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Elasticity in portion selection is predicted by severity of anorexia and food type in adolescents

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ABSTRACT

The size of portions that people select is an indicator of underlying mechanisms controlling food intake. Fears of eating excessive portions drive down the sizes of portions patients with anorexia nervosa (AN) can tolerate eating significantly below those of healthy controls (HC) (Kissileff et al., 2016). To determine whether patients with AN will also reduce the sizes of typical or ideal portions below those of controls, ANOVA was used to compare maximum tolerable, typical, and ideal portions of four foods (potatoes, rice, pizza, and M&M's) in the same group of 24 adolescent AN patients and 10 healthy adolescent controls (HC), on which only the maximal portion data were previously reported. Typical and ideal portion sizes did not differ on any food for AN, but for HC, typical portions sizes (kcals) became larger than ideal as the energy density of the food increased, and were significant for the most energy dense food. Ideal portions of low energy dense foods were the same for AN as for in HC. There was a significant 3-way (group × food × portion type) interaction, such that HC selected larger maximum than typical portions only for pizza. We therefore proposed that individuals of certain groups, depending on the food, can be flexible in the amounts of food chosen to be eaten. We call this difference between maximum-tolerable, and typical portion sizes selected "elasticity." Elasticity was significantly smaller for AN patients compared to HC for pizza and was significantly inversely correlated with severity of illness. This index could be useful for clinical assessment of AN patients, and those with eating problems such as in obesity and bulimia nervosa and tracking their response to treatment.

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1. Introduction

Individuals with anorexia nervosa (AN) are preoccupied with calorie counting and food portion sizes, and they have extensive knowledge about the energy content and macronutrient composition of foods (Halmi, 2007). In one study, participants were asked to evaluate 38 different foods (Sunday, Einhorn, & Halmi, 1992). Both anorexic and bulimic patients were more accurate than control participants in their assessment of the caloric and macronutrient content of the foods, and AN patients displayed an aversion to high-fat and highly energy-dense foods (Sunday et al., 1992). These findings confirmed that patients with eating disorders show an aversion to fat and a preference for low-calorie foods (Drewnowski, Yee, & Krahn, 1988). Drewnowski et al. also found that AN patients tend to prefer a sweet taste over a fatty taste, while controls preferred a taste that had a more balanced ratio of sweet to fat (Drewnowski, Halmi, Pierce, Gibbs, & Smith, 1987), a finding that was subsequently confirmed by Sunday and Halmi (Sunday & Halmi, 1990). AN patients also have a strong aversion to carbohydrates or "carbohydrate phobia" (Crisp & Kalucy, 1974), due to perceptions about the weight-promoting properties of carbohydrate-rich foods. Furthermore, Halmi and Sunday found that anorexic patients report lower hunger and higher fullness, before, during, and after an experimental liquid meal, compared to control participants (Halmi & Sunday, 1991).

AN patients also tended to overestimate food portion sizes compared to controls (Milos et al., 2013), and to rate energy-dense foods to be 12% larger than controls (Yellowlees, Roe, Walker, &

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Ben-Tovim, 1988). AN patients report less hunger and eat less than controls in general (Halmi & Sunday, 1991). Consequently, differences in the sizes of portions among foods between AN and HC might be an indicator for the onset of disordered eating in AN. The use of a non-threatening test that can measure the differences in portion selection between anorexic and healthy individuals and the correlates of these differences can thus provide an objective marker of eating disorder risk. In a preliminary study by Kissileff, et al., (2016), a novel computerized method of measuring responses to pictures of portion sizes (Brunstrom & Rogers, 2009; Brunstrom, Shakeshaft, & Scott-Samuel, 2008) was used to measure the maximum tolerated portion of food participants could consume and their anxiety response to increasing portions. In the present paper we now include data on typical and ideal portion sizes as well as ratings of liking, healthiness, and familiarity (measured by frequency of consumption) in order to determine whether maximum portion sizes were under a different control (and hence would generate a different profile of responses to different foods) than what the participants would typically eat or what they thought they "should" eat (ideal portion size). Given the large differences in maximum portions of high but not low energy dense foods chosen by patients compared to controls, it was expected that anorexic patients would also select both a smaller typical and ideal portions of energy-dense foods than controls, due to fear of weight gain or because AN patients perceive portion sizes to be bigger than they actually are.

A new variable, which we call '**elasticity**', was derived by subtracting typical from maximal portion size and is, therefore, an index of flexibility in portion size selection across foods and groups. A wider disparity between the two types indicates an ability to eat flexibly, while a narrow disparity indicates rigidity. Hence, the elasticity variable demonstrates a participant's flexibility in portion selection. Our expectation, based on the concept of cognitive rigidity and behavioral restraint rigidity in AN patients (Westenhoefer, 1991), and as described by Steinglass, Walsh, and Stern (2006), was that anorexic patients would exhibit less elasticity than healthy controls (reflecting their rigid eating habits).

In addition, participants' ratings of the perceived healthiness of a food, how much they liked and how frequently they ate a food, were solicited, in order to analyze how these factors impact the portion sizes selected. We hypothesized that patients' concept of the food's healthiness would be significantly and positively related to their ideal and typical portion sizes and elasticity, and their frequency of eating that food. Findings regarding typical and ideal portions sizes and elasticity in anorexic patients may aid in elucidating factors that characterize the disorder, and be applied in a clinical setting to diagnose patients and evaluate progress in targeted therapies.

2. Materials and methods

2.1. Study sample

Data for this study were collected between October 2, 2008 and June 16, 2010. Twenty-three female participants and one male participant with AN were recruited from the Outpatient Services of the Weill Cornell Westchester Division and through an NIH Family Therapy Study. Participants were not undergoing treatment at the time of the study. Individuals were eligible to participate in this study if they were between 12 and 18 years old and met DSM-IV diagnostic criteria for AN (the version of DSM used during that time period), except for amenorrhea, which was not included as a requirement for inclusion (American Psychiatric Association, 2013, Herpertz-Dahlmann, 2015). Hence, the subjects met the equivalent to the DSM-V definition of AN. The sample included Restricting and Binge/Purge subtypes. Ten healthy adolescent controls with an average age of 14.6 years (±2.63) were obtained from community news advertisements, including two males. These participants did not meet DSM-IV diagnostic criteria for an eating disorder, as determined by an MA psychologist who was trained in DSM-IV diagnosis. Individuals who met the criteria for Bulimia Nervosa or Binge Eating Disorder were not eligible to participate. All diagnoses were made with the Structural Clinical Interview (DSM-IV) by a clinical psychologist trained and approved in the assessment for the NIH study. Written informed consent and assent for minors was obtained from all potential participants and their parents. The study was approved by the Institutional Review Board of Weill-Cornell Medical College.

2.2. Assessment of severity of illness

The Yale-Brown-Cornell Eating Disorder Scale (YBC-EDS) is a semi-structured, clinician-administered interview used to assess the severity of eating disorder symptomatology (Jordan et al., 2009). Scores are obtained from the YBC-EDS on four domains: preoccupations, rituals, total (the sum of preoccupations and rituals scores), and motivation to change (the sum of the resistance, insight, and desire for change scores for both preoccupations and rituals). Both current and highest experienced severity were recorded, but only the current severity is reported here.

2.3. Computer tasks

Participants were positioned in front of a computer screen and asked to participate in a series of computer tasks that involved responding to images of four foods differing in energy density: Two low energy dense – potatoes (0.75 kcal/g) and rice (1.43 kcal/g) and two high energy dense – pizza (4.08 kcal/g) and M&Ms® (5.26 kcal/g). The macronutrient composition was taken from the food packaging, (see Kissileff et al., 2016, for nutrient composition of foods and rationale for selection). All portion sizes were measured in kilocalories.

2.3.1. Liking and healthiness ratings

In separate trials, the participants were presented with images of the four foods and were asked to rate liking and healthiness. Using the computer mouse, they placed a vertical line at an appropriate position along a horizontal line anchored at the left end by "not at all" and at the right by "extremely". The order of the foods was determined randomly for each participant. The assessment of healthiness was an identical procedure in which participants were asked to respond to the questions, "How much do you like this food?" and "How healthy is this food?"

2.3.2. Frequency of eating

Participants indicated frequency of eating each of the four foods by selecting how often they ate each food from one of four periods: day, week, month, and year. Frequency of eating was quantified in units of days-per-month.

2.3.3. Maximum tolerable portion size

Maximum tolerable portions were measured using a variant of the method of constant stimuli (see Kissileff et al., 2016; for further details), in which participants were shown pictures of foods in varying portion sizes on a computer screen and asked to respond with "yes" or "no" to the question: "Imagine you were going to eat ALL of this food. Would this portion be too big for you to tolerate eating it?" The Point of Subject Equality (PSE) was determined as the portion size around which the probability of the participant responding "yes" was 50% (Watt & Andrews, 1981). The portion size

at the participant's PSE represented their maximum tolerable portion size. Each trial consisted of four test foods, each shown 56 times in total (56 × 4 = 224 trials in total).

2.3.4. Typical and ideal portion size

Measures of typical portion size and ideal portion size were obtained using a "method of adjustment" task. Participants were shown pictures of the four test foods (M&Ms, pizza, potatoes and rice), photographed on the same white plate (255-mm diameter). Particular care was taken to maintain a constant lighting condition and viewing angle in each photograph. For each food, picture number 1 showed a 20 kcal portion, and each photograph increased by 20 kcal (i.e., picture 2 = 40 kcal, picture 3 = 60 kcal, and so on). In each trial one of the test foods was displayed on a computer screen. Pressing the left arrow-key on a keyboard caused the portion size to decrease (a smaller picture number was displayed) and pressing the right arrow-key caused the portions to increase. Each food was viewed twice, and each trial started at the top or bottom of the response range in a random sequence across participants and foods. In the first set, they were instructed to "Create the portion of this food that you think you would typically eat." We refer to this as the 'typical' portion size. Once the appropriate portion size had been selected, participants selected a button marked "continue" and the next trial began. In a second set, the participants were instructed to "Create the portion of this food that you think you ought to eat in a snack/meal (inserted as appropriate for each test food)." We refer to this as 'ideal' portion size. In each set of trials the test foods were presented in a different randomized order for each participant. Each of these tasks was conducted twice on each food for each participant.

2.4. Statistical analysis

SAS version 9.2, and later 9.3 and 9.4 was used to conduct a three way ANOVA with repeated measures on participants, in which the response to the portion size shown was the dependent variable and the independent fixed variables were food (pizza, M&Ms, rice, and potatoes), group (AN versus HC), and type of portion (ideal, typical, and maximum tolerable). A two-way repeated measures ANOVA was conducted on dependent variables; liking, familiarity (i.e. frequency of consumption), and perceived healthiness, with food and group as fixed factors and separate ANOVA's followed by planned comparison with Duncan tests were conducted separately for each group. Portion sizes were regressed on YBC-EDS scores to measure the relationship of those variables to severity of illness. Liking, frequency of consumption, and perceived healthiness ratings were included as independent variables in a regression model with ideal portion size, typical portion size, and elasticity as outcome variables. Elasticity was calculated by subtracting participants' typical portion sizes from their maximum tolerable portion sizes on each food, yielding a difference between the two types of portion sizes that a participant is willing to select. Differences in elasticity were tested in a two-way ANOVA with planned comparisons between groups and foods. Given the preliminary nature of these studies the statistical tests were not adjusted to control for multiple tests on the same data. Throughout, we applied a critical p value of 0.05.

3. Results

3.1. Participant characteristics

The participants, 21 anorexic-restrictors (AN-R) and 3 anorexic-binge-purgers (AN-P), did not differ on any of the measured demographic variables and thus were combined for all analyses. Furthermore, there were two males included in the healthy controls group and one male included in the patient group. The control participants (N = 10) did not differ in age but had a higher body mass index (BMI) and weight than did the AN patients. At the time of testing, AN-R participants' BMI ranged from 14.8 to 20. Severity of the eating disorder as measured by the YBC-EDS ranged from 0 to 24. Higher scores indicate a greater severity of illness.

Preliminary inspection of the data revealed that two participants, one in each group, had outlying estimates of their maximum portion size (greater than 3 × SD from mean). This resulted in non-normally distributed data. Elimination of participants from the analysis of responses to portion-types resulted in the data becoming normally distributed, and the subsequent analysis proceeded without these participants (see Kissileff et al., 2016; for descriptive statistics of study sample).

3.2. Three-way ANOVA

There was a significant group effect and group by portion type interaction, such that controls selected significantly larger maximum (by 132 kcal ± 38 SED, $p < 0.01$) and typical (112 kcal ± 37 SED, $p < 0.01$) portions, but not significantly larger ideal portions (58.5 kcal ± 37 SED, $p = 0.12$) than AN patients (see Table 1 for ANOVA statistics). Significant main effects were also found for portion type (maximum > typical = ideal) and food (high density > low density), and there was a significant portion type by food interaction as well as a significant 3-way interaction ($F(6, 435) = 2.52$, $p = 0.02$).

3.3. Typical and ideal portion size effects

The only food for which there was a significant group difference in typical and ideal portion sizes was M&M's, which was the most energy dense of the foods shown. AN patients compared to HC selected significantly smaller typical (difference = 239.4 kcal ± 52.75 SED, $p < 0.0001$) and ideal (113.24 kcal ± 52.75 SED, $p = 0.04$) portions of M&Ms (see Fig. 1). For both AN and HC, portion sizes among foods were directly related to their energy densities. That is, the higher the energy density, the larger the portion size selected. Differences between ideal and typical portion size within each group differed across foods. For AN, there were no significant differences between ideal and typical portion size for any food, although typical portions were numerically smaller than ideal portions for all foods, thus the typical − ideal portion size differences were all negative. In contrast the typical − ideal difference increased with energy density in HC but was only significant for M&Ms. (see Table 2 for individual differences between foods and Table 3 for group differences). When typical − ideal difference was averaged across all foods within groups, the difference (i.e. group × portion type interaction) was

Table 1
Analysis of variance for group, food and portion-type.

	DF	Mean square	Error DF	F Value	P Value
Group	1	1,179,553	30	8.41	0.007
Food	3	1,204,970	93	25.38	<0.000
Group*Food	3	93,979	93	1.98	0.123
Portion-Type	2	421,195	60	38.80	<0.000
Group*Portion-Type	2	59,430	60	5.47	0.007
Portion-Type*Food	6	22,851	435	3.54	0.002
Group*Portion-Type*Food	6	16,290	435	2.52	0.021
ID(Group)	30	139,831	102	2.72	<0.000
ID(Group*Portion-Type)	60	10,849	435	1.68	0.002
ID(Group*Food)	90	52,070	435	8.06	<0.000
Residual	435	64,621			

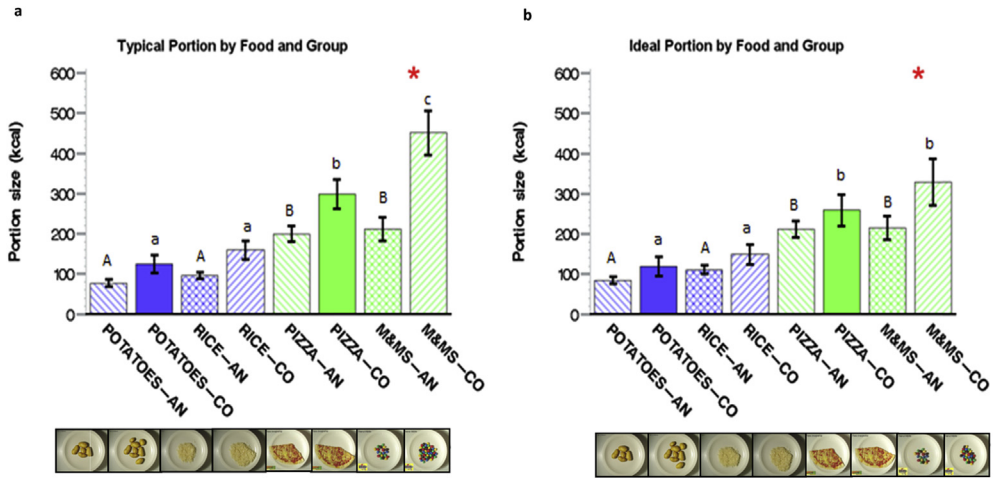

Fig. 1. Typical (a) and Ideal (b) Portion Size Selected in kcal. The portions corresponding to each food are shown on the bottom. AN represents anorexia nervosa patients. CO represents healthy controls. Asterisk represents p-value < 0.05 for difference between groups for the same food. Uppercase letters compare differences between foods within AN patients. Lowercase letters compare differences between foods within healthy controls. Foods labeled with the same letter are statistically similar (p-value > 0.05).

Table 2
Differences in typical and ideal portion size between foods for each group.

	Contrast	Typical			Ideal		
	Difference in typical portion size between foods	Difference (kcal)	SE	P-value	Difference (kcal)	SE	P Value
Anorexic	M&Ms – Pizza	11.6	33.6	0.731	3.5	33.6	0.917
	M&Ms – Rice	115.3	33.6	<0.000	104.4	33.6	0.0027
	M&Ms – Potatoes	134.4	33.6	<0.000	131.7	33.6	<0.000
	Pizza – Rice	103.7	33.6	0.002	100.8	33.6	0.003
	Pizza – Potatoes	122.8	33.6	<0.000	128.2	33.6	<0.000
	Rice – Potatoes	19.1	33.6	0.570	27.4	33.6	0.417
Healthy Controls	M&Ms – Pizza	152.6	53.8	0.005	69.7	53.8	0.197
	M&Ms – Rice	291.1	53.8	<0.000	180	53.8	0.001
	M&Ms – Potatoes	326.7	53.8	<0.000	208.9	53.8	<0.000
	Pizza – Rice	138.5	53.8	0.011	110.3	53.8	0.042
	Pizza – Potatoes	174.1	53.8	0.001	139.2	53.8	0.011
	Rice – Potatoes	35.6	53.8	0.510	28.9	53.8	0.592

Table 3
Difference in typical and ideal portion sizes by food and group.

Food	An Patients	P Value	Healthy controls	P Value
	Difference ±SD (kcal)		Difference ±SD (kcal)	
Potatoes	−6.5 ± 18.5	0.725	4.4 ± 29.5	0.881
Rice	−14.8 ± 18.5	0.426	11.1 ± 29.5	0.708
Pizza	−12 ± 18.5	0.520	39.4 ± 29.5	0.187
M&M's	−3.9 ± 18.5	0.833	122.2 ± 29.5	<0.000
All Foods	−9.3 ± 11.4	0.419	44.3 ± 18.2	0.018

significant (mean difference = 53 kcal ± 21.5 SED (p = 0.015).

3.4. Elasticity

Elasticity (see Fig. 2) was significantly lower in AN than in HC only for pizza; difference 98.1 kcal ± 44 SED (DF = 119, p = 0.03). In AN patients, elasticity for pizza was the smallest value across foods and elasticity for rice selection was significantly higher than for potatoes (73.61 kcal, ±32.79, DF = 119, p = 0.03). Elasticity for pizza was significantly lower than for rice (−73.87 kcal, ±33.16, DF = 119, p = 0.03), and for M&Ms was significantly higher than potatoes (89.75 kcal, ±32.79, DF = 119, p = 0.01) and pizza (90.01 kcal, ±33.16, DF = 119, p = 0.01). Elasticity among foods was not significantly different in HC.

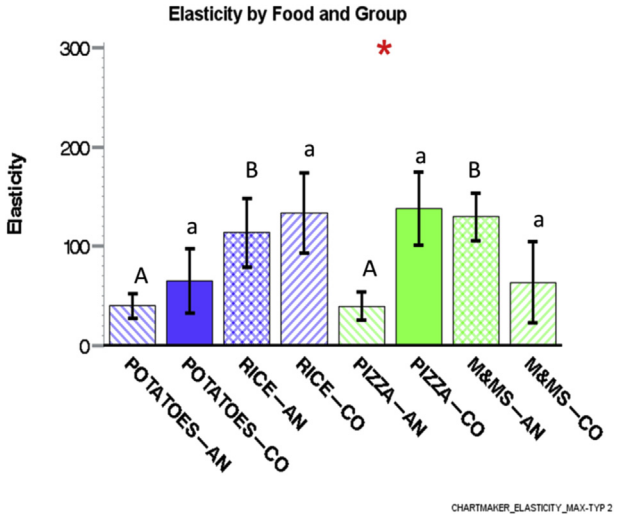

Fig. 2. Elasticity of Foods within each group. The portions corresponding to each food are shown on the bottom. AN represents anorexia nervosa patients. CO represents healthy controls. Asterisk represents p-value < 0.05 for difference between groups for the same food. Uppercase letters compare differences between foods within AN patients. Lowercase letters compare differences between foods within healthy controls. Foods labeled with the same letter are statistically similar (p-value > 0.05).

A regression of elasticity on YBC-EDS score in AN demonstrated that elasticity was significantly and inversely related to portion sizes of pizza ($R = -0.432$, $p = 0.045$) and M&M's ($R = -0.472$, $p = 0.023$), the two higher energy foods in this study.

3.5. Perceptions of foods: liking, healthiness, and frequency of consumption

3.5.1. Liking

Mean liking ratings over all foods for controls were higher than for AN patients. For patients, there were no differences across foods, and ratings were uniformly close to the midpoint, although liking for M&Ms was slightly, but not significantly, lower than for the other three. Controls gave equivalent liking ratings for pizza, rice, and potatoes, and rated pizza significantly higher than M&Ms. Controls also gave significantly higher liking ratings for pizza compared to AN patients (See Table 4 for means and LSD).

3.5.2. Healthiness

For both groups, potatoes and rice, which were not significantly different from each other, and were rated significantly more healthy than pizza and M&Ms. For AN, pizza was rated significantly healthier than M&Ms, but in HC the ratings of the two items did not differ significantly. Comparisons within the same food revealed no significant differences between patients and controls (see Table 4 for means and LSD's).

3.5.3. Frequency of consumption

For controls, the only significant difference between foods was that potatoes were consumed more frequently than M&Ms. Rice and pizza were intermediate and not significantly different from either M&Ms or potatoes. For patients, rice was consumed significantly more often than both pizza and M&Ms, and potatoes were not different from either pizza or M&Ms (see Table 4).

3.6. Contributions of liking, healthiness, and frequency of consumption to portion sizes selected

AN patients' liking for the specific foods significantly predicted the amounts chosen for maximum tolerable portion size for potatoes and pizza, typical portion size for potatoes, ideal portion size potatoes, and frequency of eating potatoes and pizza. Maximum tolerable portion size for pizza and M&M's, typical portion size for potatoes, ideal portion size for potatoes, and frequency for pizza, were significantly predicted by the AN patients' perception of foods' healthiness. Healthy controls' liking for the specific foods only significantly predicted typical portion size for pizza. The healthy controls' perception of healthiness significantly predicted maximum portion size for potatoes, typical portion size for potatoes, ideal portion size for potatoes, and frequency of consumption for M&M's (See Table 5 for statistics for significant regressions).

3.7. Predictions from severity of illness

Severity of illness (YBC-EDS-score) significantly predicted maximum tolerable portion size for pizza and M&Ms and typical and ideal portion sizes for all foods, except pizza. All these regressions were negative, indicating that the sicker the patient the smaller the portion size chosen (see Table 6 for regression statistics).

4. Discussion

4.1. Elasticity and novelty of results

Elasticity is a novel index of flexibility in portion selection on a computerized eating behavior task. This construct has not been previously explored in adolescents with anorexia and may potentially aid in differentiating normal and disordered eating behaviors in individuals suffering from the disorder by characterizing behaviors that are unique to each group. Our results provided limited support for the hypothesis that AN patients would exhibit reduced elasticity in portion selection compared to healthy individuals for high-energy dense foods, since differences were significant only for pizza, out of the two energy dense foods. This result could be related to the significantly greater liking of pizza by the controls, which allowed them to expand their maximal portion size, while pizza was liked no better than any other food by the patients with AN. Berridge (2009) suggests that anorexic behaviors may result in dysfunction of brain reward systems that can impact liking of foods, and thus explain why AN patients did not display the preference for pizza over rice, potatoes, and M&Ms that was found in healthy controls. Elasticity for anorexics was also significantly different between rice and potatoes, pizza and rice, M&Ms and potatoes, and M&Ms and pizza. In contrast, there were no significant differences between foods for controls. These differences in elasticity suggest that, unlike healthy individuals, anorexics' perceptions regarding the energy density or macro-nutrient content of foods may attenuate the flexibility with which they select portions of food. In fact, elasticity was significantly and inversely correlated with severity of illness for pizza and M&M's, the two high energy-dense foods in the study, but not for the low energy dense foods, potatoes and rice (as shown by Fig. 3). The difference in correlation between high and low energy dense foods suggests that the more severely ill the patient is the more likely he/she will engage in rigid selection and consumption of foods when confronted with high rather than low energy-dense foods. While anorexics' reduced intake has already

Table 4
Liking healthiness and frequency by food and group.

		Food				LSD
		Potatoes	Rice	Pizza	M&Ms	
		Mean	Mean	Mean	Mean	
Liking	Control	$60.9^{ab} \pm 5.1$	$55.9^{ab} \pm 8.6$	$73.8^{a1} \pm 7.8$	$49.5^{b} \pm 11.6$	22.5
	Patient	$48.7^{a} \pm 5.6$	$48^{a} \pm 5.6$	$48.9^{a2} \pm 7.4$	$36^{a} \pm 6.4$	15.8
Healthiness	Control	$52.2^{ab} \pm 7.1$	$57.5^{a} \pm 6.0$	$34.2^{bc} \pm 5.4$	$27.4^{c} \pm 9.0$	20.4
	Patient	$55.6^{a} \pm 4.0$	$59.1^{a} \pm 4.2$	$24.3^{b} \pm 3.8$	$15.7^{c} \pm 3.2$	7.2
Frequency	Control	$9.8^{a} \pm 2.7$	$6.6^{ab} \pm 1.6$	$5.6^{ab} \pm 1.7$	$4.2^{b} \pm 1.5$	4.8
	Patient	$7.1^{ab} \pm 1.6$	$16.2^{a} \pm 6.5$	$1.9^{b} \pm 0.5$	$2.6^{b} \pm 1.3$	9.3

Liking and healthiness of scale of 0 to 100 mm, Frequency in days per month. LSD = Least significant difference for tests across foods within groups via Duncan planned comparison method. Means with the same letters are not different. Letters refer to differences across foods within groups, whereas numbers refer to differences between groups within foods. Between group differences are shown by different numbers. If there are no differences, there are no numbers.

Table 5
Significant regression statistics for liking and healthiness on portion size and frequency of consumption by food for patients and controls.

Group	Independent Variable	Dependent Variable[a]	Food	Intercept	Slope (Dependent/Independent) ±SE	P Value	R^2
Anorexic	Liking (mm)	Maximum Portion	Potatoes	56.86	1.27 ± 0.49	0.017	0.24
			Pizza	137.44	1.83 ± 0.63	0.009	0.30
		Typical Portion	Potatoes	33.76	0.92 ± 0.41	0.037	0.19
		Ideal Portion	Potatoes	32.23	1.09 ± 0.38	0.010	0.28
		Frequency	Potatoes	0.64	0.13 ± 0.05	0.024	0.21
			Pizza	0.64	0.03 ± 0.01	0.045	0.17
	Healthiness (mm)	Maximum Portion	Pizza	160.43	2.87 ± 1.33	0.043	0.19
			M&M's	230.03	7.22 ± 2.80	0.018	0.24
		Typical Portion	Potatoes	−12.85	1.66 ± 0.54	0.006	0.31
		Ideal Portion	Potatoes	−9.11	1.71 ± 0.52	0.004	0.34
		Frequency	Pizza	0.51	0.06 ± 0.02	0.021	0.22
Controls	Liking (mm)	Typical Portion	Pizza	−9.82	4.15 ± 1.55	0.032	0.51
		Maximum Portion	Potatoes	−254.64	7.6 ± 1.93	0.006	0.69
	Healthiness (mm)	Typical Portion	Potatoes	−96.76	3.87 ± 1.18	0.013	0.61
		Ideal Portion	Potatoes	−149.11	4.7 ± 1.16	0.005	0.70
		Frequency	M&M's	1.24	0.11 ± 0.04	0.035	0.44

[a] See Table 4 for units of dependent variable.

Table 6
Significant regression statistics for variables predicted by severity of illness.

Dependent	Food	Slope (Dependent/score)	SE	P Value	R^2
Maximum tolerable (kcal)	Pizza	−11.05	2.65	<0.000	0.464
	M&Ms	−28.21	3.65	<0.000	0.740
Typical portion(Kcal)	Potatoes	−4.76	1.44	0.003	0.343
	Rice	−5.45	1.25	<0.000	0.473
	M&Ms	−20.58	3.8	<0.000	0.583
Ideal portion (Kcal)	Potatoes	−4.53	1.44	0.005	0.320
	Rice	−5.31	1.63	0.004	0.336
	M&Ms	−16.4	4.42	0.001	0.396
Elasticity (Kcal)	Pizza	−3.90	1.82	0.045	0.187
	M&Ms	−7.62	3.11	0.023	0.223
Healthiness (mm)	Potatoes	−1.47	0.48	0.006	0.299
	Pizza	−1.8	0.38	<0.000	0.507
	M&Ms	−0.92	0.41	0.037	0.184
Liking (mm)	Potatoes	−1.8	0.71	0.019	0.225
	Pizza	−2.25	0.95	0.027	0.204

been extensively documented, these data shed light on the notion of cognitive rigidity in anorexics and how rigidity might manifest itself in the selection of portion sizes.

4.2. Ideal and typical portion size differences between patients and controls

Severity of illness, as measured by the YBC-DES scores, significantly predicted the sizes of typical and ideal portions selected by anorexic participants, across all foods, except pizza, perhaps because they don't like it as much as controls do. However, both the ideal and typical portion sizes were significantly smaller than those chosen by healthy controls, only for M&Ms. This observation is puzzling considering marked food restriction reported in anorexic patients. It is possible that anorexics deny their pathological eating behaviors by professing to eat portion sizes that are typical of most people (Kleifield, Wagner, & Halmi, 1996) or that they do not recognize a difference between ideal and typical portions for certain foods, such as M&Ms which are high in energy density and sweetness. However, while AN patients' typical and ideal portion sizes were not statistically significantly smaller for pizza, rice, and potatoes than sizes chosen by control participants, AN patients' typical portion sizes were smaller than ideal portion sizes for all four foods. In contrast, healthy controls showed the opposite tendency, choosing larger typical portion sizes than ideal portion sizes, across all foods. Although the differences between ideal and typical portion sizes were not significant, these patterns suggest that AN patients are aware to some degree that they are under-eating in comparison to what is considered the ideal amount of food consumption. In contrast, by choosing smaller typical portions than ideal ones, healthy participants indicate an awareness that they typically eat larger portions than would be considered ideal.

4.3. Liking, healthiness, and familiarity predictions

For some of the foods, measures of liking and healthiness were significant predictors of ideal, typical, and maximum tolerable portions. Owing to a lack of information as to patients' perceptions and beliefs about the various foods in our study, we are unable to ascertain any particular principle regarding why some foods and not others were significantly predicted by healthiness, liking, and familiarity (frequency of eating) ratings. Future studies of this nature should include participant beliefs and attitudes toward foods that span perceptions of caloric content, macro-nutrient content, weight-inducing potential, situation under which the foods are eaten, and other possible contributors, in order to understand differences in preferences across foods between patient groups.

4.4. Advantages and limitations

The use of food images in our study as opposed to actual foods is both an advantage and a limitation. An advantage of using computerized testing was that all AN patients invited to participate in this study did so and fully cooperated, which is unusual for persons with AN. Several possibilities may account for the willingness of participants: (a) patients were aware that their responses would not, and could not, affect their treatment and (b) patients were not required to eat the food presented in the images. The use of images allows for the efficient testing of a long range of food cues, without subjecting AN patients to the intense distress they feel when confronted with and made to eat food. Additionally, the adolescent participants seemed to particularly enjoy the method of adjustment paradigm, which operated similar to a computer game. However, the self-reported ratings and behaviors made in connection with food images may not map onto real-life scenarios of eating behaviors, which may be a reason that AN patients' typical and ideal portions sizes did not vary significantly from those chosen by healthy participants. Since M&Ms are a snack food, it is possible that they elicit a different response than the

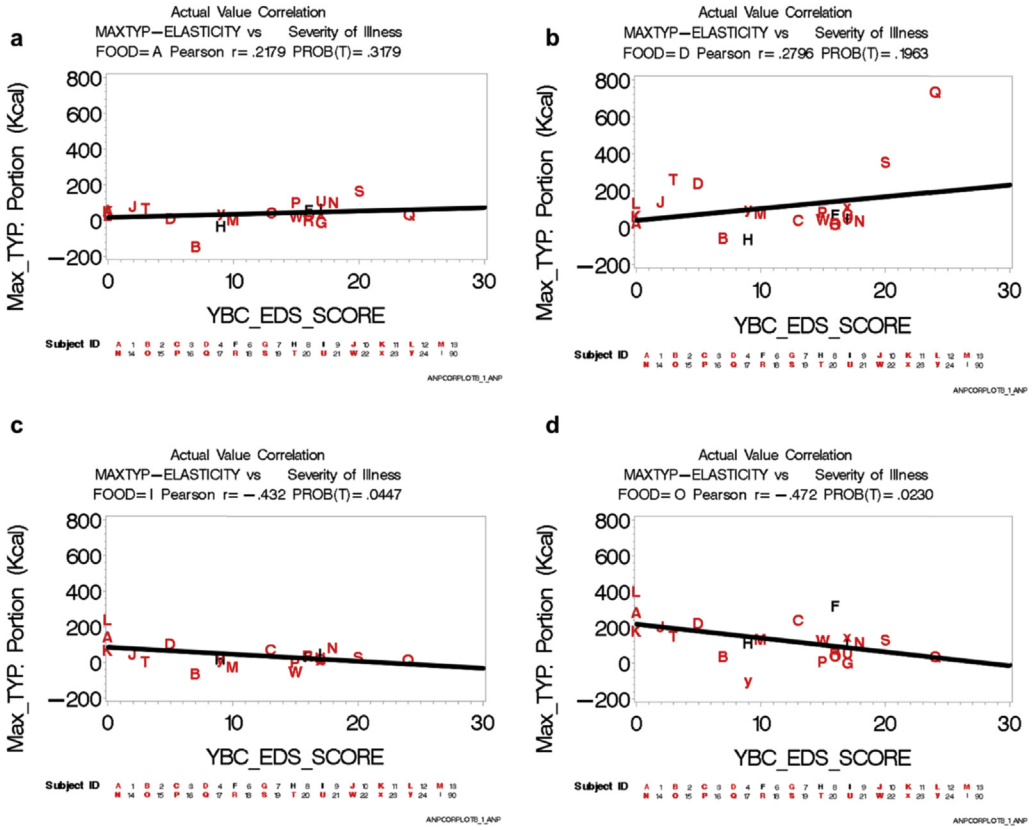

Fig. 3. Regression of Elasticity and Severity of Illness for each food. Each individual participant is represented by a letter and corresponds with a Subject ID as shown on the bottom of each figure. Each figure represents a different food a) Potatoes b) Rice c) Pizza d)M&M's. Participants labeled with letters "H", "F", and "I" are AN-P. The only male is represented by the letter "D". Regression statistics are tabulated above each panel.

three meal foods (pizza, rice, and potatoes) and are selected in different quantities; therefore their inclusion may have been a confounding factor. Future research should explore the differences in results when experimental conditions are applied to actual food, and should endeavor to provide balanced options in terms of flavor profile, energy density, and food type (i.e. snack versus meal foods). It is also important to note that as this was an exploratory study, the sample was small and there were only three males represented in total. In addition, the healthy control group contained less than half of the number of participants in the AN patient group and patients were studied at varying severity of illness levels. It should be noted that the previous study (Kissileff et al., 2016) found no relationship between BMI and severity of illness, so BMI in a group like this is not a useful indicator of the illness. Most participants were in the moderate range of severity of illness as reflected by their BMI and YBC-EDS Scores, another factor that may have weakened the effects noted above. Due to the preliminary nature of the research, we had no expectation of the effect size and could not conduct a pre-study power analysis or determine the sample size to test a hypothesis. Consequently, all statistical tests reported here should be interpreted with caution until a replication is conducted with a sample size and power that could be based on this report. Further studies with a larger sample size and more equitable sex ratio should be performed in order to improve external validity and significance of results.

4.5. Potential applications

In the present study, we were successful in obtaining a clearer picture of the portion size selection behavior that characterizes disordered eating in AN patients compared to healthy individuals, and the various factors that may play a role in this behavior. These findings may be helpful in the diagnosis of patients with anorexia nervosa, the assessment of the response to treatment, and the clarification of appetitive behaviors of other weight and eating disorders. In addition, the measures used may provide useful tools to quantify severity of eating attitudes and behaviors in patients who deny symptoms and are resistant to seeking treatment specifically for disordered eating disorder. These measures may also be used to clarify portion selection behaviors in patients with other weight and eating disorders such as obesity binge eating disorder, and bulimia nervosa, and have the potential to be useful predictors of treatment outcome.

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