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Original Article:

THINKING ABOUT FOOD: AN ANALYSIS OF CALORIE ESTIMATION ACCURACY

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Abstract

The rising rates of obesity in the United States is of paramount concern. While there are many factors that contribute to this epidemic, we wish to make the case that additional focus should be paid to cognitive factors. Individual cognitive differences such as numeracy and cognitive reflection contribute to differences in performance on judgment and decision tasks. In some cases, individuals are prone to systematic biases that impair their ability to accurately use the information at hand to make informed food decisions. In this paper, we will discuss in more detail the extent to which cognitive factors influence dietary decision making, and more specifically the accuracy of food calorie estimations. In this study, we sampled undergraduates and ascertained their propensity for cognitive reflection, their numeracy abilities, restrained eating behavior, and their ability to accurately estimate calories. Results demonstrated that participants routinely underestimate calories on entrees over 500 calories. Furthermore, those with lower numeracy scores were more likely to underestimate entree calories. Underestimating calories for high calorie items has direct implications concerning overconsumption and potential weight gain or obesity.

Keywords: obesity, food choice, calorie estimation, numeracy

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INTRODUCTION

We are in the midst of an obesity epidemic in the United States. Rates of adult obesity more than doubled from the late 1970s to the late 2000s, and rates of childhood obesity more than tripled (Nielsen & Popkin, 2003; Task Force on Childhood Obesity, 2010). Nearly 40% of adults are reportedly obese, while two-thirds are overweight (Hales et al., 2017; Bublitz et al., 2010). As obese adults have been shown to have an increased risk for a variety of medical conditions such as type 2 diabetes, heart disease, stroke, and cancer, the obesity epidemic represents a significant health emergency in the United States.

Recent estimates show treating obesity and related illnesses could amount to more than $147 billion annually, which amounts to almost 10% of all national medical spending (Finkelstein et al., 2009). Furthermore, as of 2006, it was estimated that obese individuals spend an average of $1,429 more in medical related expenditures annually. In order to effectively curtail the obesity epidemic, efforts must be made in many domains. From understanding risk factors to nudging consumers through behavioral change interventions, there are countless ways to investigate the obesity epidemic and offer potential suggestions. In the present paper, we contend that cognitive abilities also have a role to play. From the estimation of calories to the impact of potential cognitive biases or miscalculations that may occur, it is important to understand the role that individual differences in cognitive abilities play in the dietary decision making process. In the present study, we investigated how cognitive variables, such as cognitive reflection and numeracy, as well as dietary factors, such as restrained eating, contribute to the biases and miscalculations regarding calories.

Addressing the Epidemic of Obesity

There are many factors contributing to the rising rates of obesity. For instance, the nation's children are growing up with amplified screen time, spend less time playing outside, and eat fewer home cooked meals (Task Force on Childhood Obesity, 2010). Already prepared and processed food is now more available than ever, and often available at a cheaper cost. Both portion sizes and energy intake have increased, and meals eaten both at fast food establishments and in the home are being affected (Nielsen & Popkin, 2003). Obesity is growing at higher rates than ever before, causing health complications and increased personal and national health costs.

In addition to these aforementioned concerns, there is also the way in which consumers seek to obtain dietary information in order to inform their food selections. For instance, one of the most common ways individuals interact with this information is in the form of Nutrition Fact Panels (NFPs) that are found on all packaged foods in the U.S. Whether nutritional information be presented on the back of packaged foods, on menus at restaurants, or through other means, these numeric values serve as a vital source of information about the foods we choose to consume. Because so much of this dietary information comes in a numeric form, as opposed to pictures, images, or color schemes, it would stand to reason that one who is more comfortable with numeric information, have high levels of numeracy, or describe themselves as more math literate, might be better able to make sense of this information, especially if time is of the essence when making a quick decision. Therefore, it is expected that numeracy and cognitive reflection, which concerns our preference for quick intuitive decisions versus more analytical reflective decisions, may impact the ways in which consumers quickly attempt to make sense of numeric dietary information, such as calories. However, in order to better understand the influence of cognitive variables like these, it is important to first discuss how nutrition information is presented to consumers and how these presentations may facilitate or impair the understanding of this information based on individual differences in cognitive abilities. How serving sizes are constructed, how nutrition labels are presented and used, and how food packaging impacts choice have been closely examined and warrant further discussion with regard to their connection with cognitive factors. For instance, if nutritional labels vary in the onus that they place on consumers to perform complex calculations to understand the nutritional content, then these individual differences in cognitive abilities would affect some consumers more than others (Roberto & Khandpur, 2014). A greater understanding of the connection between the use and understanding of nutrition information and cognitive variables can help to facilitate a productive discussion regarding the changes to Nutrition Fact Panels that has already begun.

Nutrition Fact Panels

Nutrition Fact Panels (NFPs) are present on almost all packaged foods sold in the United States and are arguably the most utilized source of nutritional information for consumers (Hydock et al., 2016). Despite the dramatic increase in obesity since the start of the 1990s, one might be surprised to discover that the serving sizes on most NFPs are based in part on "Reference Amounts Customarily Consumed (RACC)," which were created from nationwide food consumption surveys from the late 1970s and 1980s. As serving sizes can serve as an anchor to guide consumers in deciding how much of a particular food they should eat, the way in which these are constructed and more broadly, how serving sizes, along with NFPs, are utilized, matters a great deal in the quest to combat obesity. For one thing, considering that Americans today consume larger servings than reported in the 1970s and 1980s, people would probably be better served if serving sizes on NFPs were modernized to today's norms (Task Force on Childhood Obesity, 2010). In other words, if we do not want NFPs and other forms of nutritional information to become obsolete, we should probably be realistic with the amount of food people are actually eating in one "serving."

These out of date RACC amounts would not be a primary concern if individuals were not using NFPs to make their decisions. However, results from a 2014 FDA survey found that 77% of U.S. adults reported using the labels always, most of the time, or sometimes when buying a food product (Lin et al., 2016). Additionally, in the same survey, a larger percent, 79%, reported using the label often or at least sometimes when buying a product for the first time. Labels were reportedly most often used to find the nutrient contents of the food or to compare between products (Lin et al., 2016). Despite these seemingly high rates, eye-tracking research has found that when compared to Americans self-reports on how often they use NFPs, their self-reported estimates may be inflated (Roberto & Khandpur, 2014). While Americans may think they are comprehending the nutritional content of their food, they often make food decisions without considering the nutritional value (Roberto & Khandpur, 2014).

Interestingly, while NFPs are often used by consumers at grocery stores, they do so for a future self, as these foods are often not for immediate consumption (Christoph et al., 2018). This could mean that the nutrition information read at the time of purchase might carry less weight in the purchase decision or be less significant to the consumer, because it will not be eaten until a later time, by a future self. This idea is important to keep in mind as we consider the decision making process and the role of cognitive reflection. Additionally, while there appear to be gender effects regarding NFP usage with women reporting reading nutrition labels more often (Carels et al., 2007), women also have higher rates of obesity among all racial groups, but are particularly high among non-Hispanic black women (Hales et al., 2017). Thus, reading nutrition labels by itself may not be sufficient to garner understanding or impact habits.

Packaging Versus Reality

The design of packaged foods also contributes to the choices consumers make. Oftentimes, food items will feature a printed image on the front of the package or box that displays what the food looks like or how it could be used to make a certain dish (Madzharov & Block, 2010). These images greatly contribute to the overall representation of the food product that the consumer receives. In other words, how a food company is able to market and design their packaging can contribute to a consumer choosing to buy their food, despite potential poor nutritional value. Again, it is important to note this finding in the context of cognitive reflection, where poor intuitive decisions may have the power to undermine long-term health or dietary goals. Further, in comparison to generic clip art images, when product photos are displayed, research participants tend to choose those products with lower nutritional value (Helfer & Shultz, 2014).

Importantly for our purposes, one study found that consumers are more likely to consume larger amounts of a food product if the packaging shows a larger unit of the food on the front of the package (Madzharov & Block, 2010). Therefore, front of package marketing techniques play a very important role in consumer food choices. According to one analysis, 90% of consumers pick a food product after only visually examining the front of the package and do not even pick it up for a more thorough dissection (Clement, 2007). While Americans may think they have all the tools necessary to make smart food decisions, sometimes other factors, habits, or quick decisions may be more important to the decision process than their nutritional assessments. Once more, this finding highlights the need to further assess the impact of cognitive factors in order to better understand their role in many of these quick dietary decisions.

Changing Labels?

Further complicating an individual's ability to make healthy decisions using NFPs and serving sizes is the discretion manufacturers and retailers have with setting the benchmarks for appropriate portion sizes (Antonuk & Block, 2006). For example, prior work has shown that listing smaller serving sizes can minimize guilt and in turn increase consumption (Mohr et al., 2012). Similarly, artificially creating larger serving sizes have been shown to reduce consumption (Hydock et al., 2016). Specifically, Hydock and colleagues found that using larger serving sizes, which are naturally coupled with increased values for items such as calories and fat grams, can lead consumers to perceive foods as less healthy and reduce consumption of the food. Clearly, the serving size noted on the packaging can have an impact on both consumption and overall healthy eating habits. Findings such as these are pivotal in demonstrating how consumption changes using larger serving sizes and how intuition can be a guiding factor in this decision process. As these larger servings more accurately reflect how much consumers are eating in a single serving, we continue to find further rationale to update the serving size RACC's and more accurately present serving and nutrition information so that consumers can make informed decisions.

It is possible that altering NFPs to display more realistic serving sizes would help nudge Americans into less consumption of packaged foods. As noted, the RACC values are from consumption surveys that are more than 30 years old. In addition to updating the serving sizes, care should be taken to consider whether the serving size noted on the label is consistent or inconsistent with the image depicted on the packaging. Consider a scenario of an ice cream carton with a large bowl depicted on the front with 3 or 4 perfect scoops of ice cream displayed, in contrast to a recommended two-thirds cup serving size equal to 160 calories, which was just recently updated from a half cup in 2020. It is preposterous to assume the average American will stop at a half or two-thirds cup of ice cream when the image on the packaging differs so drastically from this amount. This not only makes the label and image inconsistent, but also places increased cognitive burden on the consumer to make an accurate food decision in light of these conflicting cues.

As others have taken stock of some of the inherent concerns we noted thus far regarding the present NFPs, some changes have been discussed and implemented. For instance, a dual-column structure has been proposed and is recently required on products meeting specific criteria related to quantities in the entire package. Lando and Lo (2013) demonstrated that individuals more accurately calculated nutritional values, such as calories and total grams of fat per serving, when there were two columns presenting the nutritional information instead of just one. In this format, one column details the nutrition facts for one serving, while the other column details the facts for the entire package. Additionally, for food packages containing two servings, but which are reasonably consumed in one sitting, a dual-column nutritional label displaying all the content for both one serving *and* the entire container helped study participants make more accurate calculations and decisions than if they were to only look at the serving size label (Lando & Lo, 2013). Similarly, Hydock et al. (2016) found that using larger serving sizes may reduce consumption by altering perceptions of the health content of the food. They further posit that "providing consumers with easier to comprehend and more accurate information on all foods served in all contexts could reduce overeating," and point towards updating serving sizes as a mechanism that may help curb the obesity epidemic in the U.S. It is here where concepts like cognitive reflection and numeracy once more come into play and warrant further discussion. These changes might reduce the reflection and calculation burden for some consumers, but investigation into who is currently more or less affected by the present framing and presentation of NFPs is also needed. Therefore, these studies and conclusions highlight the need for additional investigation into serving sizes and nutrition labeling, but also how cognitive variables impact calorie comprehension.

Assessing Influential Factors

When making food choices, Americans are faced with nearly unlimited options. Whether at a restaurant, fast food establishment, or grocery store, there are often many options to choose from. These choices naturally lead to a narrowing process in which consumers use simplifying strategies in order to classify foods into various categories (diet-friendly, junk food, healthy, etc.) (Carels et al., 2007). These categories, while helpful and arguably necessary for making sense of these complex choice environments, may also lead to substandard decision making. There is evidence to suggest that these categories may influence estimations of calories in particular foods based on their categorization. For instance, prior work has shown that individuals are likely to overestimate calories in "unhealthy" foods, and underestimate calories in "healthy" foods (Carels et al., 2007). Despite assumptions that calorie estimation inaccuracy might be a problem only for those overweight, this appears to not be the case, as calorie estimation accuracy appears similar regardless of weight status (Carels et al., 2007). Given the abundance of numeric estimation errors, it is therefore worthwhile to investigate whether cognitive variables impact calorie estimation and can predict these miscalculations in a more predictable way, regardless of weight status. As both cognitive reflection and numeracy have been shown to impact the accuracy of judgments involving numeric information, both were investigated to determine whether they could reliably predict food calorie estimation in the present study.

Cognitive Reflection and Numeracy

In addition to the concerns regarding the use and effectiveness of NFPs, there is also evidence to suggest that simply estimating the number of calories in a particular food is difficult for many people (Carels et al., 2007; Roberto & Khandpur, 2014). Estimating calories becomes more important when making food decisions in the absence of an NFP, when one actively or passively ignores the NFP, if one is consuming multiple servings, or when attempting to quantify total calories in a complete meal. As an illustration, imagine a scenario in which one looks at the NFP on a box of spaghetti. One may see 6-8 servings in the box, proceed to take a few handfuls of noodles, and then be somewhat at a loss when attempting to estimate the quantity in the pot and the associated number of servings and calories in the entire meal. One can see how being able to accurately estimate and perform a mathematical calculation like this can easily become burdensome or difficult. Certainly, there are a number of potential pitfalls consumers may fall into. But perhaps overlooked is the question of whether these pitfalls are uniformly distributed to all consumers? If one routinely struggles to perform complex calculations, accurately estimate, or acts intuitively rather than reflectively, what impact will that have on their decision making and food selection and consumption process?

Prior research has shown that a person's numeric ability, or numeracy, can greatly contribute to their decision making and might even play a larger role in decision making than intuition (Sinayev & Peters, 2015). Lipkus et al. (2001) and Schwartz et al. (1997), among others, have demonstrated that many individuals today have trouble understanding numbers and quantitative information. Prior studies have also cited an influence of numeracy in health decision making (e.g., Cavanaugh et al., 2008; Marden et al., 2012). Numeracy can predict inabilities to understand common health risks when expressed statistically, as well as predict how well individuals perform routine maintenance for their chronic health conditions such as diabetes (Cavanaugh et al., 2008; Marden et al., 2012; Rolison et al., 2012; Schwartz et al., 1997). Given the impact of numeracy in a variety of health domains, we feel consumers may also struggle when asked to routinely make healthy food choices where numeric calculations are necessary and pivotal to their decision making. Unsurprisingly, consumers have shown difficulty dealing with quantitative aspects of nutrition labels, especially regarding serving sizes (Daly, 1976). Therefore, the present study sought to further assess the impact of numeracy on the food estimation process.

Similarly, if food decisions are made by depending heavily on an intuitive decision process, cognitive reflection and the Cognitive Reflection Test (CRT) may be a useful measure or attribute. The CRT measures one's propensity for thinking intuitively (system 1) versus reflectively (system 2) (Frederick, 2005). The CRT is an efficient method to ascertain whether an individual prefers to depend on intuitive or reflective processes. Items are designed so that it is easy to come up with a common intuitive response, which in this test happens to be incorrect. In order to correctly answer the items, most individuals need to engage reflective processes, think further on their original incorrect answer, and adjust. Accordingly, those with lower CRT scores were more likely to make impulsive and impatient decisions in a variety of domains including health and financial decisions (Sinayev & Peters, 2015). Those with poorer CRT performance are also more likely to succumb to decision biases (Oechssler et al., 2009; Toplak et al., 2011), choose smaller immediate rewards (Frederick, 2005), and make riskier hypothetical financial decisions (Cokely & Kelley, 2009). Given these findings, in the present study, we sought to investigate whether the CRT could predict food estimation accuracy in order to assess whether those who are more or less reflective show differences in estimation accuracy.

Because understanding health, and specifically nutritional information, is vital to public health, various methods have been proposed in order to reduce the cognitive burden of making food decisions. Several retailers have added simplified nutrition information or symbols located on the front of packaging, thereby making the information more visible to consumers (Hersey et al., 2013). Additional alternative labels such as the Traffic Light, Facts Up Front, NuVal, and Swedish National Food Agency's Keyhole have all been evaluated for their ability to aid consumers (Helfer & Shultz, 2014). A key element with all of these labels is that they reduce the quantitative burden placed on consumers and allow them to better use their intuition to make wise food decisions by using more simplistic, often colored cues, thereby reducing the need to decipher a table of numeric information, which some may struggle with or simply be unwilling to do. Helfer and Shultz (2014) succinctly summarize this notion when they contend that nutrition "knowledge needs to be translated into information that people can understand and use rather quickly." The Traffic Light scheme is an easy example. Green, yellow, and red colors are used to summarize the nutrition information into low, medium, and high levels for consumers (Roberto et al., 2012). Not surprisingly, it has been suggested that using colors or other logos or symbols in this way can help consumers interpret numeric information more accurately (Roberto & Khandpur, 2014). Roberto et al (2012) observed that both the Traffic Light and Facts Up Front labeling systems help improve the accuracy of judgments about the nutritional content of various foods and beverages. As these alternative labels seek to minimize the impact of the wide range of numeracy abilities individuals hold and to further shift dietary decisions in order to coincide with the intuitive thinking process, both numeracy and cognitive reflection warrant further investigation in conjunction with the dietary selection process, despite not being included in prior research in this domain.

Dieting and Restrained Eating

Thus far, we have focused our review primarily on the potential biases inherent in NFPs and individual differences in cognitive abilities, but the dietary process and the ways in which consumers choose to restrict their consumption is also important to this food selection process. Therefore, an investigation of the impact of dietary restraint, in conjunction with cognitive abilities like numeracy and cognitive reflection, is also important. As we will discuss below, there are natural parallels between cognitive reflection and restrained eating that make both worth pursuing in the present study.

While consumers in America are facing a greater threat of obesity than ever before, it is also common for people to experiment with dieting, often more than once. Approximately 47% of men and 75% of women report having dieted at some point during their lifetime (Bublitz et al., 2010). Despite these high rates of dieting and increased awareness of health concerns, obesity rates are still on the rise. As dieters seek to alter their consumption, their perceptions of food play a role in this process, along other variables. For instance, according to Carels et al. (2007), “Individual difference characteristics, such as diet-status, weight, and gender, influence people’s perceptions of foods’ healthiness or capacity to influence weight, and in some instances systematically bias their estimates of the caloric content of foods.” One bias observed is that “unhealthy” foods are inherently perceived to have more calories than they actually contain. Such errors in estimation for “unhealthy” food items presumably can also occur for “healthy” food items and are investigated in the current study.

Consumers may take a variety of approaches to alter their dieting habits and eating behaviors to meet their health goals. A common approach is one in which self-denial occurs, often by what can be described as restrained eating. Restrained eating is the conscious restriction of food intake to prevent weight gain or promote weight loss and has been found to be positively correlated with BMI and body fat percentage (Ashok & Karunanidhi, 2015). Restrained eating can play out when a consumer seeks to engage in behaviors that they hope will lead to weight loss. In this process, restrained eaters assume that they need to strictly control their consumption and begin to deny themselves some of the more enjoyable foods that they now perceive as bad for them (Ashok & Karunanidhi, 2015). As restrained eaters face a constant inner battle over what foods they allow themselves to eat, they begin to ignore their body’s physical signals of hunger, which can become harmful after an extended time (Bublitz et al., 2010). Bublitz et al. (2010) continues by offering that when restrained eaters condition themselves to follow constructed guidelines for when and how much they can eat they ignore physical cues and eat only on a predetermined regimen that outlines eating schedules and the amount of food allotted for consumption. Most restrained eaters assume this will cause them to hold more control over their diet choices and eat less, but this kind of eating behavior actually contributes to increased weight fluctuation and obesity (Bublitz et al., 2010).

Consider for a moment the special case of pre-packaged “minipack” size snack food. Often these packages are even marketed as reduced or low-calorie options. Used to market foods like cookies, popcorn, and chips, these bags are pre-portioned amounts dictating a specific serving. Research has suggested that when restrained eaters, who are often the target consumers of minipack foods, engage in snacking of these items, they will eat more of this type of food than they would eat from a regularly packaged amount of the food (Scott et al., 2008). How ironic then that these snack size foods have a cumulative effect in direct opposition to the consumer's intended goals. These minipack food options are designed to have a pre-portioned amount, such that an intuitive decision maker need not think twice about how much of a particular food to consume and yet these thinkers still may overconsume in this scenario.

When restrained eaters follow intensely regulated eating regimens, the more rules and sub-goals the eater attempts to follow, and the more cognitively draining the decisions become (Bublitz et al., 2010). As restrained eating is an exercise of willpower, it involves delaying gratification for immediate rewards and therefore over time becomes increasingly difficult when considering how often these eaters face these instances where willpower must be expended (Scott et al., 2008). Because making accurate food choices relies heavily on cognitive factors such as prior nutritional knowledge and ability to understand labels, engaging in restrained eating can cause cognitive strain, and therefore, promote less-adept food choices (Miller & Cassady, 2015). Restrained eaters often also face the reality of an emotional relationship with food, which when combined with their cognitive depletion, can lead these eaters to choose foods in accordance with intuitive system 1 processes, regardless of actual healthfulness of the foods (Scott et al., 2008). Given the connection between restrained eating and cognitive reflection, it makes sense to further evaluate both of these variables in the present study.

Summary

As should be clear by now, there are a multitude of factors that influence food choice and overconsumption. So many in fact, that analyzing all factors within one study is out of the question. Therefore, we have analyzed only a select few in this current review and present study. Specifically, we sought to further investigate the influence of numeracy, cognitive reflection, and dietary restraint and their associated impact on a calorie estimation task. We choose this approach for a number of reasons. First, by using a calorie estimation task with food items from a validated food image database, complete with nutritional information, we were able to assess whether there were systematic ways in which consumers over or underestimated calories in a variety of categories (entrees, vegetables, fruits, desserts). This allowed us to get sense of the overall picture of calorie estimation before examining whether specific groups were more or less prone to miscalculations based on their individual differences. Secondly, by assessing individual's cognitive reflection, numeracy, and restrained eating using validated measures of these constructs, we were able to further examine their individual and collective impact on the decision making process. We hypothesized that those with higher numeracy skills and those more likely to utilize reflective system 2 processes would have more accurate calorie estimations. We also sought to examine whether restrained eating could predict systematic differences in calorie estimation accuracy, though without a priori hypotheses. Finally, we decided to use food images of the prepared food, rather than packaged food because we felt it presented a more real world scenario with a more evocative visual cue, rather than a packaged visual.

Certainly, follow-up studies could use packaged foods in order to determine whether differences in calorie estimation and associated measures are present using these stimuli, which might be more analogous to a grocery shopping selection process.

METHOD

Participants

88 undergraduate students from Introductory Psychology courses participated in the current study by completing a survey administered through Qualtrics in exchange for research credit in their courses. The median time to complete the survey was 26 minutes. 22 participants were removed for failing to complete the survey, leaving the analysis on the remaining 66 participants. The sample included 41 females and 25 males. 51.5% of the sample was 18 years of age, 33.3% were 19, 10.6% were 20, and 3% were 21. 66.7% of the sample were freshmen, 21.2% were sophomores, 10.6% were juniors, and 1.5% were seniors. 81.5% lived on-campus, 15.4% lived off-campus with parents or family members, and 3.1% lived off-campus by themselves or with at least one roommate.

Materials

Cognitive Reflection Test

A three item CRT scale has been widely used to measure cognitive reflection (Frederick, 2005); however, an expanded CRT with additional items has also been validated (Toplak et al., 2014). In the current study, in addition to the three item CRT (Frederick, 2005), three additional items came from the expanded CRT (Toplak et al., 2014), and one item was created by the authors. In this test, participants are given a word problem (Ex: A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?) and asked to provide an answer. Answering these items incorrectly was characterized as engaging only intuitive system 1 processes, whereas answering correctly was taken as an indication of engagement and utilization of reflective system 2 processes. Thus, if participants had lower accuracy scores, this was taken as an indication that they have a stronger propensity to depend on system 1 processes. Participants had as much time as they needed to respond to each item and typed their answers into a free response box. In this sample, the mean was 20.0% accuracy (*SD* = 27.6%) and scores ranged from 0% to 100%.

Numeracy Scale

An 11-item Lipkus et al. (2001) numeracy scale was used to determine each participant's level of numerate abilities. This scale asks participants to compare frequencies, translate frequencies into percentages, convert percentages into frequencies, convert decimals into frequencies, and other similar comparisons of numbers across different representation formats. For example, one item asks participants, “The chance of getting a viral infection is .0005 out of 10,000 people, about how many of them are expected to get infected?” Participants typed their answer into a free response box or selected their answer from multiple options when appropriate. In this sample, the mean was 70.0% accuracy (*SD* = 20.2%) and scores ranged from 18.2% to 100%.

Restrained Eating Scale

The 10-item Dutch Restrained Eating Scale (van Strien et al., 1986) uses a 5 point Likert scale (never, seldom, sometimes, often, very often) to assess an individual’s degree of eating restraint behavior. Items such as “Do you try to eat less at meal times than you would like to eat?” are used, where higher scores indicate higher levels of restrained eating. In this sample, the scale was reliable ($\alpha = 0.93$) with a mean of 24.64 (*SD* = 9.13) where scores ranged from 10 to 48.

Calorie Estimation Task

The calorie estimation task presented images of various foods from a validated database of food images with associated nutrition information (Blechert et al., 2019). 20 images were used originally, but one had to be eliminated due to missing calorie information, thus 19 images were examined in data analyses. For analysis purposes, the items were sorted into the following categories: entrees (Ex: spaghetti, salmon), fruits (Ex: mixed berries), vegetables (Ex: salad), and desserts (Ex: cookies, cake), but were provided in a random order during the task. Participants were asked to give their best estimate of the calories present in the food pictured. Since the database of food images also includes the specific calories in each food, we were able to compute the accuracy of the participants’ estimates.

Demographic Questions

Additional demographic characteristics were also obtained. These questions ascertained information such as age, gender, height, weight, dieting status, and exercise status. Participants were asked about their eating behaviors with questions such as, “How often do you check Nutrition Facts panels before purchasing or eating items?”

RESULTS

Sample Characteristics

Before delving into the details of the calorie estimation task and more specific comparisons, we felt it important to provide some pertinent participant characteristics. Specifically, factors such as the participants' BMI and how often they report using NFPs understandably could influence results, so a summary of this information is pertinent. Based on participants' self-reported height and weight, we calculated their BMI. Within our sample we observed 3.1% were underweight, 49.2% were normal weight, 27.7% overweight, and 20.0% obese. It should be noted that these values are below the overweight and obese rates in the U.S. at present. Additionally, when asked how often participants use NFPs, 16.7% reported never, 19.7% reported rarely, 39.4% reported sometimes, 13.6% reported often, and 10.6% reported always. In sum, 63.6% reported at least sometimes checking NFPs, putting our sample slightly below the 77 - 79% values reported by Lin et al. (2016).

Calorie Estimations

With regard to calorie estimation accuracy, we start by presenting the results by item and move towards analyzing whether the cognitive and dietary factors we investigated significantly impacted accuracy. With an item by item analysis, we observed a general pattern where the higher the calories, the more likely the participants were to underestimate. All of the items over a 500 calorie threshold (five items) had average estimates more than 100 calories below the actual calories, with an average underestimation of nearly 167 calories. This equates to underestimates 27.7% below the actual calories.

For items below 500 calories (14 items), we found three items resulted in underestimations (orange, bran cereal, and chocolate muffin), while 11 items resulted in overestimations varying from a slight overestimating of calories in salmon (+2.3 calories), to a larger overestimate for a steak, baked potato, and mixed veggies (+190.52 calories). For items under 100 calories, which consisted of only fruits and vegetables, we found one item resulted in underestimations (orange), while four items resulted in overestimations, the largest difference being a salad without salad dressing (+152.64 calories). A summary of calorie estimations, actual calories, and the mean differences by items is presented in Table 1 below.

***Table 1*. Calorie Estimations**

Item	Mean Estimate	Actual Calories	Mean Difference
Entrees			
Gyro	469.41	672	-202.59
Ham Sandwich	346.8	536.08	-189.27
Cheeseburger	571.02	759.5	-188.48
Turkey Sub w/ Chips	404.94	545.3	-140.36
Pancakes w/ fruit topping	389.29	503.2	-113.91
Salmon	214.8	212.5	+2.30
Spaghetti	383.88	347.5	+36.38
Steak and grilled veggies	418.27	320.58	+97.69
Steak, baked potato, veggies	565	374.48	+190.52
Fruit			
Orange	66.36	94	-27.63
Mixed Berries	116	64.5	+51.50
Fruit cup	138.47	79.5	+58.97
Vegetables			
Salad w/o dressing	159.82	37.5	+122.32
Salad w/o dressing	184.62	31.98	+152.64
Desserts			
Chocolate Muffin	242.65	343.2	-100.55
Chocolate Donut	258.97	231	+27.97
Chocolate Cookies	333.86	259.11	+74.76
Chocolate Cake	412.2	243.75	+168.45
Bran cereal	205.11	284	-78.89

For subsequent analyses, we grouped the items by category (entrees, fruit, vegetables, desserts). Looking at the participant characteristics for a moment, we did observe differences in calorie estimation for entrees as a function of participants BMI.

Table 2 summarizes these mean differences in estimations for the entrees. While not significantly different, there was a trend showing that the obese participants had less accurate and lower estimates for the calories in entrees compared to the normal and overweight participants. There were no notable differences in fruits, vegetables, or desserts estimations across BMI groups.

***Table 2*. Calorie Estimations for Entrees by BMI**

	Underweight	Normal	Overweight	Obese
n	2	32	18	13
Entrees - Mean Differences	-109.02	-40.68	-30.74	-112.02
Entrees - SD	84.85	174.99	135.52	154.76

Cognitive Factors

We next assessed the impact of cognitive reflection, numeracy, and restrained eating on calorie estimation accuracy. Within these comparisons, we sought to examine whether individuals higher or lower in these factors were more or less likely to over or underestimate the calories. While both are concerning regarding accuracy, underestimates are arguably more concerning for their potential contribution towards overconsumption and obesity. In these analyses, we were assessing whether there were systematic ways these factors could make someone potentially more prone to less accurate calorie estimations.

Cognitive Reflection

We did not observe significant differences in calorie estimation as a function of cognitive reflection after using a median split to create high and low CRT groups. In examining the mean calorie estimates, both low and high CRT participants underestimated entrees and overestimated fruits, vegetables, and desserts. That said, for entrees, fruits, and vegetables, the high CRT group had estimates that were marginally closer to the actual calories, on average. No significant differences between CRT participants were observed in any of the food categories however. These results are summarized in Table 3 below.

***Table 3*. Summary of Calorie Estimations by CRT**

	Low CRT Mean Differences	High CRT Mean Differences	*t*	*p*	*d*
Entrees	-69.09	-42.94	-0.665	.508	-.16
Fruits	35.95	18.75	1.043	.301	.26
Vegetables	154.05	119.87	1.496	.140	.37
Desserts	35.46	50.31	-0.459	.648	-.11

Note: Mean Differences represent the mean of estimated calories minus actual calories in the above categories. Therefore positive values represent overestimations, while negative values represent underestimations.

Numeracy

With regards to numeracy, we found a significant difference in entree estimation accuracy, and nearly a significant difference in dessert estimation accuracy. Using a median split of numeracy, we found that the low numeracy group was more likely to underestimate the calories of the entrees, while those with high numeracy scores were more accurate on average, $t(64) = -2.663$, $p < .05$, $d = -0.66$. This is troubling for the low numeracy participants given the higher caloric totals in the entrees. Interestingly, high numeracy participants were more likely to have higher estimates for the desserts, as the difference between estimates based on the numeracy groups was nearly significant in this category, $t(64) = -1.931$, $p = .058$, $d = -0.48$. There were not significant differences amongst the fruits and vegetables categories. These results are summarized in Table 4 below.

***Table 4*. Summary of Calorie Estimations by Numeracy**

	Low Numeracy Mean Differences	High Numeracy Mean Differences	*t*	*p*	*d*
Entrees	-99.16	1.60	-2.663	.010*	-.66
Fruits	27.42	27.87	-0.027	.979	-.01
Vegetables	134.22	141.90	-0.327	.745	-.08
Desserts	16.55	78.09	-1.931	.058	-.48

Note: Mean Differences represent the mean of estimated calories minus actual calories in the above categories. Therefore positive values represent overestimations, while negative values represent underestimations.
*p<.05

Restrained Eating

We observed no differences in calorie estimation as a function of restrained eating. Participants low and high in restrained eating both underestimated entrees on average, overestimated fruits and vegetables, and overestimated desserts, consistent with the pattern observed on the overall calorie estimations in Table 1. We did observe a positive correlation between restrained eating and how often participants reported checking NFPs, $r = 0.43$, $p < .001$, where participants who more often report checking NFPs also appeared more prone towards restrained eating behaviors.

Demographic Influences

In conducting further exploratory analyses based on demographic variables, we observed differences in calorie estimation based upon gender. As summarized in Table 5, within the entrees, female participants had significantly lower estimates than their male counterparts, with males being more accurate on average, $t(64) = 2.43$, $p = .018$, $d = 0.62$. Additionally, we observed that within desserts, the difference between genders was approaching significance, with females trending towards being more accurate on average, $t(64) = 1.70$, $p = .094$, $d = 0.43$.

***Table 5*. Summary of Calorie Estimations by Gender**

	Female Mean Differences	Male Mean Differences	*t*	*p*	*d*
Entrees	-92.12	2.145	2.43	.018*	.62
Fruits	22.03	36.76	0.86	.391	.22
Vegetables	132.93	144.94	0.50	.617	.13
Desserts	21.60	77.20	1.70	.094	.43

Note: Mean Differences represent the mean of estimated calories minus actual calories in the above categories. Therefore positive values represent overestimations, while negative values represent underestimations.
*p<.05

Multiple Regression

In further assessing the impact of cognitive reflection, numeracy, and restrained eating, a multiple regression analysis was used to test if these variables impacted the accuracy of the calorie estimation. In using cognitive reflection, numeracy, and restrained eating as predictors of calorie estimation in the four categories, no significant models emerged. However, numeracy alone was nearly a significant predictor of entree calorie estimation, $R^2 = .06$, $F(1, 64) = 3.89$, $p = .053$, which is unsurprising given the aforementioned significant t-test.

DISCUSSION

The goals of the present study were to assess how accurate consumers are in their ability to estimate calories and secondly, to examine whether cognitive and dietary factors could predict accuracy. A number of factors were assessed, including cognitive reflection, numeracy, restrained eating, and additional demographic factors such as BMI and gender. BMI appeared to potentially influence entree estimation when analyzing mean values, but overall did not show any significant predictive ability. Similarly, cognitive reflection and restrained eating also failed to predict calorie estimation accuracy.

Overall, when analyzing calorie accuracy we found that the higher the actual calories, the more likely consumers were to underestimate the calories. As shown in Table 1, the five items over 500 calories all had mean estimates more than 100 calories below the actual calories on average, and three of the items had mean estimates more than 180 calories below the actual calories. This finding is perhaps the most concerning one, especially as we consider the accuracy of potential estimates for foods that are well over 500 calories or those that approach or exceed 1000 calories. While that number may sound inflated or unrealistic to some, one must only look at a fast food combo meal to see how realistic it is. The inability to accurately estimate calories is a fundamental problem for the way in which consumers seek to eat and maintain a healthy lifestyle. If consumers struggle to properly estimate calories for the foods or meals they consume, and if these misestimations or miscalculations occur numerous times per day, this presents a monumental concern given the accumulating effects of even small underestimations over time.

Looking more specifically in regards to estimation accuracy and our predicted variables of interest, numeracy was found to impact calorie estimation among the entrees. To recap, those participants who scored higher on the numeracy measure had significantly more accurate entree estimations, while those with lower numeracy scores were more likely to underestimate the entree calories. Having low numeracy has been associated with a range of health concerns, and now we see the impact in this domain (Cavanaugh et al., 2008; Marden et al., 2012; Rolison et al., 2012; Schwartz et al., 1997). While we are not contending that one need to brush up on their mathematical skills while sitting at the dinner table, we are concerned that these numeracy struggles will continue to rear themselves not only in somewhat narrow domains like calorie estimation, but also more broadly in domains related to dietary decisions and other health and well-being domains where numeric information is at the forefront. We also observed differences in entree estimation based upon gender, where male participants had more accurate entree estimations than their female counterparts. This finding is perhaps influenced by differences in numeracy as males (M = 76.0%, SD = 19.1%) on average scored higher on the numeracy measure than females (M = 66.3%, SD = 20.3%), and numeracy itself nearly predicted entree estimation accuracy. Analyzing who is more or less prone to these misestimations and which factors are more important in these estimations allows researchers and policy makers to consider whether there are systematic biases inherent in the way calorie and nutritional information is currently utilized by consumers. With such an understanding, positive changes can be brought about to the structure of NFPs, such that the way the information is presented might be not only more usable, but also more equitable.

Conclusions

Taking these findings collectively, we feel the broad pattern of results paints a picture that is problematic for consumers. For the higher calorie foods, it appears more likely a consumer will underestimate the calories. When considering foods well above 500 calories, one can envision these underestimates becoming even more severe. In our study, the highest calorie count was a cheeseburger at 759.5 calories. That is, just a cheeseburger, with no additional items that one might naturally consume in a meal with a cheeseburger. For comparison, a McDonalds Quarter Pounder with cheese combo meal with medium fries and medium Coca-Cola is 1100 calories. It hardly feels like a stretch to imagine one might further underestimate a higher calorie combo meal compared to the sandwich itself, however research should seek to confirm this claim.

Underestimating calories for high calorie items has direct implications concerning overconsumption and potential weight gain and/or obesity. The inability to accurately estimate foods with a higher number of calories means the potential negative impact of high caloric meals is not fully understood or recognized by consumers. It is one thing to consume a high calorie meal and then adjust future consumption accordingly. However, when consumers are not able to accurately estimate their caloric intake, adjustments thereafter presumably become scarcer. If one is unable to recognize through their estimate that a food is x amount of calories then any adjustments thereafter will also be flawed by this initial misestimation. Thinking about this beyond just the scope of meals within a single day or week or month, but collectively over months or years, it becomes even more concerning and distressing. These conclusions become further troublesome when we think about certain groups being even more likely to make these underestimations. As a reminder, both women and low numerate participants appeared more likely to underestimate the calories in the entrees making them potentially even more at risk of these miscalculations. If we couple these concerns together, we see a pattern in which it is hard to conclude that consumers are getting the calorie information they need in a way that meaningfully informs their decision making.

These findings present further evidence that there is a need to find ways to simplify calorie and nutrition information so that all consumers have equal access to the information. If this information remains difficult to ascertain, either by complexity or by promoting miscalculations, it is unable to offer consumers vital information that they could use to make their dietary selections. It is our view that when advocating for changes to NFPs and the presentation of nutrition information, all parties should be concerned with simplifying the way this information is presented if there is to be any hope for positive changes in how this information is used by consumers. If the majority of consumers say they check these NFPs and a large portion actually do, these panels should be constructed in such a way that accurately and meaningfully informs their decisions. Using visual cues, decreasing the amount of numeric information, and creating a system that allows consumers to use their intuitive system 1 in order to get the information they need is paramount if we hope these NFPs will be useful. Beyond NFPs, we should also concern ourselves with how all parties ascertain numeric health information. How we construct health literature, how charts and graphs are presented, how numeric information is displayed all need scrutiny in order to ensure that this information is presented in an accessible and equitable manner. The present study was concerned only with calorie estimation and NFPs, but there is much that can be done in this area.

Using labels that inform consumers of the nutritional value of their food, in a way that informs their decisions, has the potential for an enormous impact on the obesity crisis. Even if a relatively small percentage of consumers are affected, these alterations in behavior can have a significant impact on the health of the populous. Tackling the obesity crisis is not a one size fits all approach with only a few interventions, but rather a host of small interventions and improvements that can seek to collectively have a large impact. The more we take into account a broad range of possible concerns like the ones noted here, the more we can hope to make a meaningful collective difference in obesity rates and positively affect the health and well-being of all.

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