$, $p = .028$) than the cold one (figure 2). To check for the distinction between the two inferential processes underlying the calorie judgments, we ran a parallel mediation model (temperature → fillingness/tastiness → calorie content). These results show that the effect of food temperature on calorie inferences incrementally operated through fillingness (ab = 0.074, $CI_{95\%}$: 0.004; 0.200) and tastiness (ab = 0.157, $CI_{95\%}$: 0.019; 0.299) perceptions, in support of our theoretical model. We again found that both paths are unique and incremental to the intuition.

The calorie inferences then translated into greater willingness to pay ($\beta = .417$, $t = 4.57$, $p < .001$; temperature direct effect: $p = .131$). Specifically, a t-test including 102 participants (four participants did not report the price they were willing to pay and one was excluded as an outlier) showed that warm temperature enhanced willingness to pay by 40 cents (M_{warm} = \$1.44 vs. M_{cold} = \$1.04; $t(100) = 2.48$, $p = .015$), signaling a temperature premium of +38% (figure 2) and supporting hypothesis 2a. To test whether this increase is due to temperature-driven inferences, we conducted a path analysis with temperature as the independent variable and the composite scores of tastiness and fillingness perceptions as parallel mediators predicting calorie inferences, which in turn affected willingness to pay. The analysis confirmed a significant, indirect temperature effect on willingness to pay, operating through both fillingness and tastiness perceptions and thus calorie inferences (standardized indirect effect ab = 0.112, $z = 2.46$, $p = .014$). It is important to note that the temperature effect on calorie inferences disappears completely once tastiness and fillingness perceptions are included as first mediators. Likewise, the positive impact of the first mediators on the dependent variable disappears when calorie inferences are entered into the model as the second mediator. This underscores mediation in the suggested sequence. Also, we conducted an alternative serial mediation analysis to test for potential reverse causality, with a model in which consumers might infer calories prior to tastiness and fillingness perceptions. However, no indirect effect emerged, lending further support to our theorized model (ab = 0.077, $z = 1.93$, $p = .053$; for further details, refer to web appendix A).

Study 2 provides additional evidence of the “warm is calorie-rich” intuition and its two distinct mechanisms. It also identifies a downstream consequence of the intuition: Consumers are willing to pay more merely because a product is heated, due to their anticipation that it provides more energy value (i.e., calories).

STUDY 3: THE IMPACT OF TEMPERATURE ON AMOUNT SERVED

We now explore if product temperature influences the consumption (i.e., amount served) of an individual product. In study 3, we assess the amount of a product (popcorn) consumers serve themselves. In line with our prediction that consumers value warm products more, we expect them to serve more when the product is warm (vs. cold).

Participants and Procedure

Three hundred seventy-four undergraduate students from a major French business school (M_{age} = 20.76 years, SD = 1.63, 61.8% females) participated in this study in exchange for course credit. The temperature of the product (popcorn, with neither salt nor sugar added) was randomly manipulated for each lab session (with 10 students maximum) by heating (vs. not) the popcorn and serving it on a warm (vs. cold) buffet tray. We reinforced the temperature manipulation with a sign (i.e., "Please be careful because the tray might be hot [cold] and heavy"). Participants received instructions to serve themselves as much or as little popcorn as they wanted by pouring it into a plastic bag. After serving themselves, the participants were instructed not to eat the popcorn. They then completed the fillingness and tastiness perception measures from previous studies (Cronbach's α: fillingness = .82; tastiness = .92), followed by our manipulation check of product temperature (i.e., "The popcorn is ..." cold–warm) and sociodemographic questions. When leaving the laboratory, participants were requested to leave their served bags and invited to take a bag of pre-served popcorn as a gift for participation. An assistant unobtrusively weighed the served bags after the participants left the room. The amount of popcorn served (in grams) is our key dependent variable. Consumption did not happen at the outset of the study and was thus not measured. To control for a potential dependency of the intuition on environmental temperature (i.e., eating behaviors may depend on the weather, Lefebvre and Biswas 2019; Moellering and Smith 2012), the data collection happened in two waves, 6 weeks apart. The outside temperature varied from 55.4–72°F in the first wave to 33.8–41°F in the second wave, but the food temperature effect on consumption occurred in both waves.

Results and Discussion

The temperature manipulation was successful (perceived temperature: M_{warm} = 3.58 vs. M_{cold} = 2.22; $t(372)$ = 9.51, $p < .001$). For the distribution of the amount of popcorn served, we log-transformed the variable to deal with normality issues. Next, we ran an analysis of covariace (ANCOVA) entering product temperature as the independent variable, and the data collection period as a covariate predicting the amount served. The results showed a significant effect of the data collection period ($F(1, 371)$ = 200.90, $p < .001$), such that consumers served themselves more when the environmental temperature was colder (M = 1.54 vs. 1.15). Importantly, we also found a significant effect of food temperature (M_{warm} = 1.49 vs. M_{cold} = 1.39; $F(1, 371)$ = 31.15, $p < .001$). Participants served themselves more popcorn when it was warm rather than cold, in support of hypothesis 2b. Specifically, when the popcorn was warm, consumers served themselves 37.75 grams, while those in the cold condition only served themselves 30.74 grams of popcorn. Two follow-up ANCOVAs show that food temperature also influenced fillingness (M_{warm} = 3.68 vs. M_{cold} = 3.27; $F(1, 371)$ = 7.88, p = .005; environmental temperature effect: p = .901) and tastiness (M_{warm} = 4.95 vs. M_{cold} = 4.45; $F(1, 371)$ = 13.91, $p < .001$; environmental temperature effect: p = .286) perceptions. The parallel mediation indicates that the temperature effect on the amount of popcorn served operated through both fillingness (ab = 0.008; $CI_{95\%}$: 0.0002; 0.0190) and tastiness (ab = 0.009; $CI_{90\%}$: 0.0005; 0.0199) perceptions. Corroborating the study 2 findings of both temperature-induced mechanisms, we confirmed another downstream consequence of food temperature with this study, namely, the amount served. So far, we investigated the presence of temperature cues and its impact on product judgments. Next, we concentrate on the boundary conditions and on situations when the temperature effect might disappear.

STUDY 4A: THE INTUITION AND PRODUCT CHOICE

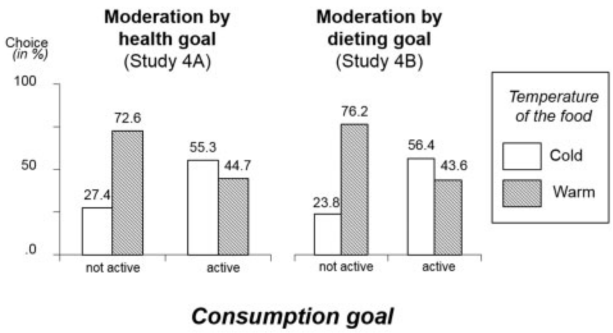
Having substantiated the consequences of the "warm is calorie-rich" intuition, we now turn to situations that might offset them, namely, when higher inferred calorie content does not provide utility to consumers in pursuing their consumption goals. Study 4A tests a health goal as a boundary condition on the preference for warm (vs. cold) products. Following our model, we expect that the preference for the warm option may disappear when a health goal is active during the decision-making.

Participants and Procedure

Two hundred nine students from a major French business school (M_{age} = 21.67 years, SD = 2.58, 55.6% males) participated in this study voluntarily during a social gathering. Participants read a scenario designed to manipulate their consumption goal. To activate the health goal (vs. not), respondents were instructed to choose a product for a friend, who was trying to maximize health (vs. pleasure; adapted from Haws et al. 2016; see appendix C for details). Participants then encountered two trays, side by side, and could choose between a broccoli or zucchini snack, which varied in temperature (table 1). Both dishes consisted of similar ingredients: bread, cheese, and one of the vegetables (broccoli or zucchini). We manipulated the actual product temperature by serving one of the two snacks warm and the other cold. We counterbalanced the presentation order of the snacks and their temperature to rule out any snack preferences. Our dependent variable was the snack choice (warm vs. cold). We successfully pretested this study design with 146 MTurk workers using a very subtle visual temperature cue (steam), which revealed a dampening effect of the health goal on warm (vs. cold) food preferences (web appendix C).

FIGURE 3

CHOICE OF WARM AND COLD FOOD OPTIONS DEPENDING ON CONSUMPTION GOAL



Results and Discussion

A logistic regression with the consumption goal predicting product choice (controlling for product presentation order and type of vegetable) showed that the consumption goal guides the choice of the warm over the cold snack ($B = 1.20$, SE $= 0.30$, $Z = 4.06$, $p < .001$), in support of hypothesis 3a. As figure 3 indicates, when the health goal was not active, 72.6% of the participants chose the warm option (cold 27.4%, one-tailed $p_{\text{warm choice} > 50\%} < .001$). When the health goal was active during the judgment, the preference for the warm option disappeared (cold 55.3% vs. warm 44.7%, $p_{\text{cold choice} > 50\%} = .077$).

These results show that the effect of temperature cues on choice depends on the active consumption goal: if pleasure guides the purchase (as in many food decisions), consumers favor warm over cold food. If instead health goals drive their decision, this preference disappears, because more calories do not help these consumers reach their goal. Yet health is an abstract, fuzzy concept for many consumers, and calories constitute only one dimension of healthy eating (e.g., vitamins, no genetic modification; André, Chandon, and Haws 2019). Therefore, we designed study 4B to focus on a dieting goal (i.e., calorie restraint), in line with our additional analysis of study 1B that food temperature influences perceptions of calorie content, rather than general healthiness perceptions (see web appendix A for details). Considering that consumers on a diet often focus mainly on calories (e.g., counting calories, Holloszy and Fontana 2007), we sought explicitly to manipulate the specific goal of calorie restraint.

STUDY 4B: THE MODERATING ROLE OF CALORIE RESTRAINT

Study 4B examines how the goal of dieting modifies consumers' reactions to temperature cues. We expect that when consumers seek to reduce their calorie intake, preferences for warm foods flip, and they favor cold products, with the assumption that they contain fewer calories.

Participants and Procedure

Three hundred thirty-eight MTurk workers ($M_{\text{age}} = 37.69$ years, SD $= 11.50$, 53.6% females) participated in this study in exchange for monetary compensation. They read the goal manipulation scenario (Haws et al. 2016) and then had to choose between two products that varied in temperature (table 1), reportedly for a colleague who was hungry and looking for something tasty (vs. actively trying to avoid calories, see appendix C). To manipulate temperature, we added steam to one of the bowls and altered the serving temperature in the bowl description (e.g., "The Chicken Balsamic bowl is served hot[cold] and is made of vegetables and grilled chicken with balsamic sauce"). To rule out distortions (presentation order or taste preferences), we counterbalanced the presentation order of the offerings and the product with the temperature cue. After choosing a dish, participants completed the manipulation check, indicated their perceptions of the dish's temperature, and answered sociodemographic questions.

In a pretest (web appendix D), we individually manipulated the framing for the two inferential mechanisms (tastiness vs. fillingness vs. control). For both framings, tastiness and fillingness, the choice likelihood of the warm option was 16.5% and 13.0% greater than the control, respectively. This pretest substantiated the study design and provided further evidence that both mechanisms underlie temperature effects.

Results and Discussion

A logistic regression controlling for presentation order and product type confirmed that the consumption goal significantly influenced the choice of the warm (vs. cold) food ($B = 1.49$, SE $= 0.25$, $Z = 6.03$, $p < .001$), supporting hypothesis 3b. When the dieting goal was inactive (figure 3), participants chose the warm option more often (76.2%) than the cold one (23.8%), significantly above the 50% baseline level ($p_{\text{warm choice} > 50\%} < .001$). However, when the goal of reducing calorie intake was active, participants selected the warm option less (43.6%) than the cold one (56.4%), at a rate below the baseline ($p_{\text{cold choice} > 50\%} = .044$), supporting our expectations that the preference over product temperature is different depending if consumers have a goal of dieting or not.

We further controlled for the perceived temperature of the chosen product by excluding participants who reported temperatures incongruent with what they chose (i.e., subjects who chose a warm option but perceived it as cold [<3] or chose a cold option but perceived it as warm [>5], total $N = 23$). Doing so made the effect of the dieting goal even more pronounced; when the goal of reducing calorie intake was inactive, participants chose the cold option even less often (22.1%) than the warm one (77.9%, $p < .001$). When this goal was active, participants selected the cold option more often (57.9%) than the warm one (42.1%, $p < .03$). These results underscore the qualifying role of consumption goals; the pursuit of a dieting goal can reverse warm product preferences. Even though we manipulated the same product, consumers mistakenly assumed that cold options were less caloric and made their choices accordingly. Having found triangulating evidence that temperature-driven calories inferences guide consumer decisions, in study 5, we test alternative explanations for the temperature effect on downstream consequences, such as willingness to pay.

STUDY 5: RULING OUT OTHER TEMPERATURE EFFECTS

Study 5 aims to rule out alternative accounts by including perceptions of attributes potentially affected by food temperature (e.g., perceptions of food as fresh, demanding effort, positive emotions). Given that physical warmth increases products valuation (Zwebner, Lee, and Goldenberg 2014), we distinguish the "warm is calorie-rich" intuition from a temperature halo effect.

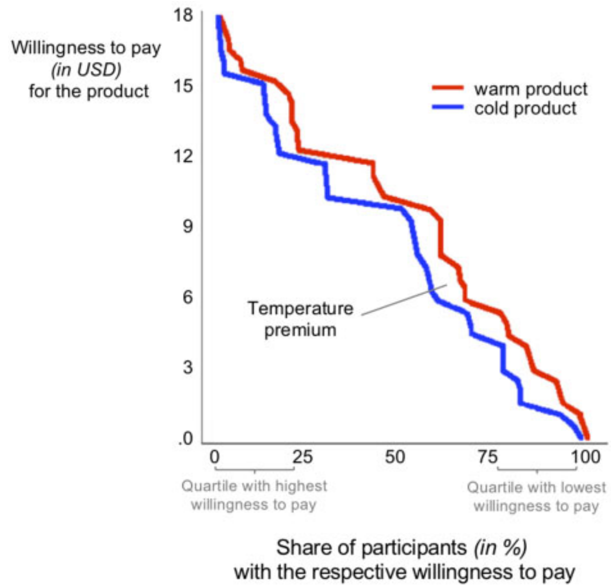
Participants and Procedure

Three hundred ninety-five MTurk workers located in the United States participated in this study for monetary compensation. Twenty-three unengaged participants (e.g., SD > 2) were excluded, leaving a final sample of 372 participants (M_{age} = 39.03 years, SD = 12.6, 55.9% females). Participants were randomly allocated to one of the two temperature (warm vs. cold) conditions and evaluated a dish composed of pasta and vegetables. For this study, we used only a subtle visual cue to manipulate food temperature (traces of steam above the product, present vs. absent), while all other elements remained constant (table 1). We measured calorie inferences (two items, "How many calories do you believe the dish you have seen has?" and "The dish I have seen probably is" not at all calorie-rich–very calorie-rich, $r = .49$) and willingness to pay ("If you had the opportunity to purchase the food you saw, how much would you pay for it? (in USD)"). We also measured fillingness perceptions (one item, "The dish I have seen probably is" not at all filling–very filling) and tastiness perceptions using the three items from previous studies (e.g., "I believe this dish is" not at all tasty–very tasty, $\alpha = .87$).

To exclude alternative explanations, we assessed other potential consequences of exposure to temperature cues, such as perceptions of the food as fresh (three items; e.g., "This product seems to have been made" a long time ago–recently, $\alpha = .89$), healthy (three items; e.g., "This food is healthy," strongly disagree–strongly agree, $\alpha = .94$), and the effort required to prepare it (four items; e.g., "it did not take any effort to prepare it–it took a lot of effort to prepare it," $\alpha = .91$). To test for simple temperature halo effects, we also measured positive emotions (seven items; e.g., "Rate the extent of the feelings you would experience when eating the dish you saw," interested, excited, inspired, $\alpha = .92$). We then assessed perceived product temperature ("The dish I saw is" cold–warm). Finally, to confirm the qualifying role of the consumption goal, we measured dietary restraint with a 4-item scale (e.g., "How often do you watch the amount of calories you consume?," adapted from Mohr, Lichtenstein, and Janiszewski 2012).

FIGURE 4

DISTRIBUTION OF WILLINGNESS TO PAY AMONG CONSUMERS ACCORDING TO FOOD TEMPERATURE



Results and Discussion

Managerial Implications of Food Temperature. After confirming the successful manipulation ($M_{warm} = 6.67$ vs. $M_{cold} = 5.15$; $t(370) = 10.79$, $p < .001$), the analysis corroborated the effect of the temperature cue on calorie inferences (standardized score: $M_{warm} = 0.09$ vs. $M_{cold} = -0.09$; $t(370) = 2.32$, $p = .021$). We observed a substantial difference in willingness to pay when the dish was warm (M_{warm} = \$10.31 vs. M_{cold} = \$9.24; $t(370) = 2.97$, $p = .003$), implying a temperature premium of 12%. Figure 4 illustrates the willingness to pay distribution; participants appear consistently ready to spend more on the food dish when it is warm. For example, among the quartile of participants willing to pay the least for the dish (75–100% in figure 4), the presence of a warm cue increased their willingness to pay by 31.2%. Meanwhile, for the 25% of participants who would pay most (0–25% in the figure 4), the warm cue increased it by 11.6%.

Further analysis corroborated the role of consumption goals as moderators of the temperature impact on decision-making, in that dietary restraint moderated the effect of calorie inferences on willingness to pay (ab = −0.289, SE = 0.143; $t(367) = 2.03$, $p = .043$). For participants low in dietary restraint (−1 SD), the indirect effect of food temperature on willingness to pay through calorie inferences was significant (ab = 0.447, $CI_{90\%}$: 0.078; 0.890), but this mediation disappeared for those high in dietary restraint (+1 SD: ab = 0.142, $CI_{90\%}$: −0.061; 0.374). Dietary restraint did not moderate the impact of temperature on calorie inferences ($B = -0.034$, SE = 0.051; $t(368) = 0.64$, $p = .520$), attesting to the prevalence of the "warm is calorie-rich" intuition. Rather, the intuition's consequences were contingent on the consumption goal that was active during judgment.

Alternative Explanations. To rule out alternative causes, we measured other attributes that might be affected by a temperature cue. The temperature cue triggered freshness perceptions ($M_{warm} = 5.95$ vs. $M_{cold} = 5.56$; $t(370) = 3.34$, $p = .001$) and positive emotions ($M_{warm} = 4.04$ vs. $M_{cold} = 3.67$; $t(370) = 2.57$, $p = .011$) but did not affect perceptions of the effort required to make the product ($M_{warm} = 4.15$ vs. $M_{cold} = 4.01$; $t(370) = 1.10$, $p = .274$) nor healthiness perceptions ($M_{warm} = 5.69$ vs. $M_{cold} = 5.62$; $t(370) = 0.78$, $p = .436$). Again, we observed a temperature effect on tastiness ($M_{warm} = 5.25$ vs. $M_{cold} = 4.74$; $t(370) = 3.95$, $p < .001$) and fillingness ($M_{warm} = 5.15$ vs. $M_{cold} = 4.86$; $t(370) = 1.93$, $p = .054$) perceptions. To test whether these perceptions might explain the impact of temperature calorie inferences, we extended our parallel mediation model to include all product perceptions as mediators that might predict calorie inferences. The results substantiated our expectation that only tastiness and fillingness perceptions mediated the temperature effect on calorie inferences (tastiness ab = 0.036, $CI_{90\%}$: 0.010; 0.067; fillingness ab = 0.097, $CI_{90\%}$: 0.017; 0.182); the alternative routes through freshness (ab = −0.009, $CI_{90\%}$: −0.031; 0.011), positive emotions (ab = −0.001, $CI_{90\%}$: −0.014; 0.012), healthiness (ab = −0.019, $CI_{90\%}$: −0.058; 0.020), and effort (ab = 0.009, $CI_{90\%}$: −0.004; 0.026) were non-significant. In support of our theory, tastiness and fillingness perceptions were the sole drivers of the calorie inferences.

We also checked for mediation of the product perceptions on willingness to pay, using calorie inferences and the attributes of the alternative accounts as mediators. This parallel mediation model showed that the impact of the food's temperature on willingness to pay operated through both calorie inferences (ab = 0.267, $CI_{90\%}$: 0.072; 0.483) and positive emotions (ab = 0.094, $CI_{90\%}$: 0.006; 0.214). We found no mediation of freshness (ab = 0.037, $CI_{90\%}$: −0.070; 0.157), healthiness (ab = 0.014, $CI_{90\%}$: −0.030; 0.073), or perceptions of effort (ab = 0.030, $CI_{90\%}$: −0.018; 0.102). These findings are congruent with prior literature that indicates that warm temperatures can trigger positive emotions such as closeness (Krishna 2012; Zwebner et al. 2014), which are then mirrored in product valuations. The results thus provide proof that temperature-evoked calorie inferences represent a unique mechanism, extending beyond a temperature halo effect. When we compare the strength of the indirect effects (0.267 vs. 0.094, $p < .05$), the effect of inferred calories on willingness to pay is much more powerful in food contexts than are emotional reactions to the product's warmth. We again checked for potential reverse causality. The temperature effect was well explained by our model: product temperature initially activated concrete impressions about product tastiness and fillingness, which prompted calorie inferences, and these latter inferences influenced consumers' willingness to pay (standardized indirect effect ab = 0.200, $z = 2.38$, $p = .017$). An alternative model in which calorie inferences preceded tastiness and fillingness perceptions could not explain this indirect effect (ab = 0.077, $z = 1.54$, $p = .123$). With study 5, we provide additional support for the mechanisms through which food temperature affects willingness to pay, due to calorie inferences. Having demonstrated the managerial consequences of the "warm is calorie-rich" intuition, next, we address the public policy implications of such biased judgements.

STUDY 6: COMPENSATORY EFFECTS OF THE INTUITION

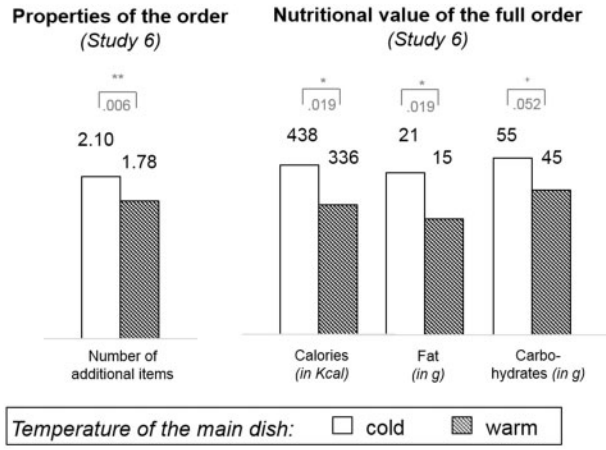
Because consumers deliberately choose cold product options when their goal is to restrict calorie intake (study 4B), we test if the (over)simplifying belief that cold options have fewer calories than warm ones can backfire, such that consumers ordering cold food may compensate for their initial choice by ordering complementary foods. That is, consumers might seek to compensate for the (assumed) lower energy intake by consuming other, complementary products. Ironically then, consuming cold foods may lead to increased calorie consumption.

Participants and Procedure

Two hundred forty workers located in the United States from a crowdworking platform (Prolific) participated in this study for monetary compensation ($M_{age} = 32.54$ years, SD = 11.94, 50.4% males). In a single-factor (warm vs. cold) experiment, participants read a scenario that described a daily lunch choice between two main dish options. We manipulated the product temperature with verbal and visual temperature cues, as in previous studies (steam, description). The scenario indicated that one of the options was sold out, forcing participants to take the remaining option, which was either the cold or the warm option (see web appendix E). After participants made their (forced) main dish choice, they could order (or not order) a side dish (i.e., mozzarella sticks, onion rings, grilled zucchini salad, or cooked vegetables), a dessert (i.e., chocolate cheesecake, ice cream, fruit salad, or apple), and/or a drink (i.e., Coke, Sprite, watermelon juice, or water). All the categories thus contained two relatively healthy and two relatively unhealthy options. The key dependent variables were the number of complementary items chosen and the corresponding amounts of calories (kilocalories), fat (in grams), and carbohydrates (in grams). After making their choices, participants answered our manipulation check of temperature (i.e., "The main dish I chose is" cold–warm) and sociodemographic questions.

FIGURE 5

IMPACT OF FOOD TEMPERATURE ON PURCHASES' NUTRITIONAL QUALITY



Results and Discussion

The temperature manipulation was successful (M_{warm} = 5.92 vs. M_{cold} = 1.12; $t(238) = 42.82$, $p < .001$), and the main dish temperature (cold vs. warm) exerted a significant effect on the number of extra food items ($t(238) = 2.78$, $p = .006$) that consumers chose. Participants selected more extra items (figure 5) when the main dish was cold (M_{cold} = 2.10) than warm (M_{warm} = 1.78), which increased the number of calories they purchased (M_{warm} = 336.09 kilocalories vs. M_{cold} = 438.45 kilocalories; $t(238) = 2.37$, $p = .019$), along with the amounts of fat (M_{warm} = 15.05 grams vs. M_{cold} = 20.55 grams; $t(238) = 2.36$, $p = .019$) and carbohydrates (M_{warm} = 45.29 grams vs. M_{cold} = 55.32 grams; $t(238) = 1.95$, $p = .052$).

Study 6 complements studies 4A and 4B by showing that consumers not only misjudge cold food but also try to compensate for the reduced energy intake they perceive by adding more side items, which increase the amount of calories, fat, and carbohydrates in their meals. This further consequence of the "warm is calorie-rich" intuition is important: using food temperature as a heuristic cue ultimately can increase total calorie intake, which may critically contribute to weight issues and obesity. These findings also inform research on health halo effects. Restaurant health claims have been shown to act as a health halo leading to increased food consumption (Chandon and Wansink 2007). Our findings further show that temperature cues also act as another type of health halo effect.

GENERAL DISCUSSION

Inspired by the fact that temperature is an important food attribute and the dichotomy of consumption habits for warm versus cold foods, this research proposed that consumers internalized intuitive beliefs that associate warm food with increased calorie content. Because warm foods are often part of consumers' main meals (Jaeger et al. 2009) and adding heat can physiologically improve taste perceptions (Guest et al. 2007; Rolls 2010), people have developed an association, such that they believe that a food has more calories simply because it is served warm. This "warm is calorie-rich" intuition shapes consumption decisions in multiple ways.

Across a series of eight studies (and three additional studies reported in the web appendix), we find consistent evidence that consumers implicitly subscribe to the belief that warm foods are more calorie-rich and behave accordingly, even though this assumption is not always true. These inferential tendencies even apply to the very same product (with the same calorie content). To determine the strength of people's subscription to this intuition, we conducted a single-paper meta-analysis (web appendix F) that synthesizes our results (McShane and Böckenholt 2017). It reveals that reliance on temperature as a heuristic cue for calorie content is pervasive, and the average temperature effect is significantly different from 0 ($M = 0.21$, SE = 0.05; $t(1154) = 4.57$, $p < .001$). Our experiments have adequate statistical power, in that the required sample size (80% power for the contrast) for one experiment would be 199 participants per condition and only 40 per condition for five experiments. We also note that the intuition arises regardless of the different product types (salad, bread, bowl, main dish, snack) and the presence of other cues (smell, haptics).

The temperature-elicited calorie inferences also affect downstream marketing consequences (willingness to pay, amount served) and overall product choice. The increase in willingness to pay stems from the deep-seated association that warm food provides greater nutritional value in terms of energy (calories), evoking a more favorable value-for-money perception (i.e., translating into monetary value). Our studies also rule out the notion that calorie inferences are simply the result of a temperature halo effect. As we show in study 5, calorie inferences are not driven by positive emotions and they translate into willingness to pay independently of positive emotions.

This research also identifies some boundary conditions of the managerial consequences of the intuition (studies 4–5) that offer insights for marketers. The positive temperature effect on choice and willingness to pay disappears when food energy does not provide utility or is counterproductive to the pursuit of a focal consumption goal, such as health goals. Consumers who hold health goals respond to temperature cues differently, because their goals shape their use of calorie inferences (Visschers, Hess, and Siegrist 2010). Consistent with the literature on inferential beliefs and consumption goals (Irmak, Vallen, and Robinson 2011; Luchs et al. 2010), we identify temperature-driven calorie inference as a double-edged sword; for example, when targeting consumers with health goals or dieters (i.e., calorie-restrained eaters) (Hirschman and Holbrook 1982). As the perception of more calories can be counterproductive for calorie-restrained eaters (study 4B), these consumers may deliberately avoid warm products. Notably, consumption goals do not influence the inferential belief but rather how consumers leverage that belief in their decisions.

Managerial and Theoretical Implications

This research extends existing knowledge by providing new insights into the automaticity of decision-making in the food domain (Haws and Winterich 2013; Irmak et al. 2011; Zlatevska et al. 2014). We identify a heuristic shortcut that is prevalent in food judgments and decisions. Prior research has provided hints that warmer scents spark preferences for less caloric products (Lefebvre and Biswas 2019) and that environmental temperatures can alter food energy consumption (Moellering and Smith 2012), information processing (Cheema and Patrick 2012), and willingness to pay during negotiations (Sinha and Bagchi 2019). To the best of our knowledge though, this research was the first to consider food temperature, presented as actual temperature or as visual or verbal cues (e.g., labels, pictures with steam), and its managerial implications. We also offer some concrete, direct recommendations for how managers and policy makers should address food marketing efforts, in terms of how the heuristic temperature cue biases product judgments, the impact on consumption patterns, and ways to limit its detrimental consequences.

Biasing Product Judgments. The demonstrated effects of the "warm is calorie-rich" intuition bolster existing calls to broaden the focus of consumer research, beyond cognitive-rational processes to include intuitively activated processes that guide product judgments and shopping decisions (Haws and Winterich 2013; Haws et al. 2016; Mai and Hoffmann 2015; Raghunathan et al. 2006; Werle, Trendel, and Ardito 2013). Especially when relevant attributes are hidden or consumers lack the capacity to judge all accessible information systematically (Petty, Cacioppo, and Schumann 1983), they rely on intuitive beliefs such as the "warm is calorie-rich" intuition in their decision-making. It is surprising that food temperature has been overlooked in the marketing discipline, in that it represents a core element of human nutrition and an important property of food products.

Converging evidence from our eight studies implies that temperature-induced assessments of a product's nutritional value spill over to judgments of its (monetary) value. The "warm is calorie-rich" intuition is rooted in intuitive thoughts about how tasty and filling a product is—two basic, quickly processed dimensions for judging foods, such that they constitute the basis of the identified intuition. Both mechanisms are physiologically and culturally learned, but they can misguide consumer calorie judgments, which might be valid sometimes but not always (Furnham 1988). This finding is particularly relevant for managers, who should be aware that consumers might (mistakenly) assume that products served cold are less calorie-rich, affecting their decisions.

Impact on Consumption Patterns. We tested the consequences of the "warm is calorie-rich" intuition and showed that product temperature has the potential to increase willingness to pay (studies 2 and 5), amount served (study 3), and product choice (studies 4A and 4B), therefore boosting a product's market share. The mere presence of visual temperature cues (e.g., food steam, temperature label) is enough to activate the intuition and its favorable consequences. Therefore, marketers can use temperature cues on packaging and in communication campaigns to enhance product perceptions and stimulate purchases. These findings imply that the simple presentation of a warm product, a warm component, or a label highlighting the temperature can create a market advantage. We thereby offer a potential explanation for our opening example of Starbucks' successful introduction of warm food. In-store signals of warm food items likely enhanced consumers' valuation of and preference for these products.

We also shed light on the mechanisms underlying these consequences, by noting not just the importance of initially formed taste judgments but also the criticality of perceptions of how filling a product is. The capacity to satisfy hunger is substantively valued in warm products. With that, we add to recent discussions about the link between product attributes and monetary value, such as between healthiness and price (Haws et al. 2016). Our findings add that managers can make effective use of the "warm is calorie-rich" intuition to derive pricing strategies according to consumers' perceptions of the value of warm food products.

From a public policy standpoint, this research also suggests new ideas for tackling obesity. To stimulate more healthful consumption patterns, previous efforts by academics and policy makers have focused on raising consumers' capacity to assess and process nutritional information (e.g., healthiness, calorie content; Andrews et al. 2014; Kozup et al. 2003). For example, several policies and labeling strategies have been implemented to increase consumers' awareness of food nutritional quality (Food and Drug Administration 2017). In daily life, however, consumers often rely on other product cues, health claims, or previous knowledge, rather than objective nutritional information (Andrews et al. 2014). Evidently, they also use product temperature as a heuristic cue to infer nutritional energy, often with erroneous conclusions. In study 4B, consumers believed that they were choosing a less calorie-rich product, just because it was served cold. Such temperature-driven assumptions can elicit compensatory choices too, such that consumers wind up purchasing more calories. In study 6, food temperature substantially affected the amounts of calories (+31%), fat (+37%), and carbohydrates (+22%) purchased. Ironically, consumers might avoid choosing a salad not only because it is a salad but also because it is served cold. In a similarly detrimental fashion, unhealthy cold options might be misjudged as containing fewer calories than they do, simply because they are served cold.

On the positive side, these results also reveal interesting means to make healthy options such as cold salads, seem more attractive and nudge healthier consumption. Provided that a product's sensory and textual properties are not compromised, marketers of healthier products might consider adding a warm component to their cold offerings (e.g., salad) to avoid the implicitly perceived liability of being calorie poor and not filling or tasty. Arguably, one might speculate that the option to heat certain elements of a dish (like the bread, meat, and cheese at Subway) could be a key success factor for some fast-food restaurants that are positioned as "healthier." Temperature cues may also be a successful strategy for healthy restaurants; Itsu, a chain restaurant that serves Japanese food, for example, adopted a marketing slogan for its store windows, touting its offerings as "hotter than ever" to increase awareness of the company's new line of products served warm.

Limiting Detrimental Outcomes. While strategically adding visual temperature cues in packaging or communication can enhance product evaluations, our results also show that marketers must first account for product's positioning. If companies are promoting low-calorie products and targeting health-conscious consumers, they should avoid warm temperature cues. To reduce prejudice against cold options and backfiring effects, restaurant managers also should take note of our findings. Restaurants often distinguish between cold and warm starters/dishes on menus, which may lead consumers to exclude cold options from further processing, especially if they are very hungry. Making this temperature distinction salient might limit the evoked set of potential options, before consumers even consider all available products. Therefore, we suggest that managers and policy makers should apply temperature cues in product descriptions with caution and in close accordance with their strategic objectives.

Limitations and Future Research Avenues

This research documents the implications of the "warm is calorie-rich" intuition across different stages of the consumption process (assessing a product, decision-making, before consumption). Heuristic processing, however, differs between pre- and post-purchase consumption phases, because different senses get activated (e.g., gustatory, haptic). The processes that operate at the moment of purchase and the consumption of a food item are not the same (Mai, Symmank, and Seeberg-Elverfeldt 2016). Furthermore, food may be purchased at one temperature and consumed in other, such as frozen meals, meant to be warmed at home. Further research should address the interplay of such diverging temperature cues (e.g., warmth cues on frozen foods).

Our series of studies suggests that the presence and consequences of the "warm is calorie-rich" intuition reflect the prevalence of warm food in main meals (Wrangham and Conklin-Brittain 2003). We investigated the "warm is calorie-rich" intuition on two continents: America (the United States and Brazil) and Europe (France). Future research should continue to explore it across cultures. In China, for example, consumers often classify foods as cooling and warming (irrespective of their actual temperature), so the presence of temperature cues might exert impacts associated with a different social habit. Even if the intuition is prevalent among consumers with different beliefs and habits (see study 1A), cross-cultural differences might arise regarding its implications. Also, in countries with warmer climates, consumption habits regarding food temperature might differ, which in turn might influence the prevalence of the "warm is calorie-rich" intuition. By highlighting the creation and consequences of a pervasive lay belief that influences consumers' food-related decision-making, this article offers a starting point for more research on temperature as a key product characteristic in the food industry.

DATA COLLECTION INFORMATION

The first author managed the data collection for studies 1A, 1B, 4B, and 5 using Amazon Mechanical Turk in May 2018 (study 1A), March 2019 (1B) April 2019 (4B), and January 2018 (study 5). The second author managed the data collection of study 6 in May 2019 using Prolific crowdworking platform. The first author conducted the data collection for study 2 in December 2018. The first author conducted the data collection for studies 3 and 4A using undergraduate students' sample of Grenoble Ecole de Management in November 2018 and January 2019 (study 3) and March 2018 (study 4A). All studies employed experimental designs, which were designed by all authors and analyzed by the first and second authors. Studies 1B and 4B were preregistered in the platform Open Science (OSF) at the following links: study 1B (https://osf.io/gmuvh/?view_only=24365380fb6544efbc9525921253203a) and study 4B (https://osf.io/nw8z5/?view_only=c3e61951eef243db84a354285dd6bb88).

APPENDIXES

APPENDIX A: IAT PROCEDURE TO MEASURE THE ASSOCIATION BETWEEN WARM AND CALORIE-RICH

Stimuli for the attributes calorie-rich and calorie-poor

Stimuli for the target concepts warm and cold

Warm:
SWEAT, FIRE, 100°C, SOUTH, WARM, DESERT, HEAT, TROPICAL
Cold:
0°C, SNOW, SHIVER, ICE, FROSTY, NORTH, COOL, CHILL

Block	Task objective	Instructions
Task 1 (24 trials)	Training: categorization of the concepts target	Press left(E) for cold words Press right(I) for warm words
Task 2 (24 trials)	Training: categorization of the attributes	Press left(E) for calorie-rich images Press right(I) for calorie-poor images
Task 3 (24 trials)	Critical incompatible block: combined task 1	Press left(E) for calorie-rich images or cold words Press right(I) for calorie-poor images or warm words
Task 4 (40 trials)	Critical incompatible block: combined task 2	Press left(E) for calorie-rich images or cold words Press right(I) for calorie-cold images or warm words
Task 5 (24 trials)	Training: new categorization of the concepts target	Press left(E) for warm words Press right(I) for cold words
Task 6 (24 trials)	Critical compatible block: combined task 1	Press left(E) for calorie-rich images or warm words Press right(I) for calorie-poor images or cold words
Task 7 (40 trials)	Critical compatible block: combined task 2	Press left(E) for calorie-rich images or warm words Press right(I) for calorie-poor images or cold words

APPENDIX B: WORDING OF THE MEASURES

Studies	Concept	Measures
1B, 2, and 5	Calorie inferences	How many calories do you believe this _____ has? This _____ is not at all calorie-rich–very calorie-rich. In my opinion, the amount of calories in the _____ is low–high.
1B, 2, 3, and 5	Tastiness	I believe this _____ is Not at all tasty–very tasty Not at all pleasurable–very pleasurable Not at all delicious–very delicious
1B, 2, 3, and 5	Fillingness	I would rate this _____ as Not at all filling–very filling Not at all satiating–very satiating Not at all nourishing–very nourishing
1A	Health consciousness	I reflect about my health a lot. I'm generally attentive to my inner feelings about my health. I'm very self-conscious about my health. I am constantly examining my health.
1A	Food involvement	Food is something very important in my life. My food choices are very important to me. I think much about food each day.
1A	Dietary restraint	How often are you dieting? Do you have feelings of guilt after overeating? Do you give too much time and thought to food? How often are you conscious of what you are eating? Do you eat sensibly in front of others and splurge alone?
1A	Habits of consuming warm food	I often eat warm food as my main meal. On a regular basis, my main meals are constituted of warm food.
1A	Explicit subscription to the "warm is calorie-rich" intuition	Warm food is more calorie-rich than cold food. Products that have warm components are rich in calories. Food products served warm are often calorie-rich. Warm foods are usually calorie-dense.
3 and 5	Healthiness	This food is healthy. This food is good for my health. This food is good for my well-being.
4A and 4B	Choice	Considering your co-worker request, which dish would you choose for her?
5	Freshness	About the characteristics of the dish you just saw. Would you say that . . . This dish seems to not be fresh at all–this dish seems to be very fresh. This product seems to have been made a long time ago–this product seems to have been made recently. It was added to the shelf a long time ago–it was recently added to the shelf.
5	Positive emotions	Rate the extent of the below feelings you would experience when eating the dish you saw . . . (not at all–a lot). Interested; excited; inspired; enthusiastic; active; happy; amused
5	Effort	About the preparation of the dish you saw, you would say that . . .. It did not take any effort to prepare it–it took a lot of effort to prepare it. It was probably easy to make it–it was probably difficult to make it. It has a brief preparation time–it has a long preparation time. It did not take any work to prepare it–it took a lot of work to prepare it.
5	Dietary restraint	How often do you watch the amount of calories you consume? How often do you moderate your sugar intake? How often do you cut back on snacks and treats? How often do you watch the amount of fat you consume?
1B, 2, 3, 4A, 4B, 5, and 6	Manipulation check temperature	The ____ is . . . Cold–warm
4A and 4B	Manipulation check consumption goal	Please, indicate your level of agreement with the statements below: I tried to choose something healthy to my friend. I tried to choose something pleasurable to my friend. I tried to choose the less caloric menu option to my friend. I tried to choose the more filling option in the menu for my friend.

APPENDIX C: SCENARIO FOR HEALTH GOAL ACTIVE [NOT ACTIVE IN BRACKETS], STUDY 4A

Please imagine that you and a friend are ordering food to eat lunch. Your friend, however, has assigned you the responsibility to order for her.
She also reminded you that she had been actively trying to choose healthier foods lately, so be sure to pick something healthy for her. [That she has been actively trying to have a pleasurable life, especially regarding her food, so be sure to pick something pleasurable for her].

SCENARIO FOR DIETING GOAL ACTIVE [NOT ACTIVE IN BRACKETS], STUDY 4B

Please imagine that you and a co-worker are ordering lunch. She has to go to a meeting right before lunch but asks you to order for her.
Right before your co-worker left, she also reminded you that she is extremely hungry and looking for something tasty and pleasurable that will satisfy her hunger, so be sure to pick something filling and tasty for her. [Right before your co-worker left, she also reminded you that she has been actively trying to avoid calories, so be sure to pick something that has fewer calories for her]
You know that in general, your colleague enjoys chicken dishes, and therefore two options are the most relevant. Please click to the next screen to view the two options and indicate which one you would select for your colleague
Please pick up the option that better fits your friends' request.

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