



Does serving vegetables in partitioned portions promote vegetable consumption?

Michelle R. vanDellen*, Janani Rajbhandari-Thapa, Julio Sevilla

University of Georgia, GA, United States

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ABSTRACT

Fruit and vegetable consumption in the United States is below the recommended level for two reasons: lack of access and low preference. In this work, we identify lack of preference for vegetables as a public health issue and apply theories from psychology and marketing literature to study the effect of partitioned presentation of vegetables on consumption of vegetables. Separating items into single units with clear partitions generally reduces consumption of relatively appealing foods by making the eater more aware of the amount consumed. For relatively less appealing foods (typically but not exclusively those lower in sugar/fat), a partitioned presentation format might operate to increase consumption. This expectation draws on two complementary theoretical perspectives. First, partitioning of relatively unappealing foods involve *initiation* rather than inhibition, and thus, fewer decision points may promote consumption. Second, because people have an intrinsic desire for completion, they may be more likely to finish a partitioned portion, even if these are made of relatively unappealing options. After conducting a pilot experiment to verify experimental procedures, we conducted two experiments (total $N = 342$) in which we randomly presented cauliflower (a relatively less appealing food) in either a whole presentation format (i.e., all pieces on one plate) or a partitioned presentation format (i.e., groups of cauliflower pieces arranged into subgroups with clear divisions) and measured consumption. We observed no effects of presentation format on total consumption, but we did observe an increase in minimal consumption in the partitioned format.

1. Introduction and theory

Diets rich in fruits and vegetables can protect against many diseases including coronary heart disease (Boeing et al., 2012), stroke (He, Nowson, & MacGregor, 2006), and all-cause mortality (e.g. Aune et al., 2017). In the United States, four of the top 10 leading causes of death are diet-related (National Center for Health Statistics, 2016), with most research suggesting an inverse relationship between fruit and vegetable consumption and central adiposity, a major predictor of health-related problems (Ledoux, Hingle, & Baranowski, 2011). However, as of 2015, only 12 and 9% of adults met the recommendations for fruits and vegetables respectively (Centers for Disease Control and Prevention, 2017). Among children, policies support consumption of fruits and vegetables in school lunchrooms, yet their consumption is low and fruits and vegetables often get wasted (e.g., Cohen, Richardson, Austin, Economos, & Rimm, 2013). Overall, these findings indicate that fruits and vegetables are not considered highly desirable foods. In fact, past research has shown that consumers believe healthy food to be less tasty and desirable than unhealthy food (Raghunathan et al., 2006). This

type of effect has also been demonstrated on children, who believe that foods that are positioned as being instrumental for their health, such as fruits and vegetables, are less tasty (Maimaran & Fishbach, 2014).

Drawing on these low rates of consumption and desirability associated with fruits and vegetables, recommendations target national mass marketing campaigns and price-reduction policies to increase their consumption (Pearson-Stuttard et al., 2017). One route to increase fruit and vegetable consumption is through choice architecture—using small environmental changes to modify decisions and behavior (Nørnberg, Houlby, Skov, & Perez-Cueto, 2016). For example, doubling portion sizes of fruits and vegetable side dishes led to a significant increase in fruit intake but not vegetable intake (Kral, Kabay, Roe, & Rolls, 2012). This research suggests simple portion size manipulations may not increase consumption of relatively unappealing foods such as vegetables. However, experimental research to test psychological and marketing theories for increasing vegetable consumption is limited. The foods commonly studied in psychology and marketing tend to be highly appealing foods (e.g., chocolates, cheese, grapes), rather than less appealing (but healthy) ones, where public health impact should

* Corresponding author at: Psychology Building, Athens, GA 30602, United States.

E-mail address: mvd@uga.edu (M.R. vanDellen).



Fig. 1. Example study set-up with partitioned servings on the left and whole servings on the right. Images display cauliflower not used in the study (all participants saw pieces of cauliflower of approximately equal size).

potentially be focused.

One candidate for widespread intervention to promote consumption of fruits and vegetables in lunchrooms and restaurants might be partitioning, which involves separating food items into distinct units rather than serving them as a whole. For example, a serving of fruits served in a separate container (e.g., fruit cup) may be viewed as more of a separate and divided unit than several servings of fruits served with a spoon out of a larger bowl (see Fig. 1 for a visual example). In research on partitioning, consumption of food decreases when food is divided into separate units relative to when it is presented as a whole group (Cheema & Soman, 2008). This effect occurs because after consuming each unit individuals must make a decision. To date, research on partitioning has been conducted on highly appealing foods, including chocolates and cookies. Individuals consume less chocolates when they are partitioned as people generally understand they should not over-consume unhealthy foods (such as chocolates), hence the decision points offer a natural place for individuals to consider their behavior and engage in restraint or inhibitory responses.

However, we propose that partitions on relatively less appealing foods should motivate *more* consumption. We base this expectation on two key theoretical premises. First, the act of making oneself eat a relatively unappealing food requires a different type of self-control. Specifically, it involves *initiation* rather than (or instead of primarily) inhibition (Hoyle & Davison, 2016). To initiate, people must engage in a desired but effortful behavior, as compared to inhibition which requires stopping an undesired behavior. Decision points for consumers are problematic when they require cognitive or volitional effort to continue (Westbrook and Braver, 2015). Because the automatic tendency of people might be to choose *not* to eat relatively unappealing foods, reducing the number of times they have to do so may increase consumption. When consuming vegetables feels like a series of decision points, continuing to consume should require initiation. However, when consuming vegetables feels like one choice (i.e., to finish a partitioned serving), less effort may be involved to initiate action to the same end point.

Second, people are motivated to finish units—what is called the goal gradient effect. Although this phenomenon was initially shown in rats running for food in a maze (Hull, 1932), similar effects have been shown in humans in business contexts. Specifically, consumers participating in rewards programs work harder towards the goal of attaining the reward as they get closer to it (Kivetz, Urminsky, & Zheng, 2006). Consistent with this apparent desire for completion, people also feel more satisfied by equal size complete versus incomplete food items (e.g., half-sandwiches, incomplete containers), which leads people to consume more of an equal sized item when its shape is incomplete versus complete (Sevilla & Kahn, 2014). Because of this preference for

completing units, partitions may provide a goal for consumption that would otherwise not exist.

1.1. Present research

We leverage work on partitioning and goal dynamics to hypothesize that partitioned presentation of vegetables promotes consumption. This work is novel because we investigate effects of partitioning for initiation (vs. inhibition) behaviors. We examined 1) total consumption of vegetables and 2) likelihood of consumption of a partitioned portion of vegetables. If partitioning increases consumption, then both total consumption and likelihood of consuming a partitioning portion should increase. All studies used random assignment to determine experimental condition and were approved by the local ethics review board. Although the studies used random assignment, they were not pre-registered as clinical trials.

2. Methods

A total of three studies were conducted. First, we conducted a pilot experiment to validate the procedure that items grouped together can be viewed as a partition. As prior partitioning work (Cheema & Soman, 2008) has only partitioned items into units of one, it was necessary for us to consider whether similar partitioning effects might be observed when items are grouped into larger units (e.g., groups of four). Thus, in this study we used both relatively appealing foods (i.e., candy) to be consistent with prior work as well as vegetables (i.e., raw broccoli) to examine whether partitioning is likely with less appealing foods. After validating that partitioning effects can be observed among groups of units, we replicated the findings in two additional laboratory experiments using a different seasonally appropriate vegetable (i.e., cauliflower). In these studies, we varied the partitioning methods and number of items per partition.

2.1. Participants

Participants for all three studies were recruited from an undergraduate research participation pool at a large university in the United States; all participants received partial course credit for their participation. Available details about participants are presented in Table 1. For each study, we aimed to include 75–100 participants per condition. There were no exclusions for participation in the study except individuals with allergies to pesticides (we deemed it unlikely even traces of pesticides would be on the vegetables because we washed them before use, however, we added this precaution to be absolutely sure). In the pilot study, participants with chocolate or dairy allergies were

Table 1
Participant characteristics and overview of experimental conditions.

Study	Pilot	1	2
Sample Size	398	155	187
Percentage female	79.65	77.92	73.80
Mean age	18.73	19.09	19.56
Foods Tasted	Raw Broccoli or Chocolate Coated Caramel	Raw Cauliflower	Raw Cauliflower
	<i>Partitioned presentation</i>		
Food units	4 pieces in 4 partitions	4 pieces in 4 partitions	6 pieces in 4 partitions
Partitioning device	4 oz plastic cup on large white plate	Small ceramic white plates	4 oz plastic cup on large white plate
	<i>Un-partitioned presentation</i>		
Food units	16 pieces	16 pieces	24 pieces
Un-partitioned presentation	Large white plate	Large white plate	Large white plate

Note: All participants came from the same participant pool and are thus likely to share characteristics such as age.

additionally excluded. Although personal preferences for and exposure to vegetables might play a role in consumption, we opted not to include or exclude participants for other reasons, instead relying on random assignment and large sample sizes to equalize conditions.

2.2. Procedures

All study sessions took place after 10:30 in the morning, with most sessions occurring after noon. All participants were informed that the study was about taste preferences for vegetables. We selected raw broccoli or cauliflower as the vegetable items. These vegetables were chosen because they are less favorably viewed relative to other raw vegetables (e.g., carrots; Morris & Zidenberg-Cherr, 2002). Additionally, unlike fruits that normally have varying levels of sugar according to maturity, (Vincente, Manganaris, Ortiz, Sozzi, & Crisoto, 2014) these vegetables do not become sweeter with maturation, which allowed us to control the taste across participants. After providing written informed consent and confirming they had no relevant food allergies, participants were escorted to a room presenting the test foods in two ways: partitioned or un-partitioned presentation. The study instructions encouraged participants to consume the served food (i.e., candy or vegetables) and required consumption of at least one bite.

Experimenters set up the room prior to the participants' arrival according to a randomization schedule. Before each session, experimenters set up the room. Using a randomization schedule, they placed either 16 (or 24, depending on the study) pieces of foods into the appropriate set up (partitioned or whole; see Fig. 1 for example set-up). Experimenters were instructed to utilize similar sized pieces of each food for a given participant (vegetables purchased naturally varied in size but were cut up by the first author to ensure similarity; average weight of each piece of cauliflower [Experiments 1–2] was ~6 g [~2 calories]). This amount of food represents approximately one serving of vegetables. After set up, experimenters weighed each food plate using a kitchen scale and recorded the total weight of the plates + food (in grams). Although experimenters could not be blind to condition, they were blind to the hypothesis. Table 1 describes the food(s) used, number of total units presented, and partitioning methods across each study. After each session, experimenters again weighed the total weight of plates + food (in grams) and recorded it. Each participant was additionally given a napkin and a cup of water. The trash bin in the experimental room was removed so that participants could not discard vegetables.

After the taste test, participants indicated their trait self-control, restrained eating status, and demographics. They also answered questions about the vegetable. These questions followed (rather than preceded) the taste test to reduce demand characteristics. One question asked about frequency of past consumption and two items asked about enjoyment during the task and intentions to eat the vegetable in the future.

2.3. Measures

The amount and weight of vegetables consumed was recorded after each session by the experimenter. We additionally recorded two measures of consumption: a) minimum consumption of one bite and b) finishing one partitioned portion. Participants who ate less than a whole piece of the relevant food were treated as consuming one piece.

3. Results

3.1. Pilot experiment

When sampling broccoli, the most common stopping point was at one piece of broccoli (28.29%). In contrast, only 13.17% of participants stopped eating chocolates after one piece. Instead, the most common consumption for chocolates was four pieces (27.80%). Combined across foods, we observed an effect of presentation such that stopping at the size of the set was more likely in the partitioned than the whole presentation condition, $\chi^2 = 20.195$, $p < .001$. We next examined each food separately. Given that the expected frequency in each cell (i.e., the frequency of stopping at any one amount of consumption) was ~6, we used Fisher's exact tests to calculate whether observed frequencies differed from expected frequencies within each food condition. Of the participants who sampled chocolate caramels, stopping at 4 pieces was more likely in the partitioned condition (20.98%) than in the whole condition (6.83%), Fisher exact test $p < .0001$. Of the participants who sampled broccoli, stopping at 4 pieces was also more likely in the partitioned condition (11.11%) than in the whole condition (6.57%), Fisher exact test $p < .017$.

These results offer key pieces of information. First, the most common amount of consumption of vegetables was one piece, confirming our assumption that most people are initiating self-control to consume more than one piece of the vegetable. This number also sets the groundwork for considering one piece of a vegetable as a minimal consumption level against which we want to increase consumption. That is, *increased public health* impact may come from encouraging individuals to consume more than their preferred minimal amount. Second, this study confirms it reasonable to think of partitions as containing more than one piece of an item. Across both foods, individuals demonstrated the same tendency to stop after completing an entire partitioned portion in the partitioned condition than to arbitrarily choose to stop at that point when the foods were presented without partitioning.

3.2. Experiment 1

There was a non-significant effect of condition on weight of cauliflower consumed. Likewise, condition did not influence number of pieces consumed across condition. However, as in our pilot study, participants were influenced by the presentation condition. Because

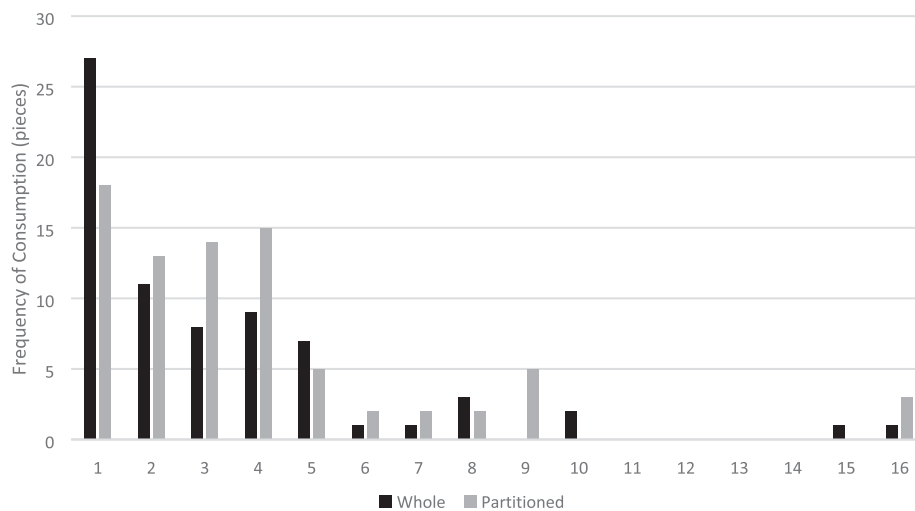


Fig. 2. Frequencies of consumption across condition pieces of cauliflower, Experiment 1.

expected frequency for each stopping point was ~ 6 , we used a Fisher's exact test to examine whether the observed frequency of a) minimum consumption and b) set size consumption differed across condition. Figure 2 shows the consumption of each number of pieces. Participants were less likely to stop at one piece of cauliflower in the partitioned condition (11.70%) than in the whole condition (17.53%), Fisher's Exact test $p = .040$. Moreover, there was a marginally significant effect of condition on the consumption of the number of pieces in the set (i.e., four), Fisher's Exact test $p = .074$, such that participants were more likely to consume one whole set size in the partitioned (9.74%) than in the whole (5.84%) condition. Thus, Study 2 provides evidence for shifts away from minimum consumption in the partitioned group. These shifts were accompanied by suggestive (but non-significant) shifts toward consumption of a set size. In sum, seeing four sets (with four pieces of cauliflower in each set) decreased the likelihood of consuming just one piece of the vegetable relative to seeing sixteen pieces in one group.

3.3. Experiment 2

As in Study 1, condition did not influence weight of the food consumed. Likewise, condition did not influence total number of pieces consumed across condition. Again, however, minimum consumption was influenced, specifically such that participants in the whole condition were more likely to stop at minimum consumption of one piece (12.30%) than were participants in the partitioned condition (7.49%), Fisher's exact test $p = .036$. Likewise, participants were more likely to stop at 6 pieces in the partitioned (11.26%) than in the whole (5.30%) condition, Fisher's exact test $p = .036$. Figure 3 shows the consumption of each number of pieces.

3.4. Combined analyses

Given the advantages of increasing sample size for determining reliability of effects, we conducted a combined analysis across both Studies 1 and 2. Participants were sorted into three groups: a) **Minimum** consumption who consumed 1 piece of cauliflower in the taste task, b) **Set size** consumption who consumed either 4 (Study 1) or 6 (Study 2) pieces of cauliflower, c) **Other** consumption who consumed any other amount of the food. Participants in the whole condition were more likely to stop at minimum consumption than at set size consumption relative to participants in the partitioned condition, $X^2 = 8.616$, $p = .013$ (see Table 2 for frequencies).

3.5. Ancillary analyses

Although we did not formulate hypotheses about our collected preferences for and prior consumption of vegetables, we explored whether they moderated the effect of condition. In both Study 1 and Study 2, participants did not differ on reports of prior consumption of cauliflower, F 's < 2.27 , p 's $> .14$. Prior consumption demonstrated some small and inconsistent relationships with the number of pieces and weight of vegetable consumed, F 's between 1.72 and 4.55, p 's between .03 and .19, but did not moderate the effect of condition on these variables. Additionally, controlling for these variables did not change the effect of condition on number of pieces or weight of vegetables consumed. We also considered whether liking or prior consumption may moderate the effects of condition on minimal consumption or a partitioned portion. The only effect to emerge was in Study 1. In this study, liking interacted with condition to predict finishing a portion, $F(1, 150) = 3.81$, $p = .053$. The pattern of the interaction was such that for participants who reported greater liking, they were more likely to eat the portion in the divided than the whole condition; there was no effect of condition at low levels of liking.

4. Discussion

We demonstrated that a subtle change in presentation of vegetables can produce shifts toward greater consumption. Although total levels of consumption did not vary by presentation format, we observed that presenting vegetables in portions decreases minimum consumption (i.e., one bite) and increases the likelihood that individuals will consume a target number of pieces. This research draws on principles studied in psychology and marketing with regards to promoting consumption of foods that are less appealing (e.g., cauliflower).

Theoretically, our results suggest that reducing decision points can promote self-control behaviors that require initiation. That is, whereas inhibition is enhanced by increasing decision points (e.g., Cheema & Soman, 2008), initiation may be enhanced by putting people on autopilot. Once they have begun consumption of a relatively less appealing food, they may be more likely to continue consuming that food until they reach a noticeable stopping point, such as the end of a partition. Our idea also converges with evidence for the goal gradient hypothesis, a pervasive phenomenon in which animals and people work harder towards a goal as they near its completion (e.g., Hull, 1932; Kivetz et al., 2006). That is, having identifiable (vs. undetectable goals), leads consumers to make steady progress toward those goals. In this context, a consumption goal would be represented by eating a full portion, which may be more likely to be perceived when partitioning separates

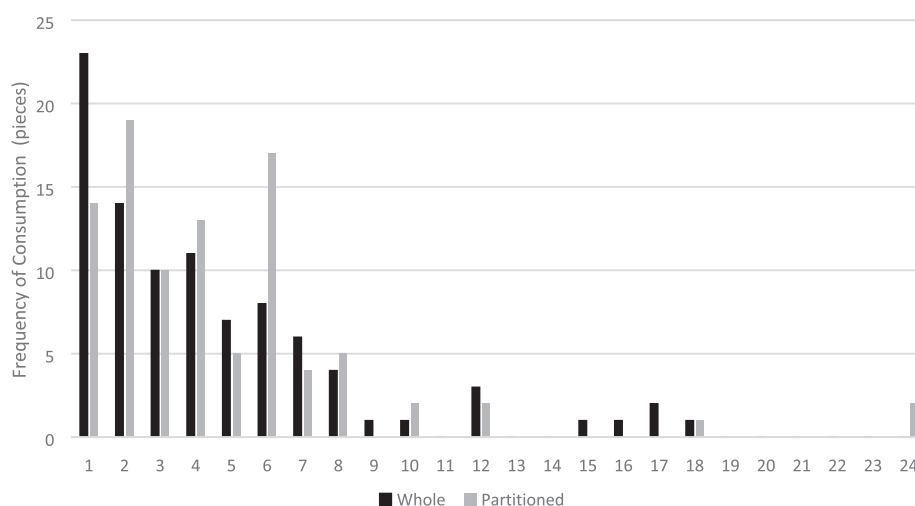


Fig. 3. Frequencies of consumption across condition and piece of cauliflower, Experiment 2.

Table 2

Frequency of consumption across Studies 1 & 2 combined (in pieces).

	Minimum consumption	Partitioned portion consumption	Other consumption
Partitioned	32	32	107
Whole	50	17	103

Note: In Study 1, set size = 4 pieces of vegetables and in Study 2, set size = 6 pieces of vegetables. Participants who ate 1 piece are represented in the minimum consumption column, participants who ate one partitioned portion are in the partitioned portion consumption column, and all other participants are shown in the other consumption column.

items into seemingly whole groups.

More generally, the present work suggests that the same ideas that promote consumption of appealing foods may be modified to promote consumption of relatively less appealing foods. Future research may consider investigating the mechanisms by which partitioning produces greater consumption. We expect that consumers' motivation for completion (e.g., Sevilla & Kahn, 2014) may facilitate this behavior. If so, the satisfaction that comes from completing a set may offer an immediate reward, which should facilitate enjoyment and persistence in consuming more vegetables in the future (Woolley & Fishbach, 2017). The results suggest that further capitalizing on the principles driving consumption of sets or partitions can increase the low rates of fruit and vegetable consumption. For instance, presentation formats that highlight "finish this" with regards to sets may identify a serving size as a goal. Serving sizes and portions are highly subjective, with most people underestimating them (Carels, Harper, & Konrad, 2007).

Estimates of serving sizes have not been as widely studied with regard to fruits and vegetables but given the widespread variability in serving size perceptions of other foods, it is likely that people misjudge how much fruits and vegetables they consume or should consume. Using set sizes that reflect recommended servings to encourage tracking of vegetables may promote overall consumption and increase the likelihood that people meet federal recommendations. However, future research should compare the effect of partitioning across types of fruits and vegetables. Because we suspect partitioning works best when initiating self-control is required, partitioning may only increase partitioned portions when the foods are relatively less appealing. An interesting possibility is that partitioning may increase total consumption when foods are relatively more appealing, which may have negative health effects.

Relatedly, another important factor to consider is the role that the size of the partitions employed plays in consumption. Although our

studies were limited to comparisons between partitioned versus non-partitioned portions, it is possible that different effects could emerge if the size of the partitions used were manipulated. That is, while we may have found partitions of one serving size increased consumption of vegetables, it is possible that the use of excessively large partitions could discourage consumers from even initiating consumption or could make it more likely that they quit consuming the partition before finishing it. In fact, this same notion may be behind the reason why we find a positive effect of partitioned portions versus whole portions, so it is possible that once partition size reaches certain magnitude, the positive effect of partitions on consumption of vegetables could disappear or even backfire.

Given the health importance and declining rates of fruit and vegetable consumption (Blanck, Gillespie, Kimmons, & Seymour, 2008), these ideas may have critical public health implications. One place where implications may be considered is in the school lunch room. Currently, consumption of fruits and vegetables in the lunchroom is relatively low (Cohen et al., 2013; Ralston et al., 2008). To some degree, low consumption occurs because students do not select fruits and vegetables from the lunchroom line. However, when students are served fruits and vegetables, food waste is still high. The school lunch line is a clear case where partitioned presentation of fruits and vegetables can occur. For instance, in most lunchrooms, fruits and vegetables are served in pre-portioned units. Our results suggest that food waste is not likely due to this serving presentation. Because students see fruits and vegetables as a unit, they should be more likely to consume the portioned serving.

The extent to which partitioning can be used to promote goal setting and reduce decision points in vegetable consumption certainly carries promise but also opens more questions as to how to most effectively use partitions to increase consumption. Social norms to finish a given unit develop early and are transmitted through parental training of eating (Birch, McPhee, Shoba, Steinberg, & Krehbiel, 1987; Rolls, Engell, & Birch, 2000). However, future research should examine partitioning effects across developmental groups to ensure that lunchroom settings capitalize on how children and adolescents are affected by partitioning and implicit consumption goals. Future research may also need to consider how other choice architecture interventions—such as interventions that increase the perceived appeal of fruits and vegetables—might complement interventions that facilitate consumption.

Another issue for further consideration with regards to set sizes is that once someone takes a partition, that item no longer visually appears to be a partition, but rather becomes its own individual set. Imagine a buffet line where steamed green beans are offered in plastic serving trays containing one serving each. Once a person selects a

partition of the green beans, they should see that unit as a goal for consumption. When that person sits down with the single green bean partition, though, it may no longer appear to be one unit of green beans, but rather to be its own whole group. The person may no longer think of starting to consume the green beans as the only decision point; rather, each new bite may feel like a new decision point and any experienced bitterness in the vegetables may lead the person to reconsider taking another bite.

5. Conclusions

The present work suggests that partitioning may be a useful way to consider increasing vegetable consumption. Consumers were less likely to stop at one bite of a vegetable and more likely to finish a complete partition when vegetables were presented in partitioned portions than as a whole group. The findings suggest that future considerations of choice architecture with regards to vegetables may be effective at shaping increased vegetable consumption, contributing to overall public health.

Author contributions

All authors contributed to the study design. MRV conducted the studies and analyzed the data. All authors contributed to the writing of the manuscript and approve the manuscript for submission.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodqual.2019.103750>.

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