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Univariate and Default Standard Unit Biases in Estimation of Body Weight and Caloric Content

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College students estimated the weight of adult women from either photographs or a live presentation by a set of models and estimated the calories in 1 of 2 actual meals. The 2 meals had the same items, but 1 had larger portion sizes than the other. The results suggest: (a) Judgments are biased toward transforming the example in question to the size and/or properties of a "standard" unit. For estimates of body weight, students assigned weights assuming a standard height, even though height information was provided in the photographs or directly present with live models. (b) There is an inclination to focus on 1 aspect or dimension of the stimulus (e.g., for female figures, their width, for meals the identity of the components as opposed to their size) and either devalue or completely ignore another parameter critical for accurate judgment (height, for the case of body weight estimations). That is, students defaulted to a normative unit size and thus treated the stimulus as a representative, categorical, and unvarying example, and focused on only 1 dimension (univariate bias) in making judgments.

Keywords: biases, unit bias, univariate bias, body image, default standard unit bias

Presented in this article are two types of biases in human judgments. Exemplars of both have been mentioned in the previous literature, but they are more explicitly delineated in this contribution. The first bias is what we coined a default standard unit bias. It refers to the fact that in making judgments, people usually treat an exemplar as if it is the embodiment of the class of entities involved that is typical in their culture, hence ignoring what may be significant departures from that standard. This relates to a previous description of unit bias, in which Geier, Rozin, and Doros (2006) showed that people's intake of food tends to be limited to one culturally acceptable standard unit.

The second bias utilized is what has been coined univariate bias, and refers to the tendency of people to assess multidimensional entities as if they have a single dimension. This idea, originating in Piaget (1932) developed particularly in the domain of unidimensional judgments of size by a number of authors (e.g., Chandon & Ordabayeva, 2008; Krider, Raghubir, & Krishna, 2001; Krishna, 2007; Wansink & van Ittersum, 2003, 2005). We discuss these two biases in more detail below.

Default Standard Unit Bias

The pragmatics of normal communication often allow for otherwise ambiguous statements to be consensually understood. Frequently, missing information is simply implied or, at the least, can be ascertained using contextual clues. When someone says, "Please pass the salt," no one feels that it is necessary to bring in a football quarterback to accomplish the request. When we ask someone, "Do you like asparagus?" we interpret that person's answer to mean asparagus prepared in the way in which they like it. If they dislike white asparagus or a sip of a friend's asparagus milkshake, we correctly presume that this would not influence their response. Although these types of heuristics are useful in day-to-day communication, we argue that they are sometimes problematic, as in weight and calorie estimations.

How many calories are there in a Coke? A particularly calorie-conscious individual might respond "110 calories," recalling the calorie value of the standard 12 ounce, nondiet Coke. However, this seemingly straightforward question is impossible to answer without crucial additional information. The caloric value depends on a number of variables: Is it a regular Coke or a diet Coke? If it is nondiet, then does it contain cherry or vanilla syrup? Is it an 8 ounce glass, a 12 ounce can or the ubiquitous, plastic 20 ounce bottle?

Despite the plethora of Coke sizes and varieties, the response of 110 calories is reasonably informed. Most individuals hearing this information would interpret it correctly because there is sufficient consensus that "a Coke" refers to a 12 ounce, nondiet, can of Classic Coke. This paper addresses this very type of situation, in which individuals make estimates on the basis of what they believe is a default standard unit. We call this a *default standard unit bias*. It is of particular importance when coupled with what we already have defined as *unit bias* (Geier et al., 2006), which indicates that people often consider a single entity or unit (such as a 230 kCal hamburger or a 680 kCal one) as an appropriate portion for, say, lunch. What constitutes a unit may or may not be part of a general consensus, and may or may not be relevant in the situation at hand.

There are similarities between what we call the default standard heuristic that we present and the representativeness heuristic widely studied in decision making (Kahneman & Tversky, 1972). In the representativeness heuristic, a probability judgment is unduly influenced and inflated when the example is perceived as

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particularly representative or typical of the relevant population. In both cases, a standard is applied or overvalued when it may be inappropriate to do so.

Univariate Bias

The definition of units, and other judgments of size are influenced by another bias, which we call *univariate bias*. Presumably as a simplification heuristic, individuals often use a single parameter to stand for a set of critical variables. The original source of information on univariate bias comes from cognitive development, and judgments of volume by children (Piaget, 1932). In recent years, several studies have examined size judgments from a marketing perspective. This research has important implications both for optimal packaging strategies and for understanding potential factors contributing to overeating. It also has implications for the basic understanding of issues in visuospatial judgments in general. Much of this work has been reviewed recently by Krishna (2007). Research, primarily in the food domain, indicates that single dimensions tend to dominate area or volume judgments (Krider et al., 2001). In particular, the dimension of height tends to dominate width (Chandon & Ordabayeva, 2008; Krider et al., 2001; Wansink & van Ittersum, 2003, 2005; see Krishna, 2006) and judgments of size follow a compressive power function—diminishing sensitivity to size as absolute size increases (Chandon & Wansink, 2007b). All of these demonstrated phenomena produce biases in both area and volume judgments, and in judgments of features tied to area or volume, such as calories. These perceptual biases are accompanied by more cognitive biases, such as a bias to assume that healthier foods have lower caloric density (Chandon & Wansink, 2007a). The tendency for people to prefer to deal with single variables has some parallels with Tetlock's (1986) ideas about integrative complexity, and the tendency for many people, especially those at the political extremes, to use a single value (dimension) to dominate their decisions.

In cases of estimation of body weight, univariate consideration of width alone, ignoring height, can lead to major distortions. A woman who weighs 140 pounds might be heavy if 5 feet tall but slim if 6 feet tall. This bias came to our attention in a pilot, in-class study on gender differences in the estimation of female body weight. We presented a photograph of a female figure (obtained from the Internet), for which we had height and weight information, and asked respondents to estimate her weight. As it happened, the photo we presented was on a uniform background that did not allow for any estimation of height (no ceiling, doors, or standard-sized objects in the picture). Over 95% of a few hundred respondents provided weight estimates. Weight cannot be estimated without height information, and we presume that individuals assigned a default (perhaps mean height to the woman in the photograph). No respondent out of a several hundred commented on the impossibility of making this judgment, and only a few left the item blank.

The Present Paper and the Relation of the Biases

Univariate bias and default standard unit bias are conceptually independent, but empirically they often co-occur. Both are operative when a multidimensional unit is treated as unidimensional (univariate bias), and then serves as a standard for judgments, with variants of that unit assimilated to the properties of the standard (default standard unit bias). This is illustrated when a person judges weight without considering height (univariate bias) and then assumes a person is of standard (e.g., mean) height (default standard unit bias).

This paper empirically tested the following three hypotheses related to estimations of body weight or caloric content.

- Estimations of body weight and calorie amounts will default to an assumed standard height for weight estimations and an assumed standard size (volume or weight) for calorie estimations.
- Estimations of body weight will be insensitive to variation in a critical second variable (height for weight estimations).
- We are uncertain about the degree to which individuals are aware of these biases. Insofar as they are, it would promote specific behaviors in food presentation or self presentation, and particular concerns. For example, because weight estimations tend to ignore height, tall women should be particularly concerned about revealing their weight because the extra weight that they carry around due to their greater height will not be compensated. A tall woman whose weight is announced as 150 pounds will be perceived as fatter than a short woman whose weight is announced as 125 pounds.

Study 1: Estimating Weight of Women From Photographs

Undergraduate students were presented with 10 pictures of women and asked to indicate the weight of the woman in each photograph. In the first picture, no height information was provided or inferable. In all other cases, height information was presented prominently; however, the height information provided for 2 of the figures was varied across participants.

Method

Participants. Undergraduate students in two introductory psychology classes (362 in class "short" and 118 in class "tall"; the term *short* refers to the fact that for the first class, the two critical figures were assigned a shorter height than the same figures were assigned in the second class, which we referred to as tall) at the University of Pennsylvania participated in the study, which was fully authorized by the university IRB. Although participation was voluntary, almost all students completed the questionnaire. The total sample contained 291 women and 189 men. The predominant race was White (61%), followed by East Asian (12%) and South Asian (8%).

Materials. A brief questionnaire was designed to obtain basic demographic information, height, and weight, and to gauge the respondent's level of concern about dieting, body shape, and being weighed. The questionnaire also provided space to record estimates of model weights.

Design and procedure. The questionnaire was administered on the same day to students in two separate sections of an introductory psychology class at the end of class time. At the beginning of the questionnaire, respondents were asked to attend to the projection screen at the front of the room. Ten color photographs of female models were individually projected on the screen for a duration of 10 s each. Respondents were asked to estimate the weight of each woman in the photographs, while the model's picture was on the screen. The stimuli were taken from two sources: a minority of the photographs from Internet sites in which height and weight information was provided and a majority taken by the authors of volunteer female university students, for whom weight and height were measured. To provide a sense of anonymity to the university females that agreed to have their picture shown to hundreds of students who then guessed their weight, the authors electronically generated a small shadow on the central portion of the woman's face in the picture so the viewers (participants in the study) would likely not guess her identity. After the study was completed, we showed the class the results, which included revealing each woman's weight, which was another reason the model's facial features were darkened to preserve anonymity. All of the women in the photographs wore reasonably tight clothing to ensure that body size was relatively apparent. Furthermore, the backgrounds in the photographs were either blank or uninformative as to height (no ceilings, doors, or standard-sized objects in the pictures). The color and style of the clothing was not controlled or systematically varied. Five of the women were wearing slacks, three relatively tight skirts or dresses, and one was in a bathing suit. In all cases, the woman displayed filled the screen vertically. The photograph was viewed by the participants on a large screen in the front of a lecture hall. Although the lecture hall was quite deep, the participants were instructed to sit in the first eight rows. After the first photograph was displayed (the one with no height information), the experimenter pointed out the height information on the following photo, so the participants knew where to look for the information.

The experimenters manipulated two distinct variables in the 10 figure presentations, availability of height information and accuracy of height information. In the remaining 9 photographs, height information (in feet and inches) was displayed clearly on the top right of each photograph (see Figure 1). For Photograph 1, and only Photograph 1, respondents in both classes had available on the questionnaire, in addition to the slot to place the estimated weight, an alternative to circle: "not possible to estimate without further information." To differentiate the two classes, we called one class-short and the other class-tall, based on whether that class saw the short heights or the tall heights. In class-short, the heights listed on the 9 remaining photographs (2 through 10) were the actual heights of the photographed women. Accuracy of height information was manipulated for Photographs 5 and 9 when presented to class-tall. For Photograph 5, class-short was given the correct height for the woman in the photograph (5 ft 3 in), but the height was presented as "5 ft. 11 in." (8 in. taller) for class-tall. In the same manner, Photograph 9, correctly described with a height of 4 ft. 11 in. in class-short, was described as 5 ft. 9 in. tall (10 in. taller) for class-tall. Figure 1 shows Photograph 5 with the shorter height (her true height) or the class-short height displayed.

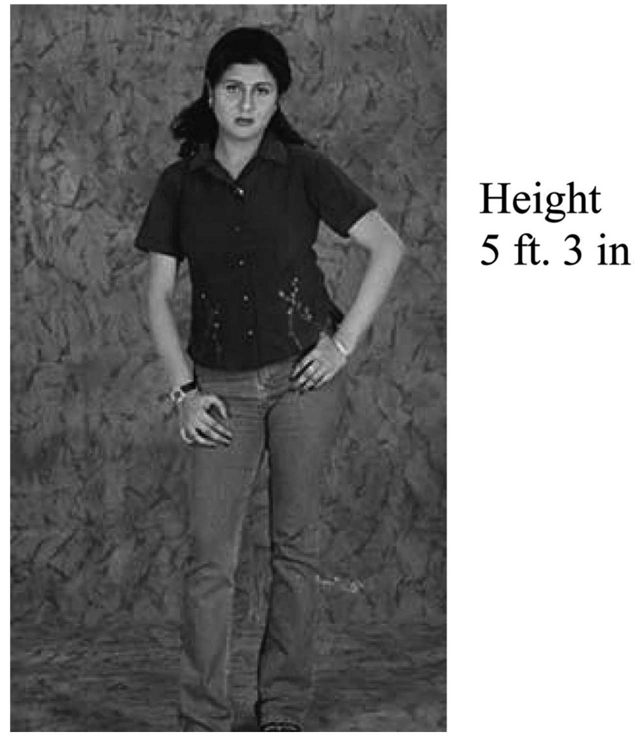

Figure 1. In Study 1, this was a photograph presented in its "short" version, meaning the height information we provided this class was the shorter of the two values. The photograph was viewed by the participants on a large screen in the front of a lecture hall. Although the lecture hall was quite deep, we kept all the participants in the first eight rows. For the other class that saw this same picture, the height was indicated as 5 ft. 11 in., making it the "tall" version. After the participants were presented the photographs and the statistical analyses completed, we learned the manipulating the height information had next to zero effect on a participant's guess of the person in the picture's weight. Body shape was the variable that did effect participants' estimations of weight.

Results

Complete weight estimation data for Photographs 2 through 9 were available for 359 students in class-short and 116 in class-tall, and these were the respondents whose data are presented in the subsequent analysis. Five respondents were excluded because they provided incomplete data. In total, seven figures with the same indicated heights were each estimated by all 475 participants. Overall, there were 288 female and 187 male participants. Distribution of gender by class was significantly different, with 68.7% of class-short participants women, and 48.3% women in class-tall, $\chi^2(1, 475) = 9.94$, $p < .01$.

Analysis of results across the seven common figures indicates that there was a significant gender difference in weight estimation, but that, within gender, there were no significant differences between the two classes. These results are presented in Table 1, broken down by gender and class, and justify combining the results from the two classes, but the data remained segregated by males versus females for the subsequent analysis. As indicated in the table, the mean estimated weight for the seven photographs was 132.8 pounds ($SD = 6.8$) for 288 women, 128.8 pounds ($SD = 9.0$) for 187 men, $t(473) = 5.48$, $p < .001$, $d = .50$. Female estimates were significantly higher. A second measure was error bias in estimates, indicated by the mean difference between estimations and actual weights for women and men. The mean female error was smaller at -1.2 pounds ($SD = 6.8$) compared to the mean male error (5.2, $SD = 9.0$), $t(473) = 5.49$, $p < .001$, $d = .51$. Similarly, the mean absolute value female error was smaller at 9.5 pounds ($SD = 3.4$) compared to the mean absolute value male error (11.4, $SD = 5.2$), $t(473) = 4.86$, $p < .001$, $d = .45$. As indicated in Table 1, in which this analysis is presented both by

Table 1
Study 1 Weight Estimates and Accuracy Across Seven Common Figures by Class and Gender

	Class short		Class tall	
	Women	Men	Women	Men
Mean weight	133.2 (6.9)*	128.8 (9.2)	131.4 (6.4)	129.0 (8.6)[a]
Mean error underestimation	0.8 (6.9)*	5.2 (9.2)	2.6 (6.4)	5.0 (8.6)
Mean absolute error	9.3 (6.6)*	11.4 (5.7)	9.0 (3.8)*	11.3 (4.0)
N	232	127	56	60

Note. The values represent mean weight in pounds with standard deviations in parentheses.
[a] All class differences are insignificant ($p > .05$).
* Indicates a male–female difference for the designated class that is significant at $p < .01$.

class and gender, although four of six gender differences were significant at $p < .01$ or better, none of the six class differences (2 classes by 3 measures) were significant (all $p > .05$).

As a test of the univariate hypothesis, three measures of the degree to which height was compensated for in estimations of weight were employed. The simplest measure was how many participants did not estimate the first figure, which was presented with no height provided. As with all other figures, no information was available in the picture to allow for height estimates in Photograph 1. Despite the obvious presence of the option "not possible to estimate without further information," only 10 out of 475 respondents (2.1%) chose not to make an estimate of the first figure.

Complete estimation data for both classes combined by gender for the seven common photographs and two varied photographs (Numbers 5 and 9) are presented in Table 2, separated by gender, along with the actual weights and heights of the nine females in the photographs and the altered heights presented in Photographs 5 and 9 for class-tall.

A second measure was a comparison of weight estimations of Photographs 5 and 9, which were assigned different heights (8 in. taller in Photograph 5, and 10 in. taller in Photograph 9; see Table 2 and Figure 2) when presented to class-tall. We calculated the BMI (body mass index) for the figures in Photograph 5 and Photograph 9 using their actual heights. We then substituted their increased assigned height into the BMI equation and solved for weight. The woman in Photograph 5 would be expected to weigh 31 pounds more at the greater height, and the woman in Photograph 9 would be expected to weigh 44 pounds more at the increased height. Insofar as participants are height sensitive, the women that were assigned the greater height (both times in class-tall) should have produced a much higher estimation of weight. In none of the four critical pairings (men and women considered separately, for Photograph 5 and 9, each test between the mean short vs. mean tall estimated weights) was there a significantly higher weight estimated for the much taller woman! In two of the four cases, the shorter female was actually estimated as slightly heavier (Table 2, Figure 2).

A third measure of the undervaluing of height in weight estimation is a positive correlation between presented height (for the nine figures for which height was presented) and the degree of weight underestimation. As height increases, weight increases in the real world, but if height is ignored, the underestimation of actual weight should increase. (Our measure of underestimation is a positive number, which is the pounds underestimated.) In particular, according to standard default unit bias, women who are taller than the mean or taller than the default/standard value for female height will have their weight underestimated and those shorter than the mean will have their weight overestimated. For the nine photographs presented in class-short, the correlation (nine

Table 2
Study 1 Weight Estimates of Nine Photographs by Gender

Photo	Height	Weight	BMI	*M* estimate female[a]	Underestimation (actual – *M* estimate)	*M* estimate men[b]	Underestimation (actual – *M* estimate)
2	66	135	21.8	133.9**	1.1	130.0	5.0
3	67	125	19.6	133.1**	–8.1	127.1	–2.1
4	63.75	115	19.9	122.4**	–7.4	117.9	–2.9
5 short	63	115	20.4	125.1	–10.1	119.3	–4.2
5 tall	71	146[c]	20.4	122.9	23.1	117.0	29.0
6	65.5	140	23.0	128.1**	11.9	124.1	15.9
7	66.5	120	19.1	117.5**	2.5	111.0	9.0
8	67	165	25.9	158.9	6.1	160.1	4.9
9 short	59	119	24.1	119.6	–0.6	116.1	2.9
9 tall	69	163[c]	24.1	120.8	42.8	116.1	46.9
10	67	138	21.6	135.9**	2.1	131.7	6.3

[a] $n = 288$ for women except for 232 in Photo 5 short and 9 short and 56 in Photo 5 tall and 9 tall. [b] $n = 187$ for men except for 127 in Photo 5 short and 9 short and 60 in Photo 5 tall and 9 tall. [c] Indicates compensated weight, holding body mass index constant with the short figure.
** Female mean weight lower than male mean weight, $p < .01$ (two-tailed t test; not including Photos 5 and 9).

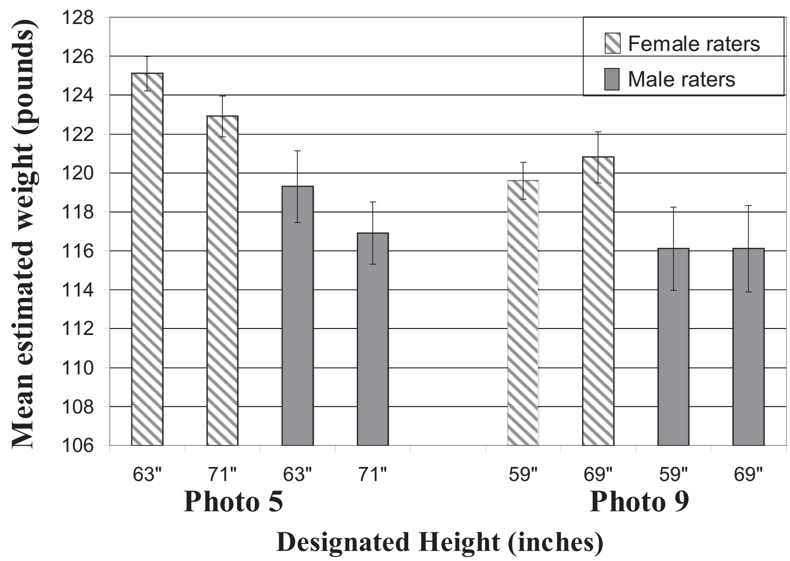

Figure 2. In Study 1, weight estimate bias as a function of stated height of target. Results are for the two photographs (5 and 9) for which different heights were provided in each of the two classes: Class short and Class tall. A woman of the same body mass index (BMI) as the shorter woman in Photograph 5, but with a stated height of 71 in., would be expected to weigh 146 pounds, and a woman of the same BMI as the shorter woman in Photograph 9 but with a stated height of 69 in. would be expected to weigh 163 pounds. Results are presented separately for male and female participants.

pairs of measures, each pair being the presented height of one woman and the difference between actual weight and the mean estimated weight) had a value of .26 for women and .30 for men—neither close to significance because of the small *n* of 9, but in the predicted direction.

For class-tall, the actual weights of the figures in Photographs 5 and 9, both stipulated as much taller, were adjusted to the calculated weights for BMI. The correlation ($n = 9$ pairs) between height and weight underestimation was .69 ($p < .05$) for women, and .71 ($p < .05$) for men, indicating respondents' failure to compensate adequately for height when making weight estimations.

To gain more statistical power to evaluate the predicted positive correlation between height and underestimation of weight, we correlated the nine actual heights with the degree of underestimation scores for each separate participant. For all of the respondents in class-short, the mean was, $r(9) = .15$ ($SD = .34$), in the predicted direction and significantly different from 0, $t(354) = 8.41$, $p < .001$. For all of the respondents in class-tall (with the different heights for Photographs 5 and 9), the mean, $r(9) = -.62$ ($SD = .15$), in the predicted direction and significant, $t(110) = 44.81$, $p < .01$.

All of the results we have described hitherto support Hypothesis 1 (employment of a default weight) and Hypothesis 2 (disregard of height). Height seems to have not simply been undercompensated but virtually eliminated from consideration.

Our third hypothesis was that, given height neglect, taller individuals with some concern about their weight (mainly, women) would be more reluctant to have their weight announced. Their weight would be high on account of their height, but this fact would not be compensated for by people knowing their weight. The questionnaire on which participants recorded weight estimates also included questions about reluctance to being weighed (employed in a separate report on this subject, Geier & Rozin, 2008) and concern about one's weight. Specifically, respondents were asked to "Indicate how uncomfortable you would feel in each of the situations described below on a 0 to 100 scale where 0 represents *not uncomfortable at all* and 100 represents *extremely uncomfortable*." The three critical items about being weighed were: (a) "Getting on a scale to get your weight in front of some male acquaintances," (b) "Getting on a scale to get your weight in front of some female acquaintances," and (c) "Getting your height measured in front of some female acquaintances." There were also three items about general weight concern and attempts to lose weight, reported on a 5-point frequency scale ranging from 1 (*never*), 2 (*rarely*), 3 (*sometimes*), 4 (*often*), to 5 (*almost always*). The items were: (a) "I consciously hold back at meal time to not gain weight," (b) "I am concerned about being overweight," and (c) "I am dieting." These three items were combined into a single weight concern score.

The correlation between a female participant's height and her concern about weight was $r(288) = .04$ (*ns*). The correlation between height and reluctance to have her weight revealed to female friends, $r(288) = .06$; or male friends, $r(288) = .10$; was not significant. Incidentally, there was no significant correlation, $r(288) = .01$; between a female's height and the mean weight she estimated for the seven photographs with the same height provided to all participants. Correlations between a female's weight or BMI and weight concern or sensitivity to having weight revealed, were all significant ($p < .05$), and ranged from $r(288) = .24$ to $r(288) = .31$.

Discussion

The height neglect effect we predicted was even stronger than anticipated. Our data suggest not only that height is undervalued in making weight judgments but also that it is often ignored (univariate bias). Instead, weight estimates from photographs tend to be based on the perception of heaviness, with reference to a more or less standard height of about 5 feet 4 in. (default standard unit bias). The weights of the shortest women tended to be overestimated, and the weights of the tallest women tended to be underestimated. Our results also suggest that women are not aware of this bias; taller women, whose greater weight would not be attributed to their greater height, are not significantly more reluctant to have their weight revealed and are not more concerned about their weight than shorter women.

Study 2: Estimating Weight of Live Female Models

Weight estimates in Study 1 were based on photographs of women, with blank or noninformative (as to size) backgrounds. In 9 of 10 photographs, height in feet and inches was displayed prominently next to the photograph; it was, for some reason, not considered relevant when making weight judgments. There was no way a participant could have not noticed the height dimensions because they were large and the experimenter pointed them out to the participants after the first picture was displayed. This is not the typical situation in which weight is estimated in the real world. Rather, one is usually in the presence of a real person, who is moving and who is in an environment in which there are many clues to height. In Study 2, we reexamined weight estimates using a live situation in which the respondents actually observed live, individual female models.

Method

Participants. Respondents for this study were 158 undergraduate students in an abnormal psychology class (103 women, 55 men) at the University of Pennsylvania, which was fully authorized by the university IRB.

Materials. Seven female graduate or undergraduate student volunteers (none from the respondent class) agreed to have their height and weight measured and to appear before the large auditorium of participants. Each model wore reasonably tight-fitting slacks or skirts, flat shoes, and reasonably tight sweaters. Participants were provided with an anonymous questionnaire, which asked for their own gender, height, and weight and a place to record weight estimates of models.

Design and procedure. Participants were asked to estimate the weight of each female model. One at a time, each model walked from the left side of the front of the lecture hall to the right side, turned 180 degrees, and walked back to the left side. The number (from 1 to 7, in order) for each model was announced as she began to walk across the front of the room. Participants were asked to make a weight estimate next to the number of the model on the provided questionnaire while she was still in the front of the room. After one model returned to the side of the class, the next model began her walk, such that weight estimates were obtained from all participants for each of the seven models.

Results

The results (see Table 3) indicate that there is some compensation for height, but support the hypothesis that weight estimates do not adequately compensate for model height (univariate bias). The weight of the tallest, very slim, model (73.5 in., 133 pounds) was underestimated by a mean of 12 pounds ($p < .01$, single value t test; Table 3), and the weight of the second tallest model (70 in., 172 pounds) was underestimated by a mean of 26 pounds ($p < .01$). These two underestimations compare to a mean underestimation of 6 pounds for the remaining five, shorter models. For the two shortest models, weight was overestimated by 5 pounds. Underestimations of the weights of the taller women and the tendency to overestimate the weight of the shortest women both provide evidence for reference to a default standard.

Overall, the correlation between model height (column 2 of Table 3) and mean underestimation of model weight (next to last column of Table 3) was $r(7) = 0.51$ (*ns*). However, this correlation is based on only seven mean observations. To generate a statistic that was easier to evaluate for significance, we computed this correlation for each of the 158 respondents. The mean correlation was $r(158) = .48$ ($SD = 24$), $t(157) = 25.13$, $p < .01$, significantly above zero.

These data also allowed us to examine sex differences in weight estimations. For all seven models, male weight estimates were lower than female estimates (binomial, $p < .02$, two-tailed). This

Table 3
Study 2: Weight Estimates of Female Models by Sex of Respondent

A Stimulus	B Height	C Real weight	D BMI	E *M* (*SD*) Female estimate	F *M* (*SD*) Male estimate	G F – M Difference from columns E – F	H Difference from real columns (I – C)	I *M* (*SD*) Total estimate
1	70	172	24.7	145.9 (10.8)	145.8 (14.1)	*ns*	–26.1***	145.8 (12.0)
2	73.5	133	17.3	121.3 (8.9)	121.0 (12.3)	*ns*	–11.8***	121.2 (10.2)
3	61.25	100	18.7	112.1 (7.6)	111.1 (8.4)	*ns*	11.7***	111.7 (7.9)
4	59	107	21.6	105.8 (7.4)	104.4 (9.6)	*ns*	–1.8 **	105.3 (8.3)
5	63.25	135	23.7	112.5 (9.2)	106.6 (13.5)	***	–24.5***	110.5 (11.2)
6	65	136	22.6	126.7 (8.3)	121.5 (10.1)	***	–11.1***	124.9 (9.3)
7	64.75	123	20.6	120.0 (7.9)	115.8 (8.3)	**	–4.5***	118.5 (8.3)

Note. $N = 158$; women: $n = 103$; men: $n = 55$. BMI = body mass index.
* $p < .05$ (two-tailed paired t test). ** $p < .01$. *** $p < .001$.

sex difference was significant (at $p < .01$ or better) for three of the seven models (see Table 3). The mean estimated weight across the seven models was 118.0 pounds for male respondents ($N = 55$) and 120.6 pounds for female respondents ($N = 103$). Thus, women estimated weight at an mean of 2.6 pounds heavier than males, $t(156) = 2.33$, $p < .05$, $d = .37$. In terms of accuracy (mean absolute error across the seven models), women were more accurate ($M = 13.77$, $SD = 3.48$) than men ($M = 16.34$, $SD = 4.16$), $t(156) = 4.14$, $p < .001$, $d = .66$. In terms of absolute error in weight judgments, or accuracy, respondents with higher self-reported weight tended to be less accurate than lighter respondents, absolute error and weight: $r(103) = -.28$ for women, $p < .01$; and $r(55) = -.22$ for men, *ns*.

Discussion

The results of both studies thus far show underestimation of the importance of height in judging weight. In Study 1, there is evidence that respondents ignored the height information provided whereas, in Study 2, there was some compensation but notable undercompensation for height. To the degree that height information was ignored, there is evidence for univariate bias. The tendency to underestimate the weight of the tallest individuals and overestimate the weight of the shortest individuals argues in favor of default standard unit bias. Apparently, the presence of real, moving models in contexts that allow for height judgments is more likely to engage consideration of the second dimension (i.e., height).

All of the judgments participants made in both Studies 1 and 2 were of individuals. It is likely that if a direct comparison were provided (e.g., two women of different height), height might have been more salient. Indeed, the better performance in Study 2 might be produced, in part, by the presence of other individuals (the lecturer and the class) when the live models were observed.

It is important to note that in both Study 1 and Study 2, the range of heaviness (BMI) was rather low, with a BMI range of 19.60 to 25.87 in Study 1 and 17.32 to 24.70 in Study 2. Only 1 of the 17 models in the two studies qualified as overweight ($\text{BMI} \geq 25.0$), and that model was barely over this value (25.87). Inclusion of heavier models might lead to different results. In both studies, women were slightly more accurate in estimating weight. In Study 2, heavier/taller/higher BMI respondents were moderately less accurate in making weight judgments.

Study 3: Physical Size of Stimulus as a Factor in Calorie Estimation

Studies 1 and 2 illustrate the phenomena of default standard unit bias and univariate bias in the particular context of estimates of weights of women. To observe the generality of these findings and attempt to discover whether the findings from Studies 1 and 2 were tweaks in the human mind particular to specific issues of height and weight guessing, we next sought to create a completely different scenario with an entirely dissimilar dependant measure, in which we could further study the depth or profundity of these bias concepts this paper has been demonstrating. In this study, in which estimates of the caloric content of meals were made, univariate bias is displayed to the degree that individuals ignore the thickness of a piece of food (meat loaf), in favor of its surface area, and default standard unit bias is illustrated to the degree that there is a categorical judgment of calories based on what would be a standard portion size. The latter default standard unit bias can express itself as underestimation of excess calories when faced with larger than normal portion sizes and overestimation of calories when faced with a smaller than normal portion size. This error in estimation has implications for weight control because perceived calories are an important determinant of the amount of food consumed.

Method

Participants. Three hundred and 88 participants (54% men) were enrolled in the first component of this study (large meal contest) and 265 participants (49% men) were included in the second study component (small meal contest) for a total 648 participants, which was fully authorized by the university IRB. There was no, or very minimal, overlap of participants between the two incidents of data collection. No significant differences were found between the two meal groups (large, small) in height, weight, or BMI ($p > .05$, two-tailed).

Materials. Each participant was provided with a professionally printed 3×5 card that requested the calorie estimation, the student's gender, whether the student had eaten yet (making the calorie guess on entry or departure from the dining facility), height, and weight, and a means of contacting the student (telephone number or email) in case he or she won the \$25 prize for the calorie guess that was closest to the actual caloric value of the displayed food.

Design and procedure. This study was run one time each in two primary student dining halls at the University of Pennsylvania. The two dining halls are located at opposite ends of campus, each near a major student residential complex. There is a strong tendency for students to eat their meals at the dining hall that is in their residence and that they eat from day to day, even though doing so is not required for all. Freshmen are required to eat in the dining halls, and many upperclassmen eat in the halls regularly, as well. Another way to be so certain that the populations did not overlap stemmed from the necessity of each student to swipe their official university ID card to enter any of the student cafeterias at mealtime. We were able to transfer the list of student ID numbers that ate at Site 1 and Site 2 to a spreadsheet and search for comparisons. The output was less than 1%, however that is the lowest this particular program goes, so it actually could have been zero. The only confounding possibility would have been if one student lent his ID to another who looked quite similar, as the guards examine them closely. If that did happen, it certainly would be on a very small scale.

A plate displaying an actual meal was placed on a table near the entrance to the dining hall. Multiple-research associates wearing white chef's coats stood at the entrance to the dining halls, distributed cards and advertised the calorie guessing contest by providing a momentary explanation and pointing to the special display meal. The contest stipulated that the student who came closest to guessing the actual number of calories in the meal on the plate would win \$25. The contest was carried out twice during dinner time, once in each of the two chosen dining halls, a few weeks apart. The calorie-guessing contest continued for one entire meal period (5:00 p.m. to 8:00 p.m.).

Both meals, prepared by the dining service, consisted of two slices of meat loaf without any sauce or gravy, a dry baked potato, and steamed string beans. Two different size meals were used in the contest, a smaller meal of 429 calories was used the first time and a larger meal of 797 calories was used the second time. The calorie increase was accomplished by increasing the sizes of each of the components of the smaller meal by approximately 86%. The plate size was held constant for both meals. The larger meal is calorically more similar to what would generally be considered a standard dinner portion in a university residential cafeteria.

The meals were presented on a pedestal, on top of a table that was difficult to miss by the students entering and exiting the dining hall—it was in the direct path of students entering and exiting the dining hall and we had a large billboard announcing the contest that was hung above the meal. There was a box on the table with a slot in it for the participants to place their filled-out contest card. Last, there was a dining hall printout, of the type and style the students are accustomed to gaining their meal information from, that listed exactly what was on the plate: two slices of meatloaf without gravy or sauce; steamed, string beans; and a dry, baked potato.

The results of the first contest were not announced until after the second iteration of the data collection was completed. However, eventually the two students who had won the contest, one from the initial trial and the other from the final trial, were each paid $25, as promised.

Results

Although the two displayed meals actually differed by 368 (797 minus 429) calories, the mean difference between the calorie estimations of the two meals was only 106 calories; the mean estimates from the two meals were 744 ($SD = 642$) calories for the small meal and 850 ($SD = 495$) for the large meal. The difference between the two conditions is significant, $t(651) = 2.369$, $p < .05$, $d = .19$. Thus, calorie estimations demonstrate some recognition of the size difference. The large meal was estimated at a mean of 53 calories more than the actual caloric value of the large meal, which is a rather accurate estimate. On the other hand, the small meal, which contained 429 calories, was overestimated at 744 calories, an excess of 315 calories, and only 53 calories less than the actual caloric value of the large meal. The larger meal is much closer to the size of the standard meal, supporting, again, the idea of a default standard unit bias for common situations in our environment.

To compare estimates of the two meals directly, we randomly selected 265 of the 388 large meal respondents and randomly paired these with the 265 small meal respondents, ensuring that no individual large meal respondent was assigned more than once. In this assignment, the mean calorie estimate for the 265 large meal respondents was 833 ($SD = 519.3$, slightly lower than the 850 value of the 388 large meal respondents). The estimated calorie difference for this set of 265 paired observations was 88.6 calories, not significant by the usual criteria, $t(264) = 1.80$, $p = .073$. On the other hand, the difference of 88.6 calories is significantly below the actual difference of 368 calories, $t(264) = 5.69$, $p < .01$.

Our findings indicate a major bias to assimilate the smaller portion to the caloric value of the larger, more standard portions. In addition, there is evidence that size difference was actually ignored by some respondents. Of the 265 difference scores (large meal calorie estimate minus small meal calorie estimate for 265 randomly paired respondents), 101 (38%) had a value of 0 or less (indicating no or reverse compensation for size). Calorie estimation was not related to any of the demographic variables collected (height, weight, or BMI, with *ns* varying between 237 and 363 across the high and low meal size groups). The highest absolute correlation of any of these variables with calorie estimation was only 0.13 for height in the small meal group, with no other correlation above 0.08.

Discussion

In accord with the results from Study 1 and Study 2, we report substantial devaluation of the importance of a critical second variable (height in Study 1 and Study 2, and portion size in Study 3). It is possible, in accord with some of the data from Study 1, that the size dimension is totally ignored by some respondents. Although this finding is consistent with univariate bias, the most important conclusion supports default standard unit bias because the smaller than typical meal is judged as very similar in calories to a more normal larger meal.

It appears that one hypothetical explanation to the question of why these detrimental biases are formed is that they are a harmful artifact of the same system that the human brain relies on to constantly build helpful biases to mentally expedite awareness, similar to heuristics, so that when a bark is heard and you catch a glimpse of a furry tail, you instantly think dog. This is useful, as it keeps you from thinking about every other possibility and provides you the correct information 97% of the time. However, with the new biases that this paper (along with unit bias by Geier et al., 2006) presents, they systematically provide the incorrect information, and sometime dramatically incorrect information.

General Discussion

The three studies in this paper support the operation of both a univariate bias and a default standard unit bias. In all three studies, critical dimensions either are devalued, in accordance with the formula offered by Krider et al. (2001), or are actually ignored. The degree to which single dimensions dominate multidimensional judgments probably depends on an individual difference factor (e.g., for weight and calories, gender, or body proportions), on the type of stimulus (e.g., food, female figures), and on the context in which judgments are made. In particular, height was taken into account more with live models than with photographs, even when height was printed on the photograph. We believe most college students, if directly asked, would report that greater height usually implies greater weight, and that larger portions have more calories. A critical question for future research is what determines the most salient or primary dimension(s). Krishna (2006) showed that although height dominates width in the elongation bias when objects are examined visually, the opposite holds when the critical modality is touch. So along with the context of judgment, the object of judgment, and individual differences, the sensory modality is also a determinant.

Specifically, we demonstrated for the first time that weight judgments of women either underestimate the importance of height or actually ignore it. These estimations seem to be based either on the assumption of a default height even with explicit contradictory evidence available and/or on a sometimes misleading correlate of weight—apparent heaviness. Finally, we find that estimates of calories in displayed food are often inaccurate and that portion size is downplayed and often ignored.

We recognize that the range of heaviness (BMI) was rather narrow in both Study 1 and Study 2, and that presentation of obese models might have modified the results. In particular, we note that for the models in Study 2, height was actually a better predictor of actual weight than was BMI, which is not the case for a broader and much larger sample of women (Rozin, Bauer, & Catanese, 2003). It is likely that if we had asked participants in Study 1 or Study 2 to estimate the height of the models, performance might have become more accurate.

Our results are consistent with the findings of both Krider et al. (2001) and Chandon and Wansink (2007b). There appears to be not only a reliance on single dimensions (Krider et al., 2001) and a compressive power function (Chandon & Wansink, 2007b), but some degree of categorical judgments. We embody the latter in what we describe as default standard unit bias. This is demonstrated by our initial example in this paper, of individuals being willing to estimate the calories in "a Coke." Resorting to a default standard is consistent with our idea about unit bias, a predilection for a particular reference amount that tends to assimilate a range of varied amounts or portions to a standard value (Geier et al., 2006).

There is wide variation in the judgments of weight and calories reported from our three studies. Standard demographic variables (gender, weight, height) played, at most, a minor role in explaining this variation. Generally, women seem to make higher and more accurate body weight judgments, but the effects are small (Wansink, Painter, & North, 2005).

Our evidence suggests that individuals are not aware of height neglect in weight judgments. One result of height neglect is underestimation of the weight of taller people, which often leads to a surprise if there is access to their true weight. Generally, taller women seem unaware of this bias in that they are no more uncomfortable about either their weight or having it revealed than shorter women are.

Our results highlight certain biases in human judgment. One, related to unit bias, is the adoption of a categorical, default standard size prior to making estimations (in our study, this normative size would be about 5 ft 4 in. or 5 ft 5 in. for women). A second bias is a tendency to focus on a single dimension to make judgments even though more than one dimension is required for accurate emphasis, what we call univariate bias (Krider et al., 2001; Krishna, 2007; Wansink & van Ittersum, 2003, 2005). It is akin to providing the number of square inches on a billboard after only measuring one of the two required dimensions.

The food domain is of particular importance, in terms of pleasure, economics, time spent, and health (Wansink, 2006). A great deal of energy is spent in the production and marketing of food. Consumers face many choices, varying along many dimensions, and are attempting to weigh different, often competing values, such as cost, healthiness, and liking. For all of these reasons, food choice is a fertile area to study biases and heuristics, including the two we have emphasized in this paper. Other documented biases include the tendency to dichotomize foods as good or bad for health, and to believe that if something is harmful at high levels, it is also harmful at low levels (see the "monotonic mind" in Rozin, Ashmore, & Markwith, 1996).

Overeating and overweight are problems for many Americans, and distortions of weight and calorie estimation, particularly calories, could work either to enhance or to reduce these problems. Creative packaging and other framings could take advantage of the distortions reported in this paper to reduce intake and weight (Wansink, Painter, & Yeon-Kyung, 2006). For example, in conjunction with unit bias (Geier et al., 2006), our results suggest that modest decreases in portion size may go unnoticed and have no effect on estimated calories consumed. Because voluntary dieting is notoriously unsuccessful, more subtle forms of involuntary and unnoticed dieting, such as small decreases in portion size, might prove to be a promising intervention for improving the health and weight of Americans (and others). Such changes can be made at institutional as well as individual levels. For example, the smaller portion sizes in France seem to have the desired effect—that is, they probably contribute to the lower BMIs of French vis-à-vis the BMIs of Americans (Rozin, Kabnick, Pete, Fischler, & Shields, 2003), and there is experimental evidence suggesting that reduced portion size decreases food intake (e.g., Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Rolls, Morris, & Roe, 2002).

More particular, insofar as height is a visually salient dimension in judging size, apparent portion size could be increased by increasing height of packages, at the expense of width. In this regard, knowing the salient dimension that tends to dominate in accord with univariate bias allows for the possibility of creating size distortions. Of course, such distortions may be used to improve health or improve profits, or both. In general, our results are in accord with an increasing cognizance of the importance of the environment in controlling food intake (Brownell, 2002; Hill & Peters, 1998; Levitsky, 2005; Nestle, 2002; Rolls, 2003; Rozin, 2005; Wansink, 2004).

References

Brownell, K. D. (2002). Public policy and the prevention of obesity. In C. Fairburn & K. Brownell (Eds.), *Eating disorders and obesity: A comprehensive handbook* (2nd ed., pp. 27–49). New York: Guilford.

Chandon, P., & Ordabayeva, N. (2008). *Downsize in 3D, supersize in 1D: Effects of the dimensionality of product resizing on estimations of size changes, size choices, and quantity discount expectations.* Manuscript submitted for publication.

Chandon, P., & Wansink, B. (2007a). The biasing health-halos of fast-food restaurant claims: Lower calorie estimates and higher side-dish consumption intentions. *Journal of Consumer Research, 34,* 301–314.

Chandon, P., & Wansink, B. (2007b). Is obesity caused by calorie underestimation? A psychophysical model of fast-food meal size estimation. *Journal of Marketing Research, 44,* 84–99.

Diliberti, N., Bordi, P. L., Conklin, M. T., Roe, L. S., & Rolls, B. (2004). Increased portion size leads to increased energy intake in a restaurant meal. *Obesity Research, 12,* 562–568.

Geier, A. B., & Rozin, P. (2008). Weighing discomfort in college age American females: Incidence and causes. *Appetite, 51,* 173–177.

Geier, A. B., Rozin, P., & Doros, G. (2006). Unit bias: A new heuristic that helps explain the effect of portion size on food intake. *Psychological Science, 17,* 521–525.

Hill, J. O., & Peters, J. C. (1998). Environmental contributions to the obesity epidemic. *Science, 280,* 1371–1374.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology, 3,* 430–454.

Krider, R. E., Raghubir, P., & Krishna, A. (2001). Pizzas: Pi or square? Psychophysical biases in area comparisons. *Marketing Science, 20,* 405–425.

Krishna, A. (2006). Interaction of senses. The effect of vision versus touch on the elongation bias. *Journal of Consumer Research, 32,* 557–566.

Krishna, A. (2007). Biases in spatial perception: A review and integrative framework. In M. Wedel & R. Pieters (Eds.), *Visual marketing: From attention to action* (pp. 138–151). Mahwah, NJ: Erlbaum.

Levitsky, D. A. (2005). The non-regulation of food intake in humans: Hope for reversing the epidemic of obesity. *Physiology and Behavior, 86,* 623–632.

Nestle, M. (2002). *Food politics. How the food industry influences nutrition and health.* Berkeley: University of California.

Piaget, J. (1932). *The child's conception of casualty.* London: Kegan Paul, French, Trubner.

Rolls, B. J. (2003). The supersizing of America. Portion size and the obesity epidemic. *Nutrition Today, 38*(2), 42–53.

Rolls, B. J., Morris, E. L., & Roe, L. S. (2002). Portion size of food affects energy intake in normal-weight and overweight men and women. *American Journal of Clinical Nutrition, 76,* 1207–1213.

Rozin, P. (2005). The meaning of food in our lives: A cross-cultural perspective on eating and well-being. *Journal of Nutrition Education and Behavior, 37,* S107–S112.

Rozin, P., Ashmore, M. B., & Markwith, M. (1996). Lay American conceptions of nutrition: Dose insensitivity, categorical thinking, contagion, and the monotonic mind. *Health Psychology, 15,* 438–447.

Rozin, P., Bauer, R., & Catanese, D. (2003). Attitudes to food and eating in American college students in six different regions of the United States. *Journal of Personality and Social Psychology, 85,* 132–141.

Rozin, P., Kabnick, K., Pete, E., Fischler, C., & Shields, C. (2003). The ecology of eating: Part of the French paradox results from lower food intake in French than Americans, because of smaller portion sizes. *Psychological Science, 14,* 450–454.

Tetlock, P. E. (1986). A value pluralism model of ideological reasoning. *Journal of Personality and Social Psychology: Personality Processes and Individual Differences, 50,* 819–827.

Wansink, B. (2004). Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition, 24,* 455–479.

Wansink, B. (2006). *Mindless eating.* New York: Bantam.

Wansink, B., & van Ittersum, K. (2003), Bottoms up! The influence of elongation on pouring and consumption volume. *Journal of Consumer Research, 30,* 455–463.

Wansink, B., & van Ittersum, K. (2005). Shape of glass and amount of alcohol poured: Comparative study of effect of practice and concentration. *British Medical Journal, 331,* 24–31.

Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: Why visual cues of portion size may influence food intake. *Obesity Research, 13,* 93–100.

Wansink, B., Painter, J. E., & Yeon-Kyung, L. (2006). Proximity's influence on estimated and actual candy consumption. *International Journal of Obesity, 30,* 871–875.

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