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Comments

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Abstract

We use a combination of randomized field experiments and online surveys to test how the menu design affects food choices and food waste. In our field experiment, participants face one of two menus: a *narrow* menu that only displays a small portion of food, or a *broad* menu that also contains bigger portions. While all options are equally available in both menus, they differ in how easy and fast the different choices can be made. Our results show that, compared to the broad menu, participants in the narrow menu ordered smaller portions of food. Importantly, food intake was similar across conditions, leading to significant food waste reduction under the narrow menu. Our online survey suggest that these results are consistent with a combination of anchoring and menu-dependent self-control theories. We discuss the implication of our results to menu design in real world settings.

Key words: food waste; food choice; menu design; nudge; anchoring; self-control

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1. Introduction

1.1 Food waste and food choice

Food waste attracts attention in recent years due to the substantial economic, social, and environmental costs it bears (Gustavsson et al. 2011). According to UN FAO, the estimated food loss and waste accounts to about one third of food produced worldwide. In the United States, about 30-40% of the food produced for human consumption is never eaten (USDA). On the heels of the United Nations Sustainable Development Goals to halve per capita food waste worldwide, in 2015, United States announced an ambitious national goal to reduce US food waste by 50% by 2030 (USDA 2015). Following that, in October 2018, U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and the Food and Drug Administration committed to a new food waste initiative to educate Americans on the impacts and importance of reducing food loss and waste (USDA 2018). Consumers, food service, and retailers who are in the downstream of food supply chain contribute to a large proportion of food waste in developed countries (Parfitt et al. 2010). In the United States, the estimated food loss and waste at retail and consumer levels was about 31% of food supply, which is equivalent to about 133 billion pounds and $162 billion food (Buzby and Hyman 2012). Given the substantial amount of consumer food waste, it is essential to identify efficient strategies to reduce food waste at consumer level.

Despite its central importance, the behaviors producing food waste have been poorly understood. A reason for this is that, at consumer level, there are multiple factors affecting food waste and it requires interdisciplinary efforts to understand and possibly facilitate change (Quested et al. 2013). In this article, we suggest that one important factor affecting both food ordering and subsequent consumption (and hence food waste) is the framing of the menu that consumers face. For example, the number of alternatives displayed in a restaurant menu might

affect the size of the food order and subsequent consumption, leading to food waste. Our study builds on well-grounded theories in psychology and behavioral economics to study consumers' behavior in this type of settings. Using a combination of field experiments and online surveys we test how the menu frame affects consumers' food choices and food waste by providing them with sets of alternatives that highlight different serving sizes without changing the options at their disposal.

1.2 Menu dependency

Human decision making is a complex process involving the interaction of external and internal motives, and factors affecting the individual's perception and evaluation of a choice problem. We can divide theories of choice behavior in two broad groups (Dolan et al. 2012). On one hand, cognitive theories rely on a conscious reflection of the choice environment. The premise of these theories is that, given individual preferences, behavior can only be manipulated by either changing the incentives that people face or by providing new information that alters the evaluation of the trade-offs under consideration. On the other hand, context-based theories recognize that contextual elements of the choice environment might affect people's judgment, even if they seem irrelevant to the choice problem at hand. These theories go beyond logically consistent, stable preferences, and allow for choices to be affected by the framing of the situation, which provides the theoretical foundation for a wide range of policy implications (e.g. Thaler and Sunstein 2008, Ariely and Jones 2008).

Psychologists have long recognized this more nuanced approach to decision making (Chaiken and Trope 1999; Evans 2008). For example, Kahneman (2011) uses a behavioral approach that captures the duality between cognitive and context-based theories. This "dual-

process" approach is based on different systems of cognition: "System 1", which is automatic, uncontrolled, unconscious, affective and fast; and "System 2", which is reflective, controlled, conscious, rational and slow. Therefore, when primarily relying on System 1 a person is more likely to make an impulsive decision, while invoking System 2 helps the individual to reflect more carefully about the trade-offs under consideration. Quested et al. (2013) viewed the subject of food waste through these behavioral "lenses", recognizing the complexity of the behavior. They found that buying and cooking the right amount of food, which requires System 2 thinking and planning, can lead to healthy diet and reduced food waste in households. However, habits and emotional reactions (System 1) also play an important role in food choice and food waste, implying a less conscious decision making (Darnton et al. 2011, Quested et al. 2011; Quested et al. 2013).

For many consumers, healthy food choice and lower food waste requires self-control and reflective calibration; therefore, it is possible that promoting System 2 thinking in decision making is conducive to such behavior. In this sense the framing of the menu under consideration can affect consumers' decisions by affecting the valance between System 1 and System 2 thinking. Eye-tracking technology has helped researchers identify consumers' reading behavior and attention in labeling or menus (Bialkova and van Trijp 2011; Mele and Federici 2012). Experiments show that manipulating the relative location and color of different foods on the menu can significantly alter diners' choices without limiting any options (Dayan and Bar-Hillel 2011; Keegan et al. 2019; Ozdemir and Caliskan 2014; Smith et al. 2019). When food choice also involves quantity, the options displayed in the menu are in a more salient position even if consumers have the option to order other amounts. This is because the quantity displayed can be seen as an implicitly recommended default action (Johnston and Goldstein 2003). In line with

this idea, we argue that a menu displaying only a small serving of food can provide an effective nudge to limit the amount of food ordering and hence food waste by forcing consumers to apply System 2 to consciously consider bigger, non-displayed quantities.[2]

1.3 Nudging lower food orders and food waste through menu design

Behavioral nudges have been found effective in many experiments to promote favorable food behaviors in a nonintrusive way. For example, nutritionists find displaying healthy items to the left (vs. right) can enhance healthier food choices (Romero and Biswas 2016) and repositioning healthy food at the cash register desk can promote the sale of healthy products (Kroese, Marchiori, and de Ridder 2016). Nudge is also found to be effective in a variety of eating occasions in reducing consumer food waste (Whitehair et al 2013; Williamson et al. 2016; Qi and Roe 2017). Williamson et al. (2016) and Kallbekken and Salen (2013), found, in a dining environment, that the material and size of the plates offered to diners could significantly alter the amount of plate waste. Qi and Roe (2017) and Ellison et al. (2019) conducted dining experiments in universities and identified significant impacts of food waste messages on improving consumer food waste behaviors. However, most of these studies focused on aggregate data, which cannot identify individual differences among participants, and some only measured those who volunteered to report data, therefore suffering from selection bias.

In this article, we apply theories of dual-process cognition to create a simple nudge by manipulating the options displayed in the menu faced by consumers, without changing either the

[2] Thaler and Sunstein (2008) provide the definition of nudge that we will use in this article: "A nudge (…) is any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid." (p.6)

available options or the information at their disposal. We conduct an experiment where participants can face one of two menus: a narrow menu that only displays a small portion of food, or a broad menu that also contains bigger portions. Both menus provide an extra option where the subject can write any other portion they wish to order. Therefore, all options are equally available in both menus. However, the menus differ in how easy and fast the different choices can be made. While in the broad menu, the subject can just click on one of the three most popular orders, the narrow menu forces the subjects to write down any order other than the smallest portion, which would evoke System 2 thinking. The purpose of this study is to evaluate the efficacy of a narrow menu as a nonintrusive approach to promote favorable food order and reduce food waste in a dining environment. A dining experiment was conducted in a mid-size US college where students were allowed to order pizza from a menu. Subjects were randomly assigned into two treatment groups: broad versus narrow menu. Subjects who received broad menu were asked to choose one, two, three or other (specify is required) slices of pizza while the subjects who were assigned to the narrow menu group could only order one slice of pizza or specify the preferred portion by themselves. We also weighed the ounces of pizza that subjects ordered and discarded, the differences between the two was estimated as food intake.

Our results show that participants ordered fewer slices of pizza (p-value=0.0008) under the narrow menu. Compared to the subjects who received a broad order menu, subjects in the narrow menu groups achieved about 57% food waste reduction (p value=0.0039) while maintained a similar amount of food intake (p value=0.1145). These effects were heterogeneous among the subjects, however. We find that the treatment effect comes from those who ordered 1 or 2 slices, while those who ordered 3 slices were not significantly affected by the menu. This indicates that highlighting the 1-slice in the menu does not change the behavior of those who are

unlikely to consider such a small serving. On the other hand, the narrow menu is likely to affect the decisions of those consumers who might be tempted by large servings when they are prominently displayed but they are better at exercising self-control and choose the small serving in the narrow menu.

To better understand the behavioral mechanisms driving our results, we conducted an additional online survey experiment using subjects from the same population. At the end of the survey we asked participants about their preferences and perceive healthiness for pizza. Consistent with the idea of menu-dependent self-control (e.g., Noor and Takeoka 2015) we found evidence that consumers facing a self-control dilemma (i.e., those who like pizza, but thing pizza is unhealthy) are more likely to be influenced by the narrow menu. In fact, the entire treatment effect is concentrated among this type of consumers. Consumers who do not face a self-control dilemma (i.e., those who don't like pizza, or think pizza is healthy) are unaffected by the menu design. This finding confirms the idea that our nudge is likely to affect only the behavior of those who would consider the small serving but, perhaps because of a lack of willpower, are less likely to choose it when bigger portions are highlighted in the menu.

The remainder of the article is organized as follows. In Section 2 we describe the field experiment and hypotheses; while in Section 3 we report the empirical results In Section 4 and 5 we describe the procedures and findings from the online survey. Finally, in Section 6 we summarize our results and discuss policy implications.

2. Study 1: Field Experiment

2.1 Procedures

We conducted the field experiment at our College in February-April of 2019 with two more sessions conducted in February of 2020.[3] All sessions took place during weekends (Saturday and Sunday) at noon. A total of 130 students participated in the study. Participants were recruited to complete a survey on grading systems in college, and they were offered a free meal (plain pizza and drink) as a reward. To minimize demand effects, materials were designed to suggest that our interest was in the survey and that the complementary meal was incidental (the survey is shown in Online Appendix O1). [4] In addition to the meal, all participants entered in a raffle for one of eight $100 Amazon gift cards.

We conducted all sessions in the same classroom. The classroom was big enough to accommodate students sitting comfortably apart (≈ 4 ft from each other). Upon arrival students had in their seats the following materials: the paper survey, a pen, an ID number, and a bar code (see pictures in Online Appendix O2). By scanning the bar code with their phones, participants were directed to a Qualtrics form where they could order their meals (i.e., the desired slices of pizza and drink).We show the details of the menu in Section 2.2.

Once every student had ordered their meal, one of the survey organizers gave a 5-minutes presentation on different grading systems and explained the specifics of the survey to them.

[3] We conducted the sessions at the beginning of the spring semester in order to minimize possible competing events during the Football season and the Final Exams period. The sessions we conducted in early February 2020 increased our sample size from 99 to 130 subjects. This increased the power of our analysis but did not change any of our qualitative results.

[4] We informed participants of the food-related purpose of the study in a debriefing statement that we email them after data collection was completed. In this statement we also offer participants the opportunity to withdraw from the study and destroy all their data records. No participant chose to withdraw.

During the presentation, each food order was received, prepared, and measured by survey organizers located in an adjacent faculty kitchen that students could not see. Towards the end of the presentation, the research assistant brought food orders to the classroom using a tray cart and gave each student their individual meal (pizza slices, drink, and napkins) by matching the food order and the seat's ID number. Students then conducted the survey individually while having lunch. They were also instructed that they could order more slices using their phones at any point during the survey, and that once they finished, they should leave everything in their desks and exit the room quietly, as they typically do for exams.

The pizza was ordered from a popular local pizzeria that the College uses when providing pizza for events in campus. We used the most commonly ordered flavor for campus events too: plain cheese pizza, cut in 8 slices. In a residential college where students are very involved with campus events, students are very familiar both with the size and the quality of the pizza. The pies were ordered uncut, arrived minutes before noon and was cut by research assistants using a "pizza equalizer" that divides the pie into eight slices of equal size (see pictures in Online Appendix O2). Each individual meal (pizza and drink) was then measured in the adjacent kitchen using a digital food scale. The research assistants also entered the data in real time using a laptop. They were instructed to measure the food twice to minimize possible errors. After all participants had finished the survey and left the building, leftovers were also measured using the same procedure. Therefore, we collected individual information on food orders as well as precise weight measures of the meals before and after consumption.[5] Using the individual ID numbers,

[5] Even though some people does not eat the crust of the pizza, we do not have any reason to believe this would systematically bias our results because, given our randomization, crust-eaters and non-crust-eaters should be equally distributed in both treatments.

we were also able to match these measurements with the demographic information in the surveys.

2.2 Experimental Treatments

In our experiment, we manipulate a key aspect of the decision environment, the options displayed in a menu, without changing either the available options or the information at people's disposal. In particular, we conducted two between-subject treatments which varied the options displayed in the menu that students used to order pizza. In the broad menu, participants faced three food options that were ready to be clicked-on: 1-slice; 2-slices and 3-slices. In the narrow menu, participants faced only one displayed option: 1-slice. In both treatments the subject had to click on their choice of pizza or write any other order in a blank cell at the bottom with the label "Other" (see Figure 1 below). Therefore, all options are equally available in both menus. After the food order question, subjects then make their drink orders, which consist of the choices: nothing, water (16.9 fl oz), diet coke (12 fl oz), and coke (12 fl oz), then submit their orders. All drink options were equally displayed in both treatments.

Figure 1 Experimental treatments: broad menu (left) and narrow menu (right)

2.3 Hypotheses

The broad menu and narrow menus differ in how easy and fast the pizza ordering choices can be made. While in the broad menu, the subject can just click on one of the three most popular orders, the narrow menu forces the subjects to write down any order other than the smallest portion. Therefore, using dual process theory (see Section 1) we hypothesize that subjects are more likely to use System 1 when making decisions under a broad menu, where all options are easily accessible, than under a narrow menu, where subjects are forced to invoke System 2 if they wish to order bigger portions. As a result, we expect individuals under the narrow menu to be more reflective and controlled and hence more likely to choose moderate orders of food than under the broad menu.

Hypothesis 1: We expect participants to order smaller portions in the narrow menu treatment than in the broad menu treatment.

Similarly, because System 1 is associated with impulsive buying while System 2 help individuals be more reflective about the food they really need/want to consume, we expect people to better calibrate their orders and consumption decisions under the narrow menu leading to lower food waste.

Hypothesis 2: We expect participants to waste less food when facing the narrow menu treatment than when facing the broad menu.

Finally, because all options are equally available in both menus, the narrow menu should not affect the decisions of consumers who have clear preferences about what they wish to order. In particular, we do not expect treatment differences either among those who dislike the food provided (and hence order no portion) or among those who, even upon reflection, still want to order large quantities of food and hence would not seriously consider the small portion. On the other hand, those consumers who might order larger portions but would also consider a smaller portion, should be more influenced by the menu they face. These *marginal consumers* are likely to eat most of their meal when ordering the small serving but leave some leftovers when ordering bigger portions. As a result, the narrow menu should lead to a lower overall food waste, by nudging marginal consumers to choose the lower bound of their consideration set, which they are more likely to finish. This is the idea behind the next hypothesis.

Hypothesis 3: We expect the influence of the narrow menu on food waste to be strongest among those who order 1 or 2 slices of pizza.

We conducted a field experiment to collect individual data to test these hypotheses. In Section 4 and 5 we also discuss the results of a complementary study – an online survey – that helps clarify the interpretation of results as well as elucidate the underlying behavioral mechanisms.

3. Field Experiment Results

In Table 1 we show descriptive statistics for the number of pizza slices ordered (food order); the ounces of pizza consumed (food intake), and the ounces of leftover pizza (food waste). We find

that, on average, subjects ordered less food and waste less food under the narrow menu compared to the broad menu ($p<0.01$). We also find that they decreased, to a lesser degree, food intake, but this effect was only marginally significant ($p<0.1$).

Table 1 Average Food Order, Food Intake, and Food Waste across Treatments

Average (standard deviation)	food order [in slices]	food intake [in oz]	food waste [in oz]
Broad menu	1.588	7.41	1.4
	(0.0868)	(3.803)	(1.87)
	1.129	6.365	0.61
Narrow menu	(0.735)	(2.952)	(1)
t-test P-values	0.0008	0.0573	0.0039

Figure 2 also shows the frequency of different pizza orders across treatments where red bar represents the orders under broad menu and white bar narrow menu. While the modal order in the broad menu treatment is '2-slices', the smallest order ('1-slice') becomes the most common order under the narrow menu treatment. Moreover, the number of people choosing no slices is essentially the same across treatments (9 vs 11) while there are a few more subjects choosing 3 slices in the broad menu (8) than in the narrow menu (2).

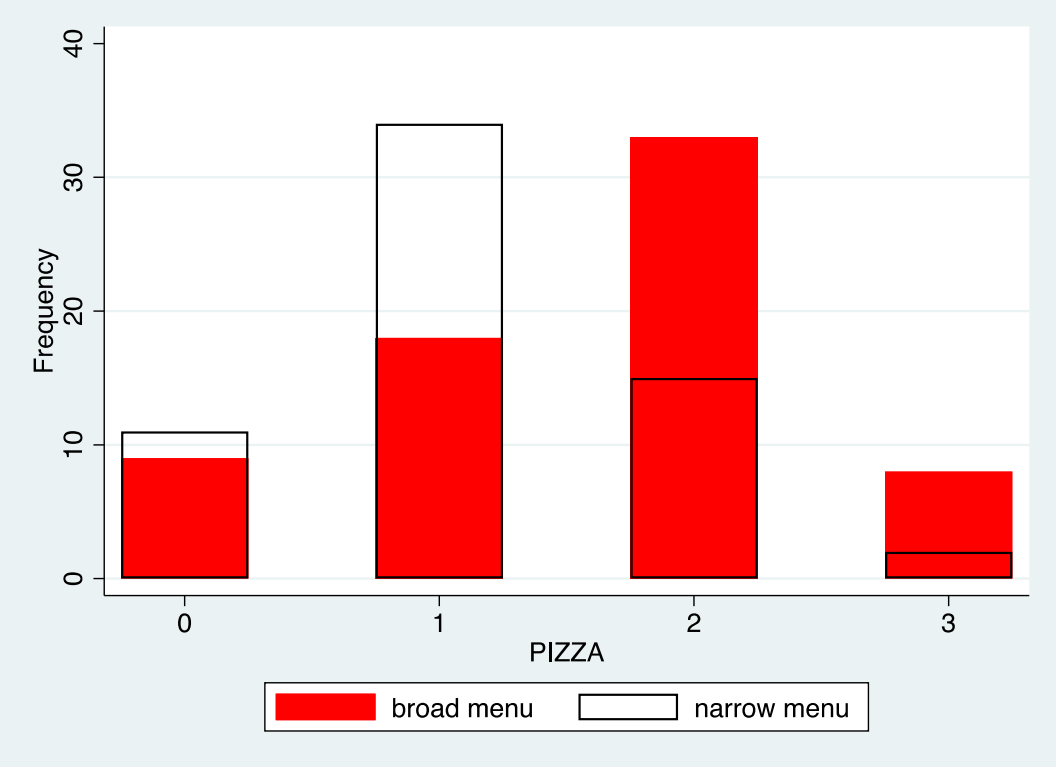

Figure 2 Distribution of pizza orders across menus

Result 1. *There were significantly more subjects ordering 1-slice in the narrow menu than in the broad menu. This leads to lower overall food orders in the narrow menu.*

Using the experiment ID, we match subject with their responses in the surveys to gather more information about the individuals. We have slightly more female students in the sample, with majority of them being white and not student athletes. A large portion of the students were freshmen or sophomores when the study was conducted, possibly because these students are more likely to be engaged or have time to volunteer to participate in weekend studies. We also see the distribution of drink orders, with the most popular choice being water. All variables in Table 2 are dummy variables taking the values of 0 or 1.

Table 2 Summary Statistics of Subjects' Information

Category	Variable	Mean	Std. Dev
Gender	Male	0.462	0.500
Ethnicity	Asian	0.169	0.376
	Black/African American	0.162	0.369
	White	0.585	0.495
	Hispanic/Latino	0.077	0.268
	Prefer not to tell	0.008	0.088
Student athlete	Student athlete	0.285	0.453
Class Year	2019	0.200	0.402
	2020	0.108	0.311
	2021	0.154	0.362
	2022	0.438	0.498
	2023	0.100	0.301
Major Division	Humanity	0.069	0.255
	Social science	0.469	0.501
	Natural science	0.285	0.453
	Engineering	0.177	0.383
Drink	None	0.246	0.432
	Water	0.500	0.502
	Diet coke	0.115	0.321
	Coke	0.138	0.347
Number of observations	130		

In Table 3, we present the results of linear OLS regressions. Our aim is to assess the impact of the menu on food order, food intake, and food waste controlling for the drink they order as well as their gender. In line with our conjectures, we find that the narrow menu significantly decreases food orders (Hypothesis 1) and food waste (Hypothesis 2). Moreover, after controlling for drink orders and other demographic characteristics, the treatment difference in food intake is not statistically significant.

Result 2. *Compared to the broad menu, the narrow menu leads to less food waste without significantly affecting food intake.*

Table 3 Treatment Effect of Food Order, Food Intake, and Food Waste

Dependent variables		Food order [in slices]	Food intake [in oz]	Food waste [in oz]
Category	Variables			
Treatment	Narrow menu	-0.490***	-1.073	-0.768**
		(0.146)	(0.710)	(0.321)
Gender	Male	0.593***	2.408***	-0.277
		(0.147)	(0.707)	(0.319)
Ethnicity	White	-0.0382	0.401	-0.385
		(0.147)	(0.698)	(0.315)
Athlete	Athlete	0.245	1.321	0.105
		(0.166)	(0.819)	(0.370)
Class year	2020	0.159	0.480	0.313
		(0.275)	(1.302)	(0.588)
	2021	0.0894	0.752	-0.255
		(0.238)	(1.135)	(0.513)
	2022	0.0172	0.220	-0.345
		(0.192)	(0.912)	(0.412)
	2023	-0.0927	-0.148	-0.198
		(0.268)	(1.321)	(0.597)
Major division	Social science	-0.153	-1.480	0.0959

		(0.282)	(1.327)	(0.599)
	Natural science	-0.299	-1.164	-0.181
		(0.291)	(1.381)	(0.624)
	Engineering	-0.149	-1.216	-0.153
		(0.305)	(1.432)	(0.647)
	Diet coke	0.0878	-1.522	1.073**
		(0.222)	(1.027)	(0.464)
Drink	Coke	0.493**	0.137	0.610
		(0.208)	(0.954)	(0.431)
Constant		1.847***	7.830***	2.458***
		(0.354)	(1.698)	(0.767)

Note: *p-value<0.1, **p-value<0.5, ***p-value<0.01

This table reports the results from linear OLS regressions. The left-out baseline drink is water/no drink. Male is a dummy variable taking the value 1 if the subject was a male and 0 otherwise.[6] There are in total 130 subjects, where 20 subjects didn't order any food and hence are excluded from the analysis on food intake and food waste.

Additional results in Table 3 indicate that males tend to order more and consume more but do not waste more than females. Those ordering carbonated drinks order more food. And, perhaps because carbonated drinks are more filling than water or no drink, they are associated with higher food waste. We didn't find any statistically significant differences among ethnicity, athlete, class year, or major.

In the previous section we also discussed that the treatment effect should be strongest for those ordering small servings of food (Hypothesis 3). This is because the narrow menu is more likely to affect the decisions of subjects who would consider eating the small portion (1 slice) but also bigger portions. Therefore, for these marginal consumers the small portion is likely to be the lower bound of their consumption potential and hence would have a relatively low food waste when ordering 1 slice of pizza. In Table 4 we confirm this hypothesis by showing that compared with those who order 2 or more slices, our treatment effects on food waste is present only among

[6] We asked for gender in our survey using an open-ended question. However, there were no non-binary responses in our sample.

those ordering 1 slice. We also find consistent results when splitting the sample into the two subgroups (Online Appendix O3).

Table 4 Heterogeneous Treatment Effects of Food Waste Shown by Interactions of Treatment

Variables	Food Waste [in oz]	Food Waste Ratio (food waste /total order weight)
Narrow menu	-0.592	-0.033
	(0.515)	(0.050)
Order 1 slice (0/1)	0.757**	0.264***
	(0.330)	(0.051)
Narrow menu* order 1 slice	-0.688*	-0.225***
	(0.326)	(0.051)
Gender	-0.143	-0.022
	(0.407)	(0.044)
white	-0.400*	-0.041
	(0.191)	(0.031)
Constant	1.442**	0.086
	(0.558)	(0.064)
Observations	110	110
Demo Control	Yes	Yes
Cluster by session	Yes	Yes

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Result 3. *Consistent with the idea that the treatment effect is stronger among "marginal consumers" (Hypothesis 3), we find that the narrow menu increases food intake and decreases food waste only among those ordering small portions.*

4. Study 2: Online Survey

The purpose of the online survey was two-fold. On the one hand, using an online platform allow us to study the robustness of our food choice results while also having access to a bigger sample subjects from the same population.[7] On the other hand, by conducting additional menu treatments we are able to make some claims about the underlying behavioral mechanisms driving our results.

4.1 Survey Design

We conducted the online survey with different subjects from the same population in March 2020 and collected 486 responses. We recruited participants through an email containing a Qualtrics link. As a reward, participants were informed that they would enter in a raffle for one of four $100 Amazon gift cards. After reading and signing the consent form, the participant faced a vignette describing the "grading systems survey" event where we collected data for our field experiment (see online Appendix O2). We also informed them about the food (slices of plain cheese pizza) and drink options; and explained how students ordered food with their phones and receive their portions on their seats. After reading the vignette, we asked participants to make a hypothetical food order by imagining that they were in the classroom and have had no lunch

[7] We chose not to ask questions about hypothetical food intake or food waste. We believe it is easier for subjects to imagine their hypothetical food orders than how much they would eat. Moreover, asking questions about food intake and food waste might have caused additional demand effects problems by providing too much information about the purpose of the study. Finally, it is important to emphasize that, in our field experiment, food order and food waste were closely related variables, as we showed in the previous section.

before arriving when selecting their orders. Participants were randomly assigned to five different experimental treatments varying the number of options displayed in the menu (see Figure 3).

Menu 0 **Menu 1** **Menu 2** **Menu 3** **Menu 4**

Figure 3 Food menu treatments used in the online survey experiment.

Note: Menu 1 and Menu 3 correspond to the "narrow" and "broad" menus used in the field experiment.

Therefore, in addition to the "narrow menu" (Menu 1) and the "broad menu" (Menu 3) used in the field experiment, we conducted three additional treatments (Menu 0, Menu 2 and Menu 4) by further manipulating the number of options displayed in the menu. After making their food choices, subjects were asked to provide a brief rationale of their decisions. In the last two questions of the survey, participants were asked "how much do you like pizza?" and "how healthy do you think pizza is?" using a 10-point Likert scale. To control for a potential correlation between the answers to these questions, we randomized the order in which they appeared on a subject's screen.

4.2 Behavioral Mechanisms

In the field experiment (Study 1) we found that, compared to a broad menu that displays three possible food orders (1-slice; 2-slices and 3-slices), a narrow menu that displays only the small portion (1-slice) effectively decreases food orders and food waste. We briefly describe three

context-based behavioral theories consistent with these results: anchoring, compromise effect, and menu-dependent self-control; then use the online survey results to test the role of these theories in our environment.

4.2.1. Anchoring bias

In our experiment, the only option displayed in the narrow menu can be seen as an implicitly recommended option (Johnston and Goldstein 2003) acting as a decision making anchor. The literature has consistently found that people have a strong tendency to make judgements that are biased towards initially presented values. This has been demonstrated in many different settings such as energy conservation (Pichert and Katsikopoulos 2008), art auctions (Beggs and Graddy 2009), or retirement savings (Choi et al. 2003). In our survey design, anchoring implies that subjects in the narrow menu (Menu 1) are more likely to select the small portion (the only one displayed) than in a broader menu that also displays bigger servings (Menu 2-4) or an open-ended menu displaying no alternatives (Menu 0).

4.2.2. Compromise effect

In the broad menu considered in our field experiment (Menu 3), the subject was presented with three alternatives, the one in the middle (2 slices) can be seen as a compromise between a small portion (1 slice) and a large portion (3 slices). Previous research has found that when subjects perceive an option as a compromise between two extremes, they are more likely to choose it (e.g., Tversky and Simonson 1993).

Note that, both anchoring and the compromise effect, can be used to explain our field experiment result that people order more food under the broad menu, although for different

reasons. However, by providing data from more menu treatments, our online survey will allow us to test the relative importance of each theory. For example, if the compromise effect is playing a role in our environment, people should order the 2 slices serving more often in Menu 3 (where it can be seen as the compromise between smaller and bigger servings) than in any other menu.

4.2.3. Menu-Dependent Self-Control

Standard economic theories assume that consumers always choose what they prefer given their well-defined preferences. In contrast to this standard view, behavioral economists have pointed out that people might suffer from imperfect self-control. A popular approach to formalizing self-control considers decision making as the product of two utility functions with conflicting goals. For example, according to Gul and Pesendorfer (2001), a decision-maker derives two kinds of utilities from a choice alternative: normative utility and temptation utility. Gul and Pesendorfer (2001) model self-control cost as the temptation utility difference between the most- and least-tempting alternatives on a menu. Some studies (Noor and Takeoka 2015; Gómez-Miñambres and Schniter 2017a; 2017b; Toussaert 2018; Huseynov, Palma, and Ahmad 2019) have shown that as this difference increases, the decision-maker becomes more vulnerable to choosing the more tempting option. Therefore, self-control cost is menu-dependent in the sense that menus with more tempting alternatives are harder to resist. We can apply these models to our current environment. For example, consider a consumer who likes pizza and wants to eat a big portion, but also wants to follow a healthy diet. A self-control dilemma arises in this case because these are conflicting goals and hence cannot be fulfilled simultaneously. Gómez-Miñambres and Schniter (2017a; 2017b) argue that how the options are presented in a menu influences the individual's self-control and subsequent decision making. So, if for example, large portions of

pizza are prominently displayed (as in our broad menu), self-control is more difficult and the individual is more likely to choose bigger portions. But if the small portion is the only one displayed (as in our narrow menu), self-control is easier and the individual is more likely to choose the small portion.

Therefore, just as anchoring bias and the compromise effect, a menu dependent self-control theory also predicts that broad menus should lead to bigger orders than in a narrow menu, but it also implies that this effect should be strongest among those experiencing from self-control dilemmas (i.e., those with conflicting goals – who like pizza but think pizza is unhealthy).

5. Online Survey Results

We start by showing the distribution of food orders across menus (Figure 4). As we can see, there is essentially no difference in how people order when we compare Menus 2-4 with Menu 0, where no options where displayed. However, in Menu 1 (the narrow menu) people chose the small portion twice as often as in any other menu, which is consistent with the relationship between the narrow menu and broad menu in the field experiment (54.84% v.s. 26.47%). Therefore, only the narrow menu seems effective in decreasing food orders. In fact, there are no statistically significant different orders among all the other menus. The orders are also in line with the distribution of the broad menu in the field experiment.

These results are consistent with a theory of anchoring bias (displaying only the 1-slice increases its demand), but inconsistent with the compromise effect. In particular, the 2-slices meal, was ordered as frequently in Menu 3 (where 2-slices can be seen as a compromise) as in Menu 2 (where no option is a compromise), or Menu 4 (where both 2 and 3 slices are in the middle) or even Menu 0 (with no displayed options). One possible reason why we cannot detect

a compromise effect in our environment is that the 2-slices order is chosen by more than 70% of participants in all menus expect Menu 1. Therefore, because it is already the most popular choice, there is no much room to increase its demand.

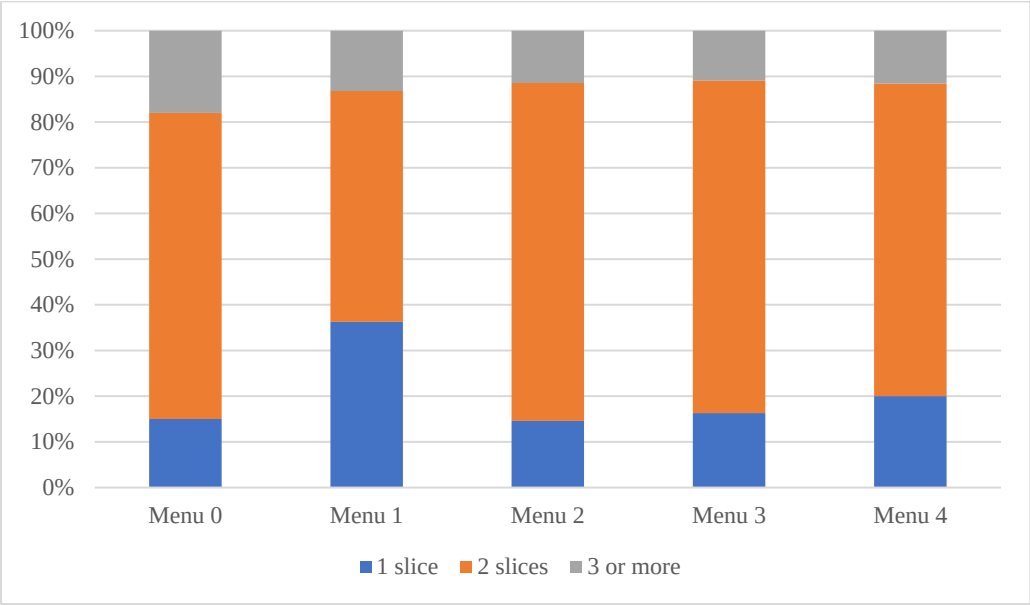

Figure 4 Distribution of food orders across menus in the online survey

In the first column of Table 5 we confirm that the narrow menu (Menu 1) is the only one leading to significantly lower food orders ($p<0.01$). A result in line with our field experiment (Result 1). We also replicate the result that those ordering carbonated drinks (coke) tend to order more food than those ordering water or no drink. Not surprisingly, we also find that those who like pizza or believe it is healthy tend to order more food.

Table 5 Menu Effects on Food Order

Dependent variable:	Food order	Food order
Menu 1 (d)	-0.353***	-0.185
	(0.110)	(0.139)
Menu 2 (d)	-0.0853	-0.139
	(0.109)	(0.138)
Menu 3 (d)	-0.122	-0.103
	(0.111)	(0.140)
Menu 4 (d)	-0.129	-0.148
	(0.110)	(0.138)
Diet coke	0.0720	0.051
	(0.131)	(0.131)
Coke	0.243**	0.312***
	(0.0992)	(0.0989)
Like pizza (1-10)	0.0405**	
	(0.0184)	
Think pizza is healthy (1-10)	0.0756***	
	(0.0276)	
Self-control (d)		0.0377
		(0.166)
Menu1*self-control index		-0.411**
		(0.233)
Menu2*self-control index		0.127
		(0.230)
Menu3*self-control index		-0.069
		(0.233)
Menu4*self-control index		-0.0141
		(0.232)
Constant	1.431***	1.962***
	(0.173)	(0.0989)
Observations	453	453

Note: *p-value<0.1, **p-value<0.5, ***p-value<0.01

Self-control index is a dummy variable taking the value 1 if the difference between how much they like pizza (on a scale of 1 to 10) and how healthy they think pizza is (on a scale of 1 to 10) is greater than 5.

In our field experiment we also showed that the narrow menu (Menu 1) was effective in changing the decisions of those ordering the small serving (Result 3). We discussed that a possible explanation for this result is that the prominent display of the small serving is likely to affect the decision of marginal consumers (who might order 1 or 2 slices), for whom the small serving is the lower bound of their consideration set. As we show in appendix O4, the food choice rationale provided by participants in our online survey is in line with this result. A text analysis of the answers (see Table O4) shows that among those ordering the small serving, there are more consumers who consider that option the lower bound of their consideration set in Menu 1 (37%) than in any other treatment (17% on average). Similarly, among those ordering 2 slices, there are less consumers who considered it the upper bound of their consideration set in Menu 1 (31%) than in any other treatment (46%). These results indicate that the relatively higher demand of the 1 slice option in Menu 1 (as compared to other menus) likely comes from marginal consumers for whom their consideration set is either 1 or 2 slices, who are more likely to go with the small serving when it is the only one displayed. Finally, our text analysis also indicates that, according to student's responses, the social preferences or social pressure considerations did not play a big role in our study. While the number of people who mention that their choice was affected by software/set-up or menu restrictions was negligible.

Our online survey also allows us to study the possibility that some of these marginal consumers are consumers who face a self-control dilemma. That is, who would like to commit to ordering a smaller serving but are tempted to ordering more food. To study the effect that self-control plays in food ordering decisions, we created a dummy variable that takes the value 1 if the difference between how much a subject likes pizza (on a scale of 1 to 10) and how healthy a subject think pizza is (on a scale of 1 to 10) is greater than 5. This captures the intuition,

consistent with the dual-self theories of self-control, that those who like pizza but think pizza is unhealthy are likely to face self-control challenges when ordering food in our experiment. Among our sample, 40% (199 people) suffer self-control problems according to this definition. In the second column of Table 5 we provide the results of a regression that includes the subject's self-control index and its interactions with the menus. Consistent with a theory of menu dependent self-control, we find that the narrow menu significantly decreases the orders of those with self-control problems. In fact, the decrease in the orders of participants suffering self-control problems explains the entire treatment effect, as Menu 1 is no longer significant in this regression.

Finally, we would like to emphasize that the food choices of those suffering self-control problems are not different in Menu 0, where no options were displayed, and Menus 2-4, where more options were displayed. Only the menu displaying the small portion alone (Menu 1) effectively affects the food choices of people with self-control. This finding indicates that in order to resist temptation, it is not enough to simply not encounter large portions in the menu; it is necessary to prominently display the small portion as well. Therefore, our results are in line with a theory of menu dependent self-control (narrow menus are easier to resist than broader menus), with the corollary that, to be effective, the narrow menu needs to include the small serving as the 'default' (i.e., only displayed) option.

6. Discussion of Results and Policy Implications

Our field experiment and online survey both show that a narrow menu, which only displays a small portion option, can effectively decrease the amount of food ordered and wasted without sacrificing subjects' freedom of choice. We also find that, simply providing an open menu that

allows for any quantity entries fails to alter subjects' selection behaviors significantly. This suggests the importance of displaying recommended alternatives to successfully nudge subjects toward healthier choices. This nudge is found to be particularly effective among those who are hesitant between small versus large portion size and suffer from self-control dilemmas. Consistent with dual-process decision making, we argue that the narrow menu with recommended option not only improves subjects' ability to calibrate their food orders, but also reduces temptation for those who face self-control dilemmas. In this way, this nudge achieved to minimize food waste without significantly affecting subjects' overall food intake.

These findings provide several insights to guide consumer food waste policy designs. First, the food waste reduction that occurred in the narrow menu treatment was achieved through better calibration in food selection, i.e., fewer slices of pizza selected, rather than food intake adjustments. According to the food waste hierarchy from US EPA, source reduction that decreases the volume of surplus food generated is regarded as the first priority among all food waste management (US EPA). By selecting fewer food from the beginning, fewer food will be served and more food will be available for others on the market which could induce a downward pressure on the price of food in short run and therefore mitigates food security. This is one of the major motivations to reduce food waste along the supply chain. Moreover, as patrons select smaller quantity of food in all-you-can-eat buffets, restaurants enjoy lower costs of food provision without limiting customers' ability to choose their desired quantity and sacrificing customer satisfaction. On the other hand, while we observed a decrease in the amount of food selected and wasted, we didn't find a significant change in subjects' food intake ($p = 0.1145$). This further supports our previous argument that subjects still enjoyed full abilities to maintain a desirable level of food intake when only narrow menu was provided. In the meantime, since this

nudge didn't provide any salient information about food waste, it didn't give rise to strong feelings of guilt about discarding surplus food. A text analysis of the online survey responses indicate that social preferences or social pressure considerations did not play a big role in food choice. As a consequence, subjects in our study didn't seem to feel obligated to minimize the generation of plate waste. Based on that, we would expect that the observed food waste reduction should be achieved without intentional extra efforts, e.g., over-eating or plate cleaning which are found to be a habit that is strongly associated with overweight and obesity (Robinson and Hardman, 2016). We believe that this design can complement the current policies and efforts and helps improve food security and achieve nutritional goals simultaneously.

It is also important to emphasize that the place where we conducted the experiment is a residential college with around 2,500 students. Based on Recyclingworks' estimation, for colleges and universities, a residential student wastes 141.75 lbs/year of food.[8] Back of the envelop calculations show that a 57% reduction from the nudge can lead to 201,993 lbs of food waste reduction, which saves the college $246,036 (Buzby and Hyman 2012). At the national level, the Food Recovery Network found that college campuses waste 22 million pounds of uneaten food each year, which wastes roughly $27 million dollars, $15.3 million of which we might be able to save.

The design can also be applied to food settings that are likely to be more relevant in the near future. For example, since the beginning of COVID-19, the food industry has moved more heavily towards noncontact services. Even before the pandemic, some universities have created mobile ordering (e.g. University of Pennsylvania's "Penn Eats"), and more colleges have started

[8] Data available here: https://recyclingworksma.com/food-waste-estimation-guide/#Jump01

similar services. The mobile ordering services are ideal to implement our design where the apps could display the recommended quantity for the desired dish and use open question for consumers to order other quantities. Buffet style restaurants could implement a similar system instead of openly displaying all the food, which not only help consumers better calibrate their choices and reduce temptation, but also reduces hygienic concerns. For traditional school or workplace cafeterias, they could serve a fixed small portion for customers as the default while allowing them to ask for more.

Finally, our results indicate potential mechanisms for consumers to pre-commit to small servings when they might be tempted by larger food servings. One promising line for research would be to study the implications of allowing participants to make an ex-ante choice between the broad and the narrow menu (Toussaert 2018). This pre-commitment decision is likely to be used by sophisticated (i.e., forward looking) consumers who face self-control problems but want to eat healthy. Our study has shown that narrowing the quantity options is effective; additional lines of future research include narrowing the types of food provided or the time for eating.

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