

The effects of satiety and hunger on normal, overweight, and obese BMI ranges

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Abstract

The purpose of this project was to determine if normal, overweight, and obese people experience different amounts of hunger before eating and satiety after eating. Our hypothesis is there are higher sensations of satiety, and lower sensations of hunger among Normal Weight than Overweight and Obese people. The study compared hunger and satiety levels before and after eating amongst normal, overweight, and obese Body Mass Index (BMI) categories using a Labeled Magnitude Scale (LMS). Forty-five subjects (29 normal, 13 overweight, and 3 obese) rated thirty phrases using LMS hunger and satiety scales. The scale was 100 mm in length having the intensity descriptors of hunger and fullness as follows: strongest imaginable sensation, extremely, very, moderately, slightly, barely detectable, no sensation. Because there were so few obese people, I grouped the overweight and obese answers to compare with the normal weight answers. The results for the first ten survey questions, which were situational hunger and fullness questions, typically showed overweight and obese people being hungrier than normal weight people, for example “how hungry/full do you feel after not have eaten for 24 hours.” Overweight and obese people were fuller than normal weight people when the scenarios were more geared towards fullness, for example, “after a complete Thanksgiving dinner.” The last twenty survey questions were specific food questions that displayed the overweight and obese people less hungry after eating the item in comparison to normal weight people. In addition, the averages of the overweight and obese people for the specific food questions

presented the overweight and obese people being fuller than normal weight people after eating the various foods asked in the survey.

Introduction

Obese compared to non-obese individuals may have different amounts of hunger and satiety experiences; although there is no current evidence that “the sensory experience associated with maximal fullness (or hunger) may be different for ... obese vs. non-obese” (Cardello et al., 2004, p. 10). We believe people generally regulate their weight precisely by responding to their inner cues of hunger and fullness to start and stop eating. Overweight/obese individuals may experience more hunger and/or less satiety, thus starting to eat sooner or stopping eating later than people with of normal weight. Overweight and obese people may gauge their fullness level based on their previous fullness experiences. If obese and overweight individuals are used to eating a certain amount of food everyday in order to feel full this amount may be different than the amount of food normal weight people are used to eating for them to feel full. Therefore, overweight and obese people may have different hunger and satiety experiences compared to normal weight people that could affect the overall answers of the survey questions.

A way to see if obese and non-obese people have different food sensation experiences is to have individuals rate their sensory experiences (Bartoshuk, Snyder, 2008, p. 401). We decided to use a 100 mm labeled magnitude scale (LMS) to measure the satiety and hunger of the participants. “The LMS, developed by Green, Shaffer, and Gilmore (1993), Green et al. (1996), has the following characteristics: (1) a high end anchor corresponding to the strongest sensation imaginable, (2) a quasi-logarithmic spacing of intermediate word anchors determined by magnitude estimation scaling of their implied intensity values, (3) a response task of making a

mark on the (usually vertical) line with the data consisting of the distance scored from the bottom end” (Cardello, Lawless, Schutz, 2008, p. 473). The number values were hidden from the panelists concerning distraction away from the focus of the question. Averages can then be calculated to make comparisons. There will be separate hunger and fullness LMS scales with “labels consist[ing] of adjective/adverb intensity descriptors” (Bartoshuk, Duffy et al., 2004, p. 109). These intensity descriptors along with the top end labeled as “strongest imaginable sensation” will be valid to compare the intensity of sensations among the different BMI groups i.e. Normal Weight, Overweight, and Obese. According to Cardello et al., “scale usage is influenced by the end anchor terms” (Cardello, Lawless, Schutz, 2008, p. 479). The label “strongest imaginable sensation” was the top anchor for both the hunger and satiety scale because by using a less intense extreme anchor ratings are produced over a larger range of the available scale producing less of a compression affect (Cardello, Lawless, Schutz, 2008, p. 479). Scale usage is also influenced by spacing of labels on the scale. As the scale gets smaller the more compression of the ratings; therefore, the results are fixed in one area.

The purpose of this project was to determine if normal, overweight, and obese people experience different amounts of hunger before eating and satiety after eating. Our hypothesis is that there are higher sensations of satiety, and lower sensations of hunger among Normal Weight than Overweight and Obese people.

Research Methods and Procedures

Participants

A total of 6 (2 males, 4 females) obese, 11 (3 males, 8 females) overweight, and 28 (9 males, 19 females) normal weight for a total of 45 adults participated in the study. All obese participants had a body mass index (BMI) of higher than 30, all overweight participants had a BMI of 25-30, and all normal weight participants had 18.5-24.9. The BMI was calculated from the panelists' weight and height information given to us in their response email. Body Mass Index was calculated using the formula: $\text{Body Mass Index (BMI)} = \text{Weight (kg)} / \text{Height (meters squared)}$. The average BMI was 31.8 in the obese group, the average BMI was 26.76 in the overweight group, and 22.26 BMI in the normal weight group. The age range for the obese group was from 27-59 (mean = 41). The age range for the overweight group was from 28-60 (mean = 42). The age range for the normal weight group was from 18-61 (mean = 36).

Sixty panelists was the maximum number of panelists that could partake on the study because of financial reasons. The participants were recruited via email using the University of Minnesota Sensory Center email list. Participants filled out an email screener (Appendix A) where eligible participants were emailed with a confirmation email with the time and day they were supposed to take the survey. The criteria for recruiting panelists were based on BMI, age, and gender. Eligible panelists were also included in the study on a first come first serve basis if there was enough room in the BMI groups of normal, overweight and obese categories. The age range for eligibility was adults ages 18-65. More females expressed interest in the study compared to males, so the study had more females. The procedures were approved by the Undergraduate Research Opportunities Program at the University of Minnesota.

Measures

A survey was conducted using two LMS scales where the panelists rated their hunger and fullness levels after reading each scenario. The survey consisted of 30 different scenarios plus warm up questions for the panelists to get familiar with the hunger and fullness LMS scales (Appendix B). Two types of questions were asked, general questions asking about how hungry and full one feels after not eating for certain amount of time and how they feel before/after eating meals. The second type of question was asking how hungry and full they feel after eating a certain food when they have not eaten for five hours. Five hours is about the time frame between main meals, so by using this time frame the panelists would imagine feeling hungry. The panelists could then focus on rating how filling the specific food object is as well as how hungry the panelists would still feel after eating it. The LMS scale was 100 mm in length where the intensity descriptors of hunger and fullness were as follows: strongest imaginable sensation (100), extremely, very, moderately, slightly, barely detectable, no sensation (0) (Appendix C). The numbers from the scales were converted from the labeled affective magnitude scale on a computer screen using the SIMS data acquisition system. Each descriptor was accurately distributed according to the LMS scale. The panelists were asked to mark on each scale a vertical line indicating their hunger and fullness for each scenario. Numerical values were given to each of the answers based on where the panelist put on the line on the LMS scale. After reading a situation, the participant was asked to assess their hunger and fullness level for that given situation by marking a vertical line on the LMS scale. This was used to help evaluate and compare hunger and fullness levels amongst the BMI categories.

Procedure

A survey of thirty questions was conducted where the questions were associated with perceived hunger and fullness levels. Warm up questions, in addition to the thirty survey questions, were provided for the panelists to get familiar with the hunger and fullness scales. Written scenarios describing eating situations were used to stimulate and suggest certain levels of hunger and fullness. Images of the specific foods were used to give the participants a visual scale of how big the portions are of what is being asked. Image-based stimuli have been shown to be a practical and efficient procedure for testing scale properties of validity, sensitivity and reliability (Cardello et al., 2003 and Schutz and Cardello, 2001).

The selected participants were directed to the Sensory Center in McNeal Hall at the University of Minnesota where all the testing was done in individual testing booths. Upon arrival, the panelists signed a consent form, details of the procedure were explained by the researcher(s), and the panelists were allowed to ask questions before starting the survey. The panelists were given written instructions about the procedure before the survey began and before the second set of questions (Appendix D). The panelists were compensated for their participation after finished taking the survey.

The participants took a survey with 30 different situations accompanied with images along with two LMS scales, one hunger and one satiety scale for each situation i.e. right after eating a banana, after not eating for 5 hours, right after eating a complete Thanksgiving dinner etc. The entire process for one panelist took about 15-20 minutes.

Results/Data Analysis

The research hypothesis was overweight and obese people are hungrier and less full than normal weight people. The null hypothesis would be there is no relationship amongst overweight and obese people being hungrier and less full than normal weight people. Therefore, the mean values would be equal. For the hunger scale comparison a level of significance was given to compare the quantitative data. For the fullness scale comparison a level of significance of 0.05 was given to compare this quantitative data set. The overweight and obese groups were put into one group for comparison because there were not as many obese participants to be in a categorical group. This was for comparison purposes.

The averaged answers revealed the panelists began the survey in similar states of hunger/fullness. Refer to questions “hunger now” and “fullness now” on table 1 and table 2 to compare the averages of normal weight to overweight and obese people.

Table 1

Mean hunger ratings of normal weight and overweight/obese panelists, t-values, and p-values

	Mean Normal	Mean of Overweight/Obese	T- Value	P- Value
Hunger Now	18.51	17.23	0.24	0.81
HungerBeforeLunch	32.66	39.91	-1.09	0.28
Hunger After Lunch	8.74	12.12	-0.47	0.64
Hunger2AfterLunch	12.83	11.69	0.38	0.71
Hunger24hrs	71.84	78.36	-0.75	0.456
Hunger Thanks Day	3.64	8.65	-0.66	0.52
Hunger After3Days	92.46	92.71	-0.02	0.98
HungerAfterDinner	4.61	8.15	-0.51	0.62
HungerAfter5Hrs	44.8	50.39	-0.69	0.5
Hunger Bagel	17.95	14.77	0.53	0.6
Hunger Granola	35.44	29.87	0.78	0.44
Hunger Banana	35.23	26.75	1.17	0.25
Hunger Steak	13.56	13.57	0	1
Hunger Water	47.02	47.5	-0.06	0.96
Hunger Salad	26.92	20.21	0.91	0.37
Hunger Yogurt	38.33	24.72	1.89	0.07
Hunger PBJ	18.65	18.11	0.08	0.94
Hunger Candy	27.98	24.63	0.49	0.63
Hunger Milk	34.23	28.91	0.71	0.48
Hunger Spaghetti	13.35	12	0.19	0.85
Hunger Carrots	34.11	25.42	1.23	0.23
Hunger Soda	40.81	41.37	-0.06	0.95
Hunger Cereal	20.7	17.37	0.51	0.61
Hunger Apples	23.69	15.97	1.07	0.29
Hunger Rice	17.06	14.47	0.41	0.69
Hunger Pretzels	24.7	21.93	0.42	0.68
HungerFrenchToast	13.31	13.48	-0.02	0.98
Hunger Chicken	13.88	13.57	0.05	0.96
Hunger Pizza	13.65	13.01	0.1	0.92
Hunger Hot Dogs	10.12	12.35	-0.34	0.74

*Green Highlight is the only P Value < 0.10.

Table 1 displays the mean values of normal weight and overweight/obese to each survey question only looking at the hunger scale answers. In addition, all t-values and p-values were calculated using data analysis. The t-values were calculated from unequal variance and two-tailed requirements. The overweight/obese group was typically hungrier than the normal weight group when the scenario emphasized on hunger- for instance: “right before normally eat lunch,” “not eaten for 5 hours,” “24 hours,” and “3 days.” This is shown on table 1 and table 2 by comparing the mean values where overweight/obese averages were higher than the normal weight group for those specific questions. The hunger responses to the specific food questions displayed normal weight people hungrier than overweight/obese people after eating the food shown by the averaged answers. The only question from the hunger scales displayed a lower p-value than the alpha p-value of 0.10 was “hunger after eating yogurt.” This shows the normal weight people being hungrier than the overweight and obese people after eating the yogurt. This shows that there is not enough evidence to reject the null hypothesis and accept the research hypothesis that overweight/obese people are hungrier than normal weight people. The same question had the highest t-value displaying the biggest difference in the means.

Table 2

Mean fullness ratings of normal weight and overweight/obese panelists, t-values, and p-values

	Mean Normal	Mean Overweight/Obese	T- Value	P- Value
Full Now	21.89	22.85	-0.14	0.89
FullBeforelunch	11.62	10.63	0.23	0.82
FullAfterlunch	38.87	45.12	-0.87	0.39
Full2afterlunch	22.19	20.01	0.58	0.57
Full 24 Hrs	1.88	6.83	-1.21	0.25
FullThanksDay	69.73	80.29	-1.28	0.21
Full after 3Days	1.19	0.28	2.3	0.03
FullAfterDinner	60	68.48	-1.06	0.3
Full After 5 Hrs	5.17	4.72	0.25	0.81
Full Bagel	24.64	32.94	-0.98	0.34
Full Granola	9.96	13.53	-1.22	0.24
Full Banana	10.9	11.83	-0.46	0.65
Full Steak	34.4	47.38	-1.61	0.12
Full Water	7.45	10.27	-0.68	0.51
Full Salad	18.52	26.44	-1.2	0.25
Full Yogurt	10.13	14.27	-1.53	0.14
Full PBJ	26.46	27.11	-0.11	0.92
Full Candy	14.17	17.95	-1.02	0.32
Full Milk	12.81	15.9	-0.77	0.45
Full Spaghetti	42.98	49.5	-0.99	0.33
Full Carrots	12.77	15.73	-0.89	0.38
Full Soda	13.16	11.73	0.34	0.73
Full Cereal	25.61	27.5	-0.41	0.68
Full Apples	22.18	32.02	-1.39	0.18
Full Rice	33.29	40.11	-1.07	0.29
Full Pretzels	17.25	20.24	-0.65	0.52
FullFrenchToast	41.34	49.27	-1.12	0.27
Full Chicken	33.05	44.32	-1.5	0.15
Full Pizza	38.07	44.25	-0.77	0.45
Full Hot Dogs	46.26	48.45	-0.27	0.79

*Red Highlight is the only P Value < 0.05

Table 2 displays the mean values of normal weight and overweight/obese to each survey question only looking at the fullness scale answers. By comparing averages, the overweight/obese group responded fuller than normal weight group after the question “not have eaten for 24 hours,” so this could show that overweight/obese sense of hunger is triggered at a fuller state compared to normal weight people. The overweight/obese group was also fuller than the normal weight group when the scenario emphasized on fullness- for instance: immediately after lunch, right after Thanksgiving dinner, and after a complete evening dinner. On the other hand these scenarios, “immediately after lunch,” “right after Thanksgiving dinner” and “after a complete evening dinner,” the overweight/obese group rated fuller and hungrier than the normal weight people. The only situational survey question where the normal weight group showed they were fuller than the overweight/obese group was the scenario, “2 hours after lunch.” The responses to specific food questions generally showed that the normal weight group was hungrier after eating the food compared to the overweight/obese group. The exceptions were peanut butter sandwich, soda, French toast, pizza and hot dogs. The difference on the scale was no more than 2. The overweight/obese group was fuller after eating the food compared to the normal weight group. The exceptions were peanut butter sandwich and soda which the difference was no more than 2.2. This could show overweight/obese people able to be aware of their fullness level, so they can prevent overeating. The only question from the fullness scales that displayed a lower p-value than the alpha-p-value of 0.05 was “fullness after 3 days of not eating.” This shows that there is not enough evidence to reject the null hypothesis and accept the research hypothesis that overweight/obese people are less full than normal weight people. The same question had the highest t-value displaying the largest difference in the means.

Discussion

The project is realistic and achievable because the data was easily gathered from the participants and the LMS scales are an effective tool to scale hunger and fullness as described earlier. The sensory experience of fullness and hunger among the different BMI groups varied. The results showed overweight/obese people are hungrier during more extreme cases than normal weight people. The specific mean scores that display this are on table 1 questions “hunger after not have eaten for 5 hours (44.8 normal, 50.39 overweight/obese),” “hunger after not have eaten for 24 hours (71.84 normal, 78.36 overweight/obese),” and “hunger after not have eaten for 3 days (92.46 normal, 92.71 overweight/obese).” The results also pointed out that overweight/obese people are fuller after eating meals and the same portions as normal weight people. The scenarios that said “Thanksgiving dinner” and a “complete evening dinner” could mean different portions to the panelists, so their different interpretation could influence their answers. During the specific food questions, images of the food were posted to give the participants an idea of the portions.

According to Lowe et al. “normal weight subjects experience more bodily hunger than overweight subjects initially but experience less hunger than obese subjects after a prolonged period of food deprivation.” Therefore, these results exemplify this conclusion suggesting that overweight and obese subjects tend to experience more extreme hunger and fullness levels in more extreme scenarios.

Our research will assist people in developing strategies for losing weight and achieving a healthy weight. Questions regarding how is the best way to lose weight, and why people are hungrier may arise for further investigation.

Conclusion

Comparing normal weight with overweight and obese panelists on the hunger scale, the majority of the questions except for one (hunger after eaten yogurt) had a greater p-value than alpha p-value of 0.10. Therefore, the null hypothesis is accepted where there is no relationship amongst overweight and obese people being hungrier than normal weight where the means are equal between the two groups.

Comparing normal weight with overweight and obese panelists on the fullness scale, the majority of the questions except for one (fullness after not have eaten for 3 days) had a greater p-value than the alpha p-value of 0.05. Therefore, the null hypothesis is accepted where there is no relationship amongst overweight and obese people being less full than normal weight where the means are equal between the two groups.

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Appendix A: Email Screener

We are recruiting people for a study on measuring hunger and fullness levels held on Wednesday, July 22. The test will take place at 126 McNeal Hall on St. Paul Campus. We will need people that are willing to assess their hunger and fullness levels after reading a variety of hypothetical situations.

To participate in the study, we would ask you to do the following things:

You would attend 1 session (approximately 10-15 minutes long). During the session you will be given a survey where it will ask you to read 30 given situations and indicate your hunger and fullness level for each one.

Each participant will be compensated \$5.

If you are interested in taking part in this study, please answer the questions below and reply to this e-mail.

Your information will be evaluated to see if you qualify to be a part of the study. We will contact you in the next few days to schedule you for the study. You may choose not to participate, even if you have qualified.

Please provide the following information about yourself. All information you provide is strictly confidential.

What is your gender? _____

What is your age? _____

What is your height? _____

What is your weight? _____

Please indicate the times on Wednesday, July 22 that you would be able to attend the session. (Please mark all applicable times)

_____ 10:00 – 10:15 am

_____ 10:15 – 10:30 am

_____ 10:30 – 10:45 am

_____ 10:45 – 11:00 am

_____ 11:00 – 11:15 am

_____ 11:15 – 11:30 am

_____ 11:30 – 11:45 am
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_____ 5:30 – 5:45 pm
_____ 5:45 – 6:00 pm

We will get back to you to let you know if you have qualified for the study and, if so, assign you a time to meet for the session.

If you have any questions about the study, please respond to this e-mail.

Thank you!

*If you would like to be removed from this email list, please reply to this email with 'remove' in the subject line.

Appendix B: Survey Questions

Warm up Questions:

Brightness of the sun when looking directly at it

Loudness of a whisper

Smell of a rose

Saltiness of potato chips

Loudness of a plane taking off 10 feet from you

Sourness of a fresh lemon slice

Your hunger after not having eaten for 3 hours

Your fullness after eating 2 hard boiled eggs

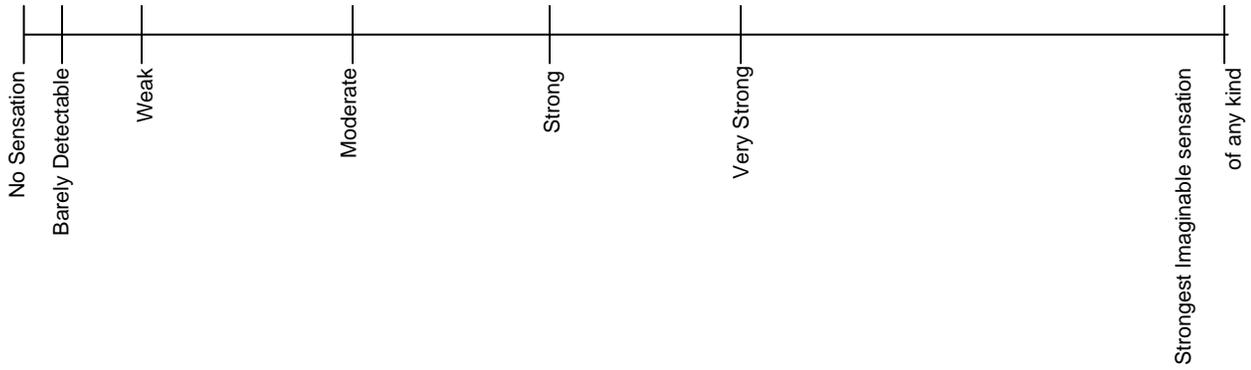
Survey Questions:

1. How do you feel right now
2. Right before I normally eat lunch
3. Immediately after lunch
4. 2 hours after lunch
5. After not having eaten anything for 24 hours
6. Right after eating a complete Thanksgiving dinner
7. After not having eaten anything for 3 days
8. Right after eating an evening dinner, with salad, main course and desert
9. After not having eaten for 5 hours
10. 5 hours since you last ate, then you have just eaten a bagel with cream cheese
11. 5 hours since you last ate, then you have just eaten a granola bar

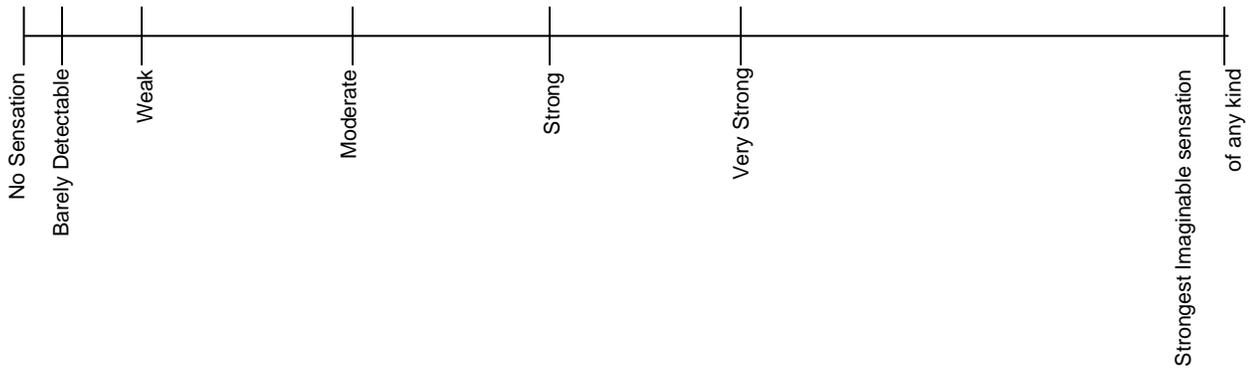
12. 5 hours since you last ate, then you have just eaten a banana
13. 5 hours since you last ate, then you have just eaten an 8 oz. steak
14. 5 hours since you last ate, then you have just eaten a spinach dinner salad
15. 5 hours since you last ate, then you have just eaten a 6 oz. cup of yogurt
16. 5 hours since you last ate, then you have just eaten a peanut butter and jelly sandwich
17. 5 hours since you last ate, then you have just eaten a candy bar
18. 5 hours since you last ate, then you have just drank a glass of milk
19. 5 hours since you last ate, then you have just eaten a plate of spaghetti
20. 5 hours since you last ate, then you have just eaten 10 baby carrots
21. 5 hours since you last ate, then you have just drank a can of soda
22. 5 hours since you last ate, then you have just eaten a medium size bowl of cereal
23. 5 hours since you last ate, then you have just eaten 2 apples
24. 5 hours since you last ate, then you have just eaten a medium bowl of rice
25. 5 hours since you last ate, then you have just eaten a snack size bag of pretzels
26. 5 hours since you last ate, then you have just eaten 3 slices of French toast
27. 5 hours since you last ate, then you have just eaten a medium size chicken breast
28. 5 hours since you last ate, then you have just eaten 2 triangular single serving slices of pizza
29. 5 hours since you last ate, then you have just eaten 2 hot dogs with buns.
30. 5 hours since you last ate, then you have just drank an 8 oz. glass of water

Appendix C: Hunger and Fullness Labeled Magnitude Scale

Hunger Scale



Fullness Scale



Appendix D: Instructions in Survey

Situational Question Instructions:

Rate the intensity of the following situations on the scales provided by clicking at the position that best describes how intense you remember/imagine that sensation to be.

Let's start with some questions to help you get used to using the rating scale.

Specific Food Question Instructions:

Now that you have become familiar with using the scale, we will begin our survey. Please rate your hunger and fullness using the scales provided after reading each situation.

Imagine you are hungry because it has been 5 hours since you were last able to eat. Then imagine that you had eaten the items in the amounts specified below.