Large portion and pack-sizes

What does the evidence say?

LARGE PORTION AND PACK SIZES – WHAT DOES THE EVIDENCE SAY?

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The portion size effect is the phenomenon by which larger portion and package sizes lead to increased food intake.
A Cochrane systematic review on the portion and pack-size effect was published in 2016 (1). This memorandum sums up the results of a follow-up review by the Danish Cancer Society including the most recent literature on the subject (late 2012 – late 2018). The present review includes 24 peer-reviewed articles (describing 34 studies).

MAIN CONCLUSION

This review confirms the robustness of the portion and pack-size effect in single meal/snack or short-term occasions (Fig.1). This effect is confirmed mainly in laboratory settings, and by exposure to larger-than-normal portions. The portion size effect seems to be generic across gender, age and socioeconomic status. Few studies also indicate that the portion and pack-size effect has similar impact on energy intake across BMI-status and for restrained and unrestrained eaters. The review also indicates that study participants do not experience different internal sensations of hunger nor satiety after eating larger portions.

There is still no sufficient evidence to confirm the persistence of the portion and pack-size effect over a longer time span in free-living conditions.
The evidence reviewed does not account for the potential of energy compensation following exposure to large portions or packages, nor the possible adaptation to eating larger-than-normal portions.
There are not enough studies available investigating whether exposure to smaller portions or packages results in sustainable reductions in energy intake or weight stability.
The evidence reviewed was of low to moderate quality.
These conclusions are in line with the conclusions from a Cochrane systematic review from 2016 (1) where the same type of shortcomings and methodological concerns were highlighted. Hence, no improvements in the quality of the evidence seem to have been added to the literature in recent years.

Future perspectives
The application of policies and practices that reduce the size and availability of large-sized portions and packages has the potential to contribute meaningfully to the building up of the evidence base in this area in the short to medium term. The potential of such strategies to help consumers navigate in highly obesogenic environments could have a broad impact, and should therefore be given a good deal of consideration. If such policies and practices are applied in the Danish context, it is important to develop good quality methodologies for data collection and analysis, that could contribute to and improve the evidence regarding the long-term effects and possible mitigators of the portion and pack-size effect.

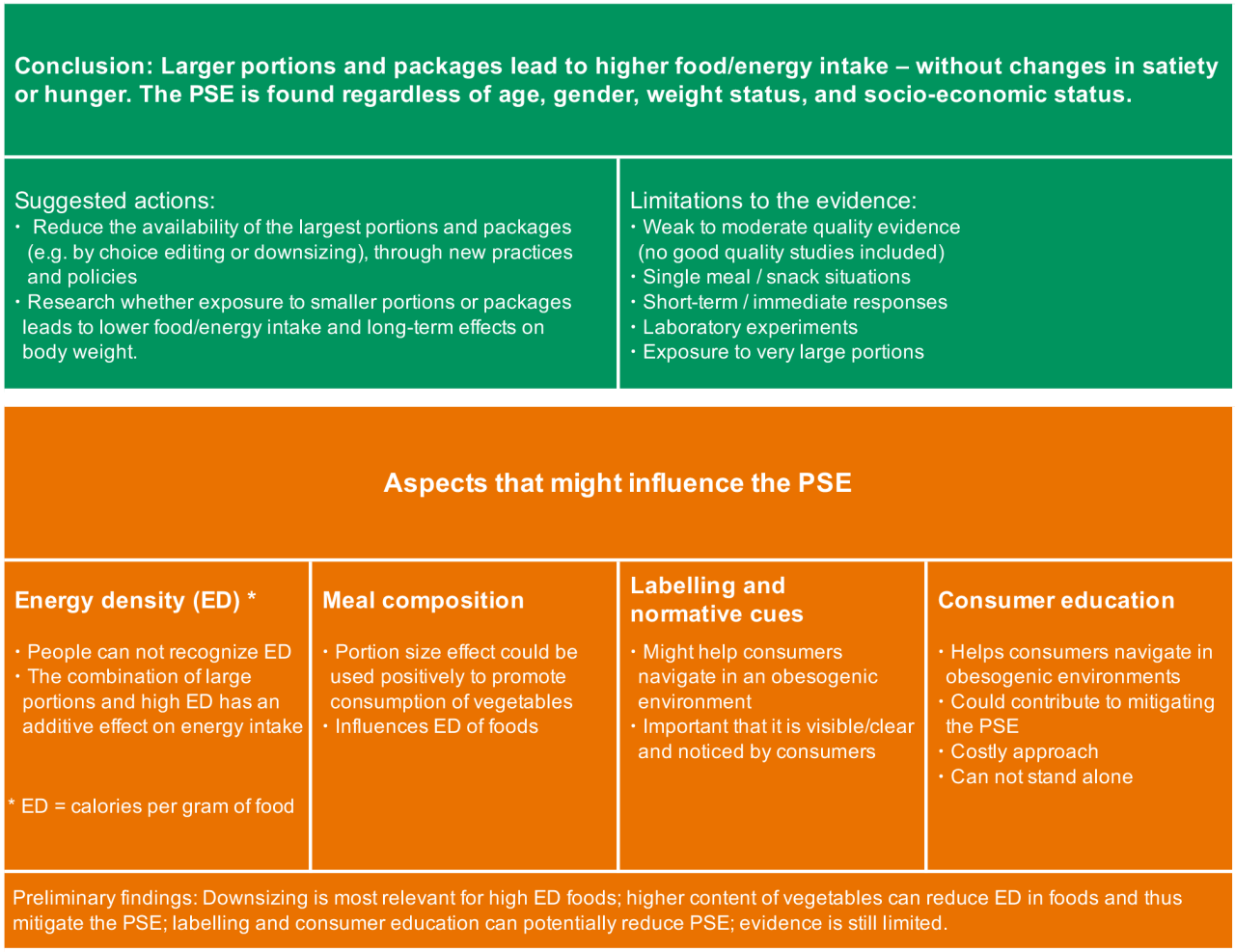

Fig. 1 – Summary of findings

INTRODUCTION AND OBEJCTIVE

The portion and pack-size effect is the phenomenon by which increasing portion and package sizes lead to increased food intake. This effect is observed in a variety of situations like with unit foods (e.g. sandwiches or ready-to-eat snacks), casserole dishes, beverages, and even low-energy dense foods like fruit and vegetables (2). The mechanisms that drive the portion and pack-size effect are poorly understood so far, but seem to include a number of possibilities. Food environment variables like convenience, meal characteristics, social influences, and cost of foods might influence the portion and pack-size effect. Food related characteristics like food type, energy density, nutrient content, and palatability might also moderate the strength of the portion and pack-size effect. Also, individual characteristics like previous experience with food, learned cues, reward value of the food, and eating behaviour might contribute to the portion and pack-size effect (2). However, research on the mechanisms driving the portion and pack-size is scarce so far.

A Cochrane systematic review published in 2016 concluded that offering larger portions or packages leads individuals to consume more food than when offered smaller sized versions (1). The estimated size of this effect was small to moderate, and was based on short-term interventions alone. The reviewers had concerns about study limitations in the literature found, arising from incomplete or unclear reporting of methods and procedures. The authors suggest that policies and practices that successfully reduce the size, availability and appeal of larger-sized portions, packages, individual units and tableware can contribute to meaningful reductions in the quantities of food and non-alcoholic beverages people select and consume in the short term. For a more detailed summary of the Cochrane systematic review please consult Appendix A.

Under the scope of the "Knæk Cancer" overweight-prevention campaign initiated by the Danish Cancer Society in late 2018, it was relevant to review the most recent evidence on the subject of the portion and pack-size effect. This memorandum describes shortly the method, results, and conclusions of the systematic review conducted to meet this need. This document is a supporting reference for the work developed by the Department of Prevention and Information with overweight-related efforts, including campaign work and work that aims at structural changes regarding portion and pack-size offers.

The aim of the review was to investigate what recent evidence (since late 2012) says about the portion and pack-size effect. One specific aim was the evaluation of the portion and pack-size effect on food/energy consumption or selection, and, if possible, weight changes. Another specific aim was to assess whether the shortcomings of the previous evidence and the concerns pinpointed by the Cochrane reviewers have been addressed in the most recent literature. Additionally, we also aim to highlight some of the most relevant aspects related to the moderation of the portion and pack-size effect covered by the included studies.

METHODS

We conducted a systematic review of randomized controlled trials and controlled studies investigating whether the portion or pack-size effect was present. Several of the included studies also investigated possible interventions/tactics to moderate the portion and pack-size effect, and we highlight some of the most relevant aspects covered by those approaches. The literature search was limited to publications from November 2012 (where the Cochrane review ended its search) through November 2018. Eligible studies had to focus on adults, and should report quantifiable measures of actual food consumption or a theoretical selection (e.g. internet-based experiments).

The authors worked independently in the performance of searches, screening of abstracts and full-text articles, the quality assessment of the included studies, and the evaluation of results. The authors then discussed and reached consensus on all steps of the inclusion/exclusion process, the quality evaluation of the included studies, and the conclusions reached based on the reported results. For a more detailed description of the methods for the systematic review, please see Appendix B.

RESULTS

In this section, we summarize results and highlight some of the most relevant aspects related to the moderation of the portion and pack-size effect covered by the included studies. For a detailed summary of results, please see Appendix C (results of the quality assessment of the included studies) and Appendix D (results of the included studies).

We included 24 relevant articles comprising 34 different studies (Fig. 2). Of these, 31 were randomized controlled trials, two were controlled trials, and one was a non-controlled trial. The majority, 29 studies, were conducted in the laboratory, with focus on immediate or short-term effects (up to one day). Five studies were conducted in free-living conditions (restaurants, cafeterias, or at the participants' homes), either with a medium or longer time span (more than 2 weeks). All studies were conducted with adult participants with a wide BMI range (18-40 kg/m^2).

In total, 28 studies investigated the portion size effect and six studies focused specifically on the pack-size effect.

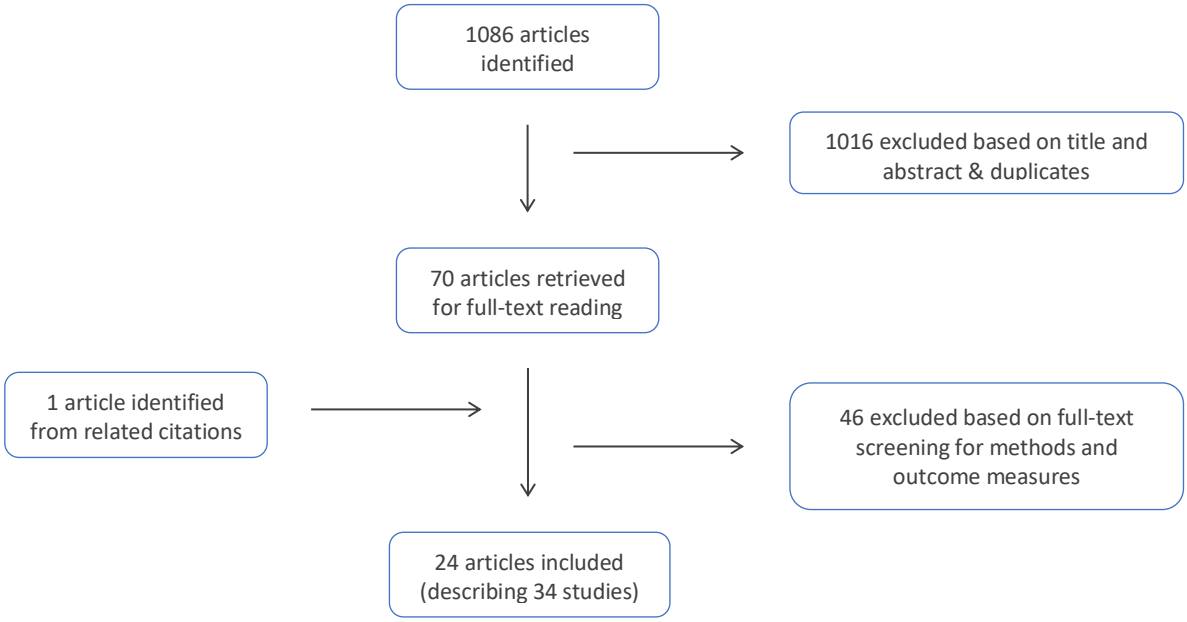

Fig. 2 – Flow chart of the literature search process

PORTION AND PACK SIZE EFFECT

A total of 28 studies focused on the portion size effect. These included 22 studies of mainly moderate quality[a] and the majority conducted in laboratory settings, that investigated the effect of portion sizes

[a] Three studies were of weak quality (15, 16, 17), the remainder studies were of moderate quality.

on the consumption of food. Most studies (19/22) confirmed that larger portion sizes result in the consumption of more food independent of other factors (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19). The majority of these studies evaluated either the immediate (intake at a single meal) or the short-term (up to one day) effect of portion sizes. Only two studies were conducted in free-living settings, and both studies found the portion size effect to be present long-term (up to 6 months) (4, 13). One of these studies was conducted in three restaurants; hence, the portion size effect here could not be attributed to the same subjects[b] and must be interpreted with great caution (13). A few studies (3/22) investigated either the effect of reducing portion sizes on consumption (25, 27), or the effect of altering portion labels/cues on consumption (27), and results from these studies are reported in later sections.
A total of 7[c] studies of mainly weak quality[d] investigated the effect of portion sizes on the selection of food for hypothetical consumption (no actual consumption of foods in these studies), and all studies found a main effect of portion size for single meal selections (9, 10, 12, 20).

A total of six studies focused on the pack-size effect. Two studies investigated the pack-size effect on consumption (21,22) three studies investigated the pack-size effect on selection (21, 23), and one study investigated both effects on selection and consumption (23). Four studies showed that larger packages lead to a higher consumption (22) or selection of food (21, 23), adding to the evidence of a pack-size effect also reported by the Cochrane systematic review.

Together, these results confirm the robustness of the portion and pack-size effect in single meal/snack or short-term occasions, but once more the available evidence does not allow for an evaluation of the long-term effects of exposing subjects to larger portion or pack-sizes (only one study had a long-term intervention with the same groups of subjects (4)).

It is also important to highlight that in eight of these studies (5, 8, 9, 10, 11, 12, 14, 16) the portion sizes in the control conditions are already rather large (see Appendix E). In these studies, single meals typically account for 30-50% of the standard daily amount of energy recommended (2000 kcal for women) – as a rule-of-thumb, single meals should provide around 25-30 % (24). Moreover, in the majority of these studies the portion sizes in the large-portion conditions vary between 50-88 % of the recommended daily amount of energy (4, 8, 10, 11, 12, 16, 17, 19), and in a few cases even exceed it (5, 11, 14).
Finally, the large majority of studies fail to account for the potential of spontaneous energy compensation following interventions and, more interestingly, over longer follow-up periods after exposure to larger portions.

[b] In order to address the fact that a long-term intervention was conducted with different subjects over the intervention period, we gave this study the same number of points as for a medium-term study in the quality assessment performed (see Appendix C).
[c] Study #3 from Robinson et al. (2015) (10) measures both consumption and selection, which explains the fact that numbers do not add up when counting studies with focus on consumption and selection.
[d] Only one study reached the moderate level in the quality assessment performed (study #3 in ref. 10).

In short, the portion and pack-size effect is confirmed on the short term, mainly in laboratory settings, and by exposure to very large portions. We did not find sufficient evidence to confirm whether this effect persists over a longer time span in free-living conditions, or when the tested portion sizes are more realistic.

EFFECT OF PORTION SIZE ON BODY WEIGHT

Evidence of whether exposure to smaller portions and packages also results in a decreased intake of food and total energy intake is very sparse, and does not allow firm conclusions for the time being. Only two studies of moderate quality conducted interventions where participants were given smaller portions than the standard sizes for test meals (25, 4). In both studies a reduction in the amount of food or energy intake was observed. However, a high level of reporting bias was registered for one of the studies, and the intervention was conducted at the group (restaurant) and not the individual level (25)[e]. For these reasons, results from this study must be interpreted with great caution.

On a more positive note, the other study was conducted in a free-living setting (work-place cafeteria) deemed as a potentially obesogenic environment, and evaluated the influence of the portion size effect on weight gain/loss (4). Participants who were given free lunches at work of either *medium* or *small size*[f] and energy content (800 or 400 kcal, respectively) over a period of 6 months kept their weight constant during the intervention period. Both participants who received a *large*, high-energy lunch (1.600 kcal) and controls (unknown energy content) experienced a small but non-significant weight gain (+1.1 kg). An analysis of the rate of weight change (kg/month) showed that both the controls and the large portion group experienced significant increases in weight over time (+0.24 kg/month and +0.19 kg/month, respectively) (4). These results suggest that significant absolute weight changes are only detectable over an even longer period of time (probably more than a year), but that a constant and significant increase does occur in the meantime, even though at a slow pace. This observation is a direct measure that weight gain is a slow and gradual process that in most cases lasts several years, hence it is hard to detect if no special attention is paid to its development. However, such results need to be replicated in other long-term studies in free-living conditions before any conclusions can be drawn.

No conclusions can be drawn on the direct influence of the portion size effect on weight gain/loss due to a lack of evidence. The lack of studies evaluating the effect of different portion sizes on weight change might be due to the difficult nature of conducting good quality interventions over a long-enough time period to register weight changes. Additionally, we have not found enough evidence of exposure to

[e] High level of reporting bias due to measures of energy intake through plate waste that were flawed since several customers took leftover foods home, and these were not accounted for. An intervention conducted at a restaurant can only register differences between one-time visits for each of the guests at the restaurant.
[f] The terms presented in *Italic* refer to the descriptive terms used by the authors of the study, and not to our perception of size for these meals.

smaller portions leading to sustainable reductions in energy intake or able to ensure weight stability.

In the following sections we highlight some of the most relevant aspects related to the moderation of the portion and pack-size effect covered by the included studies. We did not conduct a systematic literature research on these themes, so there might be other relevant articles from the same periode, that are not accounted for in this review.

ENERGY DENSITY AND MEAL COMPOSITION

Four studies of moderate quality investigated the significance of energy density manipulations (8, 17) or considered this aspect as an additional outcome measure (11, 19). Results from these studies show there is no direct adjustment of food intake in the presence of high energy-dense foods, and that the portion size effect is independent of the energy density of the meals/foods used in the interventions. This is translated into a higher energy intake both in the presence of larger portions, and in the presence of high energy-dense foods despite the consumption of a similar weight of food (confirmed by study 8). Also, differences between identical-sized meals with different energy density levels are not easily detected by participants (17), which underlines the importance of the consumption of low energy-dense meals in order to control the amount of energy intake.
Interestingly, one study showed that subjects who had received extensive training in choice strategies (including portion regulation and education in healthful and nutritious choices within food groups) were also prey to the portion size effect (19). However, these subjects had significantly lower energy intake than non-trained subjects, explained by their ability to choose more low energy-dense foods, and to downsize the amount of medium/high energy-dense foods consumed (19).

Two studies of moderate quality took meal composition into account either as an intervention parameter (13) or as an additional outcome (25). In one study, results showed the portion size effect could be used to promote a higher consumption of vegetables, and at the same time moderate the consumption of meat (13). The same study found a significant correlation between a higher intake of vegetables and a strong belief in the importance of eating vegetables when eating out, and also a significant correlation with the accuracy of knowledge of the daily recommended amount of vegetables (13). In another study, offers of reduced-portion entrées[g] in a field setting (cafeteria and restaurant) showed positive reductions in both energy intake and some nutrients (total fat, saturated fat, cholesterol, and salt), but these effects were somewhat offset by the parallel decrease in intake of common shortfall nutrients (fibre, Ca, and K) (25).

Together, these results indicate that improving meal quality in terms of food group composition and energy density could potentially moderate the portion size effect.

[g] An entrée is the technical term for a main course or main dish in English, and should not be mistaken as an appetizer.

THE EFFECT OF PORTION SIZE ON HUNGER AND SATIETY

When investigating the portion size effect, most studies took measures of post-meal hunger and satiety. This can indicate whether larger portions serve an important function of hunger appeasing and/or fulfilment. Twelve articles reported differences in post-meal hunger (7, 8, 9, 11, 12, 14, 15, 17, 18, 19, 23, 26). No differences between conditions of portion or pack-size were found in nine of the twelve studies (8, 9, 11, 12, 14, 21, 23, 17, 18). Furthermore, post-meal hunger was only marginally lower for the biggest portion size condition in one additional study, where the largest portion size weighed a little over 1 kg (19). Eleven articles included measures of post-meal satiety/fullness (7, 8, 9, 11, 14, 17, 18, 19, 21, 23, 26). No differences in post-meal satiety were found between conditions of portion or pack-size in nine of the eleven studies (8, 9, 11, 14, 17, 18, 19, 21, 23).

> *Together, these results show that study participants do not experience different internal sensations of hunger nor satiety after eating larger portions. Hence, making larger portions available or supersizing offers should not be justified as a service to the public – evidence shows that the public is perfectly capable of appeasing hunger and feeling satiated with standard portion and pack-sizes, and does not experience a further decrease in hunger or increase in satiety after eating larger portions or packages.*

PORTION SIZE INTERACTION WITH WEIGHT STATUS

Even though the portion and pack-size effect seems to be generic across gender, age, and socioeconomic status (1), we examined if there were any studies investigating differences in the magnitude of the effect on restrained eaters, or subjects with overweight compared to subjects with normal weight.

Two studies of moderate quality investigated whether differences in weight status on the portion or the pack-size effect exists (19, 22). One study found the portion size effect was independent of weight status (19). In the other study it was observed that subjects with overweight ate a larger amount of food than subjects with normal weight when presented with standard packages (22). This study also showed a clear pack-size effect: subjects with overweight ate a smaller amount of snacks when these were packed in small single-serving packages, and ate fewer times than subjects with overweight presented with standard packages.

Three studies of moderate quality investigated whether differences in eating restraining behaviour influenced the portion or pack-size effect (11, 21, 22). No differences in response to the pack-size effect were registered between restrained and unrestrained subjects (21, 22). One study found that subjects with a higher disinhibition level were more responsive to larger portions (11).

In summary, the portion and pack-size effect seems to be independent of weight status and to have a similar impact on energy intake for both restrained and unrestrained eaters, but the evidence is sparse and does not allow firm conclusions.

THE EFFECT OF LABELLING, NORMATIVE CUES, AND EDUCATION

Four studies of mostly weak quality[h] investigated whether external cues in the form of serving size information or recommendations could moderate the effect of either large portion sizes (12, 15) or large packages (23). Serving size information and recommendations showed a moderating effect in two studies (15, 23). The remaining two studies did not find any effect (12).

One study of weak quality tested whether people use a normative description of the size of a portion as guiding information on how much to consume (27). Here, subjects were presented with the same portion sizes, but these were either labelled "double" vs. "regular size" in one group, or labelled "regular" vs. "half size" in another group. In both cases the subjects' responses were independent of the actual portion size, with participants consuming less food when they believed they were served a larger than normal portion: the "double" compared to the "regular size", or the "regular" compared to the "half-size" (27).

Another study of moderate quality tested how both the selection and intake of food from a set of three portion sizes is affected when the size of all available options is increased (18). As illustrated in Figure 3, participants were exposed to the same relative range of portion sizes (small, medium, large), while the absolute magnitude of the portions available increased over three test sessions (set 1 was smaller than set 2, and set 2 was smaller than set 3). Increasing the size of a set of portions did not affect the relative portion sizes selected for consumption, with a significant amount of subjects consistently choosing the same relative size (e.g. always chose "small"). This resulted in significant increases in the weight of the selected portion and in energy intake when participants were exposed to the largest set of all (18). These results indicate that when the same options/meals are available in multiple sizes, the absolute size of the actual portions is a significant determinant of energy intake.

Set of portion sizes	Relative size		
	small	medium	large
Set 1	300 g	375 g	450 g
Set 2	375 g	450 g	525 g
Set 3	450 g	525 g	600 g

Fig. 3 – Range of portion sizes from the Zuraikat *et.al* (2016) study (18).

[h] Only one study achieved the quality assessment of moderate (23), and it remained in the lower scale of the moderate-spectrum.

Another approach proposed for attenuating the portion and pack-size effect is nutritional education and portion control training in order to help people minimize the magnitude of the effect. One study of moderate quality found that participants who had been through extensive training (one-year long) in portion-control strategies or nutritional education were able to moderate their total energy intake by choosing more of the available low energy-dense foods in a meal, compared to untrained participants (19). Another study aimed to test the effect of a very brief educational intervention on the portion size effect found no differences between subjects subjected to the intervention and controls who did not receive it (3). However, it should be noticed that participants in this study did not attend as comprehensive education/training, which might be necessary for an effect to be seen.

> *In summary, evidence is limited and not conclusive of whether there is an attenuating effect of the portion and pac- size effect through labelling with normative serving size information or recommendations, as well as through nutritional education. Providing objective serving size labels on food products could guide consumers in figuring out the appropriate amount of food to eat, but normative cues seem only effective, if* ***consumers actually notice the serving size recommendation or labelling prior to consumption.*** *Extensive nutritional education encouraging the selection of healthy, low energy-dense foods could contribute substantially to mitigating the portion and pack-size effect, but this is not a cost-effective approach.*
> ***More important is the absolute size of the portions available*** *for customers to buy and consume as this is a critical determinant of overall energy intake. It is therefore pertinent to further investigate the effect of such approaches, which was not under the scope of the present review.*

DISCUSSION

This review confirms the robustness of the portion and pack-size effect in single meal/snack or short-term occasions. This effect is confirmed mainly in laboratory settings, and by exposure to larger-than-normal portions. Previous reviews found that the portion and pack-size effect seems to be generic across gender, age, and socioeconomic status (1,2), and our results are in line with these observations. Only a few studies considering the significance of weight status or eating behaviour (restrained vs. unrestrained eating) were included in this review. Even though results indicate no differences, evidence is sparse and does not allow for firm conclusions.
The review also indicates that study participants do not experience different internal sensations of hunger nor satiety after eating larger portions or packages. This suggests that the portion and pack-size effect is not driven by feelings of hunger nor expected satiety. Hence, making larger portions/packages available or supersizing offers should not be justified as a service to the public – evidence shows that the public is perfectly capable of appeasing hunger and feeling satiated with standard portion and package sizes, and does not experience a further decrease in hunger or increase in satiety after eating larger portions or packages.

Although the portion and pack-size effect in itself can not be contested, it is of great importance to have both study limitations and moderating aspects of this effect in mind.

Study limitations

The great majority of studies are short-term experiments, and this limits our ability to interpret the consequences of a regular exposure to the portion and pack-size effect over a longer period of time. For the majority, weight gain is a gradual process, so optimally, studies should follow the behaviour of participants over a longer period of time, of say a minimum half to a whole year. Moreover, there is simply not enough evidence for the opposite effect, i.e. whether systematic exposure to smaller portions and packages over a long period of time might result in a significantly lower energy intake, or even result in weight stability or weight loss.

The current literature mainly covers studies conducted in laboratory settings, which limit the possibilities of interpretation of the portion and pack-size effect in real-life settings, where it is not possible to control for as many variables that might influence it.

Here, it is also relevant to highlight the significance of the experimental portion sizes. In the reviewed literature the portion sizes of single meals typically account for 30-50% of the standard daily amount of energy recommended (2000 kcal for women). However, as a rule-of-thumb, single meals should provide around 25-30% (24). Moreover, in the majority of these studies the portion sizes in the large-portion conditions varied between 50-88 % of the recommended daily amount of energy (4, 8, 10, 11, 12, 16, 17, 19), and in a few cases even exceed it (5, 11, 14). This indicates that the apparent magnitude of the portion size response is highly dependent on the portions researchers choose to serve (11). This was observed for a broad spectrum of meal-types. Hence, it would be welcome if future studies tested portion exposures for meals that follow the aforementioned rule-of-thumb, with meals providing a maximum of 30% of the standard daily amount of energy recommended.

Furthermore, in the majority of the reviewed studies no follow-up on energy or food intake among participants was registered over the course of the day. Hence, the literature reviewed does not account for the potential of energy compensation / adaptation after exposure to large portions or packages. Subjects could potentially decrease the amount of food / energy consumed after participating in the experiment, rendering the portion or pack-size effect observed during the experiment irrelevant, if caloric compensation was later achieved. Even though we believe that repeated exposure to large portion and package sizes in the course of a day might lead to an overconsumption of calories, this is indeed neither confirmed nor rejected, since follow-up procedures are insufficient throughout most of the available literature.

Moderators of the portion size effect

Energy density might prove an important moderating aspect of the portion and pack-size effect. Even though we did not conduct a systematic literature search focusing on this subject, four of the studies included investigated the influence of energy density manipulations on the portion size effect. Results from these studies suggest that the portion size effect is independent of the energy density of a meal, and that energy density is additive to the overall effect of larger portions. As such, it might not be possible to "protect" consumers from the portion size effect, but a great deal can be done to reduce the energy density of food offers, in order to mitigate the effect of a higher calorie intake driven by a larger portion. Here it is also important to highlight the importance of meal composition, since adding e.g. a higher proportion of vegetables to meals and other foods will result in a lower energy density for the same volume or portion.

Finally, evidence is limited and not conclusive of whether there is an attenuating effect of the portion and pack-size effect through labelling with normative serving size information or recommendations, as well as through nutritional education. Providing objective serving size labels on food products could guide consumers in figuring out the appropriate amount of food to eat, but normative cues seem only effective, if consumers actually notice the serving size recommendation or labelling prior to consumption. Extensive nutritional education encouraging the selection of healthy, low energy-dense foods could contribute substantially to mitigating the portion and pack-size effect, but this is not a cost-effective approach.
More important is the absolute size of the portions and packages available for customers to buy and consume as this is a critical determinant of overall energy intake. It is therefore pertinent to further investigate the effect of such approaches, which was not under the scope of the present review.

FINAL REMARKS AND FUTURE PERSPECTIVES

The portion and pack-size effect is confirmed on the short term, mainly in laboratory settings, and by exposure to very large portions. The evidence reviewed does not account for the potential of energy compensation following exposure to large portions. There is no sufficient evidence to confirm the persistence of this effect over a longer time span in free-living conditions. There is not enough evidence, at the moment, to support an opposite portion or pack-size effect – there are not enough studies available investigating whether exposure to smaller portions or packages results in sustainable reductions in energy intake or weight stability. These conclusions are in line with the conclusions from the Cochrane systematic review.

Further research is therefore needed to investigate whether exposure to smaller portions and packages can result in:

- sustainable reductions in energy intake
- weight stability
- or even weight reduction.

However, controlled trials aiming to research these aspects over a longer time span would be highly costly and a very long time might pass before we could expect any results. On the other hand, the application of policies and practices that reduce the size and availability of large-sized portions and packages could contribute meaningfully to the building up of the evidence base in this area in the short to medium term.

At the same time, it would also be relevant to review the current evidence on other possible approaches for mitigating the portion and pack-size effect. Themes that could be considered include:

- meal composition
- approaches for a systematic energy density reduction
- labelling and normative cues
- or if generic public education has any effect in helping consumers navigate in obesogenic environments.

The effect of obesogenic environments in the rising prevalence of overweight and obesity is highly complex, and as such it is of the uttermost importance to apply multiple prevention strategies in order to counteract this development. The reduction of large portion and package sizes – especially of highly energy dense foods and foods of poor nutritional composition – is one among many potential strategies to help consumers navigate in such obesogenic environments, but one that could potentially have a broad impact, and should therefore be given a good deal of thought.

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APPENDIX A – SUMMARY OF THE COCHRANE SYSTEMATIC REVIEW

This appendix includes a summary of the results from the Cochrane Systematic Review of **"Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco" (1)**, and notes from the memorandums authors on the quality of the review.

KEY FINDINGS AND QUALITY OF EVIDENCE – STUDIES WITH FOCUS ON CONSUMPTION

This Cochrane review concludes that people consumed and drank more food and non-alcoholic drinks when offered larger-sized portions or packages compared to smaller sized versions. The estimated size of this effect was **small to moderate** among adults, **with substantial heterogeneity**.
It was also extrapolated, that if this effect was sustained across the whole diet, it would be equivalent to approximately 12-16 % increase in the average daily intake from food among UK adults (an absolute change in daily energy intake from food of 215 to 279 kcal from baseline of 1727 kcal per day). However, this was a mere mathematical exercise and **not a thoroughly investigated approach** in the included studies.

The evidence for this effect is rated as small to moderate, due **to concerns about study limitations** arising from incomplete or unclear reporting of methods and procedures. **Effect sizes were larger in studies of less healthy food products and snacks, as well as more energy-dense food products and in studies comprising older participants.** Furthermore, effect sizes were larger in studies of food products in which the manipulated food(s) comprised all of those available in the study and all were consumed ad libitum, than in other studies of food products without these characteristics.

The reviewers did not find evidence that exposure to different portions, package or unit sizes varied substantially between men and women, across the BMI intervals, susceptibility to hunger or tendency to control eating behavior consciously. They did however find an effect of age. The reviewers highlight the need for these findings to be confirmed by further research.

KEY FINDINGS AND QUALITY OF EVIDENCE – STUDIES WITH FOCUS ON SELECTION

The review found that adults chose (or selected) more food and non-alcoholic drinks when offered larger-sized portions, or packages, or individual units than when offered smaller-sized versions. The estimated size of this effect was **small to moderate**, **with substantial heterogeneity**. The **overall evidence** for this effect is rated as **moderate due to concerns about study limitations**.

DISCUSSION AND LIMITATIONS OF THE COCHRANE SYSTEMATIC REVIEW

The Cochrane review **highlights a current lack of evidence on whether meaningful changes in the quantities of food consumed can be sustained over longer timer periods in response to prolonged or repeated exposures, and effects under free-living conditions**. Therefore, **the long-term effectiveness** of interventions introduced with the aim of reducing people's exposure to larger portions or packages **is currently unknown**. The limited body of evidence identified for the consumption effects of exposure to different portion and packages sizes at the smaller end of the size continuum results in uncertainty about whether reducing portions at the smaller end of the size range can be as effective in reducing food consumption as reductions in the larger end of the range.

The review identifies need for further research:

- New primary studies investigating the effect of exposure to larger versus smaller-sized portions, packages, individual units (and tableware) on selection and consumption of food;
- A systematic review of evidence for the effectiveness of interventions to reduce exposure to larger sizes or to mitigate the effects of exposure to larger sizes, followed by new primary studies of such interventions and policies.

Until this type of evidence arises, summary estimates of the results from the Cochrane systematic review should be interpreted with caution. For now, it can be said that reducing the sizes of portions, packages, individual units, or tableware is an interesting approach with some potential to contribute to the intake of lower energy quantities from food and non-alcoholic drinks.

The review also highlights potential interventions to promote smaller portions, such as:

Intervention strategies targeting the physical environment (in public and/or commercial sector)

- Regulatory and legislation frameworks, or voluntary agreements with the food industry, which result in reductions of the default serving size of energy dense foods and drinks where these are large in absolute terms (or providing smaller crockery, cutlery and glasses for use in their consumption).
- Various 'choice architecture' interventions in microenvironments such as restaurants or supermarkets.

Intervention strategies targeting the economic environment

- Eliminating pricing practices where larger portion and package sizes offer more value for money.
- Restrictions on price promotions for larger-sized packages.

Limited but vague evidence for the effectiveness of interventions that do not seek to directly alter the availability or cost of larger sizes, but instead aim to educate people about appropriate portion sizes exist.

STUDIES INCLUDED

The review is based on 69 randomized controlled studies that manipulated food products, of which 55 studies included adults (predominantly younger adults aged 19 to 30 years). All studies manipulated food products, and the study participants were mainly unrestrained eaters. BMI ranged between 17-34 across studies. The majority of the included studies (50 out of 72) were conducted in laboratory settings and the remaining studies (22) were conducted in field settings – restaurants, schools, or workplace cafeterias. Target manipulation was portion size in 35 of the studies (4 by Wansink) and package size in 10 studies (2 by Wansink). Consumption outcomes were reported in 59 of 72 included studies and selection outcomes were reported in seven other studies (7 by Wansink), while both selection and consumption outcomes were reported in six other studies (1 by Wansink).[1]

[1] We highlight the inclusion of studies by author Brian Wansink, since throughout 2017-18 a number of his research articles were retracted due to academic misconduct, including "misreporting of research data,

In one third of included studies, the larger of the two compared portions, packages, and individual unit size was 200% of the size of the smaller version (independent comparisons) and fell between 120-159% in half of the included studies. Absolute sizes investigated also tended to be large compared to reference portion sizes (defined as the size recommended to be consumed). Overall, the studies investigated only exposures over immediate (few hours) or short periods (few days).

problematic statistical techniques, failure to properly document and preserve research results, and inappropriate authorship.". (Munafò, Hollands & Marteau 2018, BMJ, doi: 10.1136/bmj.k4309) We agree with these authors that while "none of the included studies [sic, in the Cochrane review] has been retracted, leaving the reviews' results and conclusions unchanged […] the retractions raise questions about the veracity of other studies Wansink has authored", and might still happen in the future, which would inevitably influence the conclusions of the Cochrane review.

APPENDIX B – METHODS (detailed description)

LITERATURE SEARCH

We restricted the structured literature search to searches in PubMed, and both authors performed all searches independently.

The included search terms were:

- Portion Size [Mesh] AND adults
- Portion Size [Mesh] AND food intake
- Serving Size [Mesh] AND adults
- Portion Size [Mesh]) AND energy intake AND adults
- Portion Size[Mesh] AND eating [Mesh] AND adults
- Portion Size [Mesh] AND consumption AND adults
- Portion Size [Mesh] AND body weight [Mesh] AND adults
- Serving Size [Mesh] AND body weight [Mesh] AND adults
- Serving Size [Mesh] AND weight maintenance AND adults
- Portion Size [Mesh] AND weight maintenance AND adults
- Food Preferences [Mesh] AND body weight [Mesh] AND adults
- Obesogenic environment AND portion size [Mesh]
- Obesogenic environment AND serving size [Mesh]
- Energy intake [Mesh] AND package size
- Body weight [Mesh] AND package size
- Package size
- Portion size effect
- Energy intake [Mesh] AND portion size [Mesh]

INCLUSION CRITERIA

Time range

We included studies in the range November 2012 – November 2018.
The Cochrane review included studies up to November 2012.

Types of studies

Randomized controlled trials with between-subjects (parallel group) or within subjects (crossover) design, as well as non-randomized controlled studies.

Population

We restricted our search to studies on adults.
No exclusion criteria in relation to demographic or socioeconomic factors were applied.

Interventions of interest

Studies comparing at least two groups of participants or individuals exposed to two different interventions (control vs. intervention), each exposed to a different size of a portion of the same food or its package, and including a measure of unregulated consumption or theoretical selection of food.

Intervention: larger-sized portion or pack size (individual unit)

Control: standard or smaller-sized portion or pack size (individual unit)

Interventions measuring consumption or a theoretical selection of food over a time-period less than 2 days were categorized as immediate; 2 days up to 2 weeks as medium-term; and exceeding 2 weeks categorized as long-term.

Settings
Laboratory or real life/field settings (restaurants, canteens, cafeterias, cafés, etc.).

Outcome measures
Eligible studies had to incorporate one or more measures of unregulated consumption or theoretical selection (with or without purchasing) of food, snacks . The amount of energy (calories) or products (foods, drinks) consumed, should be measured in natural units (kcals, kilojoules or grams) or number of units/packages.

EXCLUSION CRITERIA
Any studies funded by agencies with commercial interests in the results were excluded.

SELECTION PROCESS
The two authors worked independently, and performed searches on PubMed, yielding a duplicate screening of title-abstract records. By applying the defined inclusion criteria for this review the title-abstract records were coded as:

- 'Provisionally eligible'
- 'excluded'
- 'duplicate'

Any disagreement in the coding of title-abstract records was identified and discussed until consensus was reached.

Copies of full-text articles for all title-abstracts coded as 'provisionally eligible' were retrieved, and an independently duplicate screening of full-text articles was performed. The full-text articles were coded: eligible or excluded by applying the eligibility criteria. Any coding disagreements were identified and discussed until consensus was reached.

Additional searches
In addition, both authors searched through the reference lists of the included studies to check for additional relevant references not found through the systematic searches.

QUALITY ASSESSMENT OF THE INCLUDED STUDIES
As a part of the review process, a scheme for evaluating the quality of the included study was developed with inspiration from Krieger & Saelens (2013); Sinclair, Cooper & Mansfield (2014), Swartz, Braxton & Viera (2011), and Littlewood et al. (2016). Every study was evaluated independently by each author, and rated on the basis of 6 parameters of design and method-quality (study settings, outcome,

randomization, sample size, time span, and risk of bias), resulting in a total number of points. The quality assessment scheme is presented in table B1.

Table B1 Quality Assessment Scheme

Quality parameters		Points
Study setting	Field-setting	2
	Laboratory	1
Outcome	Consumption, measured or registered by researcher	3
	Consumption, self-reported	2
	Selection, with purchase, documented	1
	Selection, with purchase, self-reported	0
	Selection, without purchase + registered by researcher	1
	Selection, without purchase + NOT registered by researcher	0
Randomization	Randomized, within subjects	2
	Randomized, between subjects	1
	Non-randomization, or non-suitable case-control match, or no description.	0
Sample size	Large sample (> 150 per group)	2
	Medium (51-150 per group)	1
	Small sample (≤ 50 per group)	0
Time span	Long-term (> 2 weeks)	2
	Medium-term (2 days – 2 weeks)	1
	Immediate or short-term (up to 2 days)	0
Risk of bias	Low	1
	Unclear	0
	High	-3
0-4 points – Weak	5-9 points – Fair	10-12 points – Good

Krieger J & Saelens BE. Impact of Menu Labeling on Consumer Behavior: A 2008-2012 Update. 2013. Princeto, NJ: Robert Wood Johnson Foundation.
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APPENDIX C – QUALITY ASSESSMENT RESULTS

Table C1 Quality assessment scheme, results.

Reference	Study setting	Outcome	Randomisation or case-control match	Sample size†	Time span	Concurrent interventions	Risk of bias	Rating
Berkowitz et al. 2016 (25)	Field setting	Consumption, researcher	CT Before and after	Medium	Long term	No	High	5 moderate
Brunstrom et al. 2016 (20) #1	Laboratory	Selection, no purchase, researcher/computer	RCT Between subjects	Small	Immediate	No	Unclear	4 weak
Brunstrom et al. 2016 (20) #2	Laboratory	Selection, no purchase, researcher/computer	RCT Between subjects	Small	Immediate	No	Unclear	4 weak
Cavanagh et al. 2014 (3)	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	Education and mindfulness exercise	Unclear	5 moderate
French et al. 2014 (4)	Free-living	Consumption, self-reported	RCT Between subjects	Medium	Long-term	No	Unclear	8 moderate
Haire et al. 2014 (22)	Free-living	Consumption, researcher	RCT Between subjects	Small	Medium	No	Unclear	7 moderate
Just & Wansink 2014 (27)	Field setting	Consumption, researcher	RCT Between subjects	Small	Immediate	Normative labels tested	High	3 weak
Keenan et al. 2018 (5)	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	No	Unclear	5 moderate
Kerameas & Vartanian 2015 (6)	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	No	Unclear	5 moderate
Lewis et al. 2015 (26)	Laboratory	Consumption, researcher	RCT Within subjects	Small	Immediate	No	Low	7 moderate
Marchiori & Papies 2014 (7)	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	Mindfulness exercise	Low	6 moderate
McCrickerd et al. 2017 (8) #1	Laboratory	Consumption, researcher	RCT Within subjects	Medium	Immediate	Eating rate (speed)	Low	8 moderate
McCrickerd et al. 2017 (8) #2	Laboratory	Consumption, researcher	RCT Within subjects	Medium	Immediate	Eating rate (speed)	Low	8 moderate

Reily & Vartanian 2016 (12) #1	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	Contextual information	Unclear	5 moderate
Reily & Vartanian 2016 (12) #2	Laboratory, online	Selection, without purchase, computer	RCT Between subjects	Medium	Immediate	Contextual information	Unclear	4 weak
Reinders et al. 2017 (13)	Free-living	Consumption, researcher	CT Crossover restaurants before/after	Large	Medium	No	High	5 moderate
Robinson & Kersbergen 2018 (9) #1	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	No	Low	6 moderate
Robinson & Kersbergen 2018 (9) #2	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	No	Low	6 moderate
Robinson & Kersbergen 2018 (9) #3	Laboratory	Selection, without purchase, researcher recorded (online)	RCT Between subjects	Medium	Immediate	No	Unclear	4 weak
Robinson et al. 2015 (10) #1	Laboratory	Selection, no purchase, researcher/computer	RCT Between subjects	Medium	Immediate	No	Low	4 weak
Robinson et al. 2015 (10) #2	Laboratory	Selection, no purchase, researcher/computer	RCT Between subjects	Medium	Immediate	No	Low	4 weak
Robinson et al. 2015 (10) #3	Laboratory	Selection, no purchase AND consumption, researcher	RCT Between subjects	Small	Immediate	No	Unclear	5 moderate
Roe et al. 2016 (11)	Laboratory	Consumption, researcher	RCT Within subjects	Small	Immediate	No	Low	7 moderate
Rosenthal & Raynor 2017 (14)	Laboratory	Consumption, researcher	RCT Within subjects	Small	Immediate	Television watching	Unclear	6 moderate
Spanos et al. 2015 (15)	Laboratory	Consumption, researcher	RCT Between subjects	Small	Immediate	Serving-size information	High	2 weak
Vartanian et al. 2017 (16)	Laboratory	Consumption, ?	Trial between subjects	Small	Immediate	No	Unclear	3 weak
Versluis & Papies 2016 (21) #1	Laboratory	Expected consumption (0)	RCT Between subjects	Medium	Immediate	Exposure to prime	Unclear	3 weak

Versluis & Papies 2016 (21) #2	Laboratory	Consumption, researcher	RCT Between subjects	Medium	Immediate	Exposure to prime	Unclear	6 moderate
Versluis et al. 2015 (23) #1	Laboratory (online)	Selection, no purchase, registered by participants	RCT Between subjects	Medium	Immediate	Presence of picture (yes/no)	Unclear	3 weak
Versluis et al. 2015 (23) #2	Laboratory (online)	Selection, no purchase, registered by participants	RCT Between subjects	Medium	Immediate	Presence of picture (pictorial/non-pictorial vs. absent)	Unclear	3 weak
Versluis et al. 2015 (23) #3	Laboratory	Selection & consumption, registered by researcher	RCT Between subjects	Small	Immediate	Presence of picture (present vs. absent)	Unclear	5 fair
Williams et al. 2014 (17)	Laboratory	Consumption, researcher	RCT Within subjects	Small	Immediate	No	Unclear	6 moderate
Zuraikat et al. 2016 (18)	Laboratory	Consumption, researcher	RCT Within subjects	Medium	Immediate	No	Unclear	7 moderate
Zuraikat et al. 2018 (19)	Laboratory	Consumption, researcher	RCT Within subjects	Small	Immediate	No	Low	6 moderate

RCT, randomized controlled trial; CT, controlled trial

APPENDIX D – RESULTS

Table D1 Summary of results – portion size effect

Reference	Intervention	Design	Subjects	Results
Berkowitz et al. 2016 (25) USA	Design: Before and after (introduction of smaller portion entrées) measures of selection and plate waste in two different locations (worksite cafeteria and upscale restaurant) Cafeteria: 5 weeks before + 7 weeks after (6 entrées) Restaurant: 3 weeks before + 4 weeks after (5 entrées)	CT Before and after	Cafeteria N = 125-200 No information on age or BMI Restaurant N = 30-75 No information on age or BMI	Cafeteria • Both energy and nutrient intakes were lower during the intervention period (all ps < 0.0001). • Plate waste was also reduced during intervention ($p < 0.0001$) • Selection of reduced-size entées increased during the 5 week intervention period (lowest 1st week) (8.2-12.8% of total weekly entrees selected). Restaurant • Both energy and nutrient intakes were lower during the intervention period (all ps < 0.0001) from a mean of 629 kcal to 555 kcal when both options were available. • Plate waste was also reduced during intervention ($p < 0.0051$) • Selection of reduced-size entées increased during the 3 week intervention period (highest in the 1st week)
PERSPECTIVE NOTES: The objective was to determine selection rates of reduced-size entrées offered in worksite cafeteria lunch meals and restaurant dinner meals and the impact on energy and nutrient intakes and plate waste. Hypothesis: offering reduced- and full-size entrées will result in decreased energy and nutrient consumption and plate waste compared with offering only full-size entrées. Reduced-size entrées typically provided about half of the energy and nutrient contents of the full-size entrées. Other measures: Nutrient contents (total fat, saturated fat, cholesterol, Na, Ca, fibre, and K). Conclusions: When both reduced-size and full-size entrées were offered, intakes of fat, saturated fat, cholesterol and Na were lower compared with when only full-size entrées were offered. Benefits from these reductions may be offset somewhat by the parallel decrease in intake of common shortfall nutrients such as fibre, Ca and K. To limit any negative impact of reduced PSs on shortfall nutrients and food group intakes, the amounts of fruits, vegetables, dairy and whole grains should be increased prior to downsizing entrées. Reduced food waste can result in decreased food costs and waste disposal costs, information that may be helpful for owners of food service establishments as loss of revenue is an important consideration. Limitations: Group tracking and not individual tracking of changes. Some patrons in the restaurant took leftover foods home, and the amount of these leftovers was not registered.			
Brunstrom et al. 2016 (20) UK	Study 1 Evaluation of the palatability and expected satiety of 5 lunchtime meals. Scenario for choice: next meal at 19:00, no other foods available. Hypothetical selection based on the rule that all foods should be eaten.	RCT Between subjects	N = 23 Mean age: 19.3 y Mean BMI: 22.2 kg/m^2	• Main effect of portion size ($p < 0.001$) and significant interaction between PS and predictor type ($p < 0.001$). • For the smallest portion (100 kcal), palatability and expected satiety were both equally good and positive predictors of choice. With increasing portion size, the role of expected satiety diminished, and even became a negative predictor. The role of palatability remained fairly stable across portion sizes. With larger portions satiety became a negative predictor.

	Study 2 Similar evaluation of 9 meals in 3 different scenarios: 1) next meal at 19:00 2) would receive only one bite of one food 3) a favorite dish would be served immediately after		N = 23 Mean age:2 4.5 y Mean BMI: 22.6 kg/m^2	• Main effect of portion size ($p < 0.001$) and main effect of scenario ($p < 0.001$). No interaction between these. • Confirmation of results from study 1 (scenario 1). Expected satiety played an important role in food choice, when no other food was available, but only for smaller portions. • When portion size was restricted or followed by a favorite food (scenarios 2 and 3), choice was motivated primarily by palatability. • Most participants (60.9%) reported prioritizing fullness when presented with smaller portions, and then palatability when presented with larger portions. The converse was true for 34.8% (scenario 1). In scenario 2 palatability was most important for the majority, and under scenario 3 56.5% prioritized palatability with smaller portions and fullness with larger portions.
PERSPECTIVE NOTES: Aim was to identify how portion size influences the effect of palatability and expected satiety on choice. Other measures: Participants were presented with 50 photographs of each meal ranging from min. 20 kcal-portions to max. 1000-kcal portions (increments of 20 kcal per photo). Photos were presented randomly. Main conclusions: In adults, expected satiety influences food choice, but only when small equicaloric portions are compared. Larger portions not only promote the consumption of larger meals, but they encourage the adoption of food choice strategies motivated solely by palatability. These findings show that larger portions not only promote increased EI, but also encourage a food-choice strategy that promotes the selection of palatable foods. The data indicated that a "satiety-to-palatability switch" occurs as food portions become larger. Limitations/strengths: no foods were consumed; however, this is how decisions are normally made in a supermarket or a restaurant. The authors calculated that "if a 65-kg person skips a 500-kcal meal, this might generate only a 0.4% deficit. Therefore, there is little reason to fine-tune food choice in order to achieve precise energy balance from one meal to the next. All else being equal, people eat and experience hunger primarily in response to emptiness of the gut, and a related capacity to consume more food."				
Cavanagh et al. 2014 (3) Australia	3 x 2 design: conditions (education vs. mindfulness vs. control) x portion size (small = 350 gr./440 kcal vs. large = 600 gr./750 kcal)	RCT Between subjects	N = 96 (F) undergraduate students Mean age: 19.7 y Mean BMI: 21.53 kg/m^2	• Ratings of initial hunger ($p < 0.001$) and liking of the food ($p < 0.03$) were associated with total food consumption. • Main effect of PS on total food consumption ($p = 0.002$): the smaller portion led to a lower intake of food (difference of approximately 70 gr./87 kcal). • No effect of information condition, and no interaction between portion condition and information condition. • Participants in the mindfulness condition appear to eat less overall (NS, $p = 0.07$). • Participants rated hunger, satiety, and taste as stronger influences on food intake than the amount of food available ($p < 0.001$), but the PS effect was not influenced by hunger nor liking of the food.
PERSPECTIVE NOTES: tested whether a brief education and a brief mindfulness exercise would reduce the effect of portion size on food intake.				

Other measures: taste rating after the first and last mouthful of pasta; current hunger level (pre and post eating); reasons for eating questionnaire; dietary restraint; positive and negative affect questionnaire (mood scale).

Conclusions: Neither education nor mindfulness was effective in reducing the effect of PS. Participants served a large portion consumed 34% more than those served a smaller portion.

French et al. 2014 (4) USA	Design: 3 conditions of free lunch (400 kcal vs. 800 kcal vs. 1,600 kcal) x no-free lunch control	RCT Between subjects	N = 229 18-60 years overweight/obese	• EI at lunch at 6 months: the 1,600 kcal box group had a higher lunch EI compared with the other groups, including control ($p < 0.0001$). • Total EI at 6 months: the 1,600 kcal box group had a higher total EI compared with the other intervention groups ($p = 0.02$). Total EI decreased over time in both the 400 kcal and the 800 kcal groups ($p < 0.05$). • Weight change over 6 months: No differences between groups. Increase in weight over time significant in the 1,600 kcal group ($p < 0.05$, +1.1 kg). • Physical activity did not differ between groups.

PERSPECTIVE NOTES: examined the effects of weekday exposure to one of 3 different lunch energy sizes on EI and body weight in a free living sample of adults over 6 months. Hypothesis: exposure to large energy sizes at lunch will cause increases in lunch EI, total EI, and body weight during the 6-month experimental period compared with exposure to smaller portion sizes.

Other measures: Anthropometric measures (weight & height); 3 x unannounced 24-h dietary recalls (baseline, 1, 3, and 6 months - 12 recalls / person); physical activity with accelerometer (baseline and 6 months); demographic info (self-reported: household income, age, ethnicity, race, education level, job type, and marital status).

Conclusions: Chronic exposure to a high energy lunch weekdays for 6 months may represent a risk for excess EI and weight gain. Lunch EI was higher in the large lunch box condition (1,600 kcal) and in the medium (800 kcal) compared to the small (400 kcal). The effect of the higher EI at lunch persisted for up to 6 months. Higher EI at lunch would not be a problem if spontaneous compensation occurred at other meals. The study results suggest that over the 6 months people might have compensated to some extent, but not entirely. But the comparison group's change in total EI was not different from the free one observed for the large lunch-box group. Participants in the large lunch-box group gained significant weight, but weight changes were not significant for the other two intervention groups. The control group gained more weight than expected. Their EI and weight change may reflect the normal intake of this sample of working people who live in an obesogenic environment. The stability of body weight and decrease in EI observed for the small lunch condition might mitigate the rate of weight gain in such an environment. Because the participants were overweight, the small box lunch condition may have provided support for lower EI at lunch that was not compensated later during the day. This effect, if replicated, could be a promising strategy to support overweight adults' effort to reduce EI and promote weight stability or loss over long time periods.

Limitations: lack of interpretative consistency for the control group in relation to the intervention groups (did not receive free lunches); the lunch conditions differed also in composition in ways that might have affected satiety and EI; fruit, vegetable and fiber composition of the intervention lunches was high relative to the participants' baseline intakes; foods across conditions were similar but not identical; validity of dietary intake assessments may have been higher for the intervention groups than for the control group because objective information was available on the food ingredients and sizes for the intervention lunches.

Just & Wansink 2014 (27) USA	2 x 2 design: PS (small vs. large) x Normative labels (half & regular vs. regular & double)	RCT Between subjects	N = 134 Age range: 18-55 years Mean age condition HALF: 19.3 y	• Individuals tend to leave more on their plates when they believe they are consuming a larger than normal portion - differences observed for all foods and sizes except for the larger size of pudding (inverse relation - small numbers buying it). • This effect was translated into a difference in total calories consumed. • For the large spaghetti, those receiving the larger label left ten times as much as those receiving the smaller label. For the sessions with the larger portions, there was a

			Mean age condition DOUBLE: 19.7 BMI not reported	significant 41% reduction in total calories consumed with the label DOUBLE compared to the HALF condition (325 vs. 463 kcal). The reduction in calories consumed when offered a 'small' regular vs. a 'large' regular spaghetti was 63%.

PERSPECTIVE NOTES: Tested the use of size names as information by monitoring plate waste for those told they were consuming a "regular", a "double", or a "half" within treatments (small vs. large portion) - how PS labels bias actual consumption. Hypothesis: if labels are used as objective information, individuals will leave more on their plate when consuming a larger named portion (e.g. "double" instead of "regular").

Other measures: none reported.

Conclusions: Size labels influence the purchase of items, and also the amount participants decided to consume after buying the products (e.g. participants left much more spaghetti in the plate when eating the large size labelled as a "double-size" than when eating the large size labelled as a "regular"; similar results for salad). When consuming the small size, individuals leave more on their plate when it is labelled "regular" than when labelled "half-size". Although participants did not purchase more with larger size names, they used those names to judge what portion of the food to eat.

Limitations: tried modelling with BMI, but study was underpowered to make use of it.

Keenan et al. 2018 (5) UK	Design: prospective consumption x PS (small vs. large) x consumption evaluation (aware vs. unaware)	RCT Between subjects	N = 48 (F) n = 33 for "aware" participants. Mean age: 20.6 y. Mean BMI: 22.3 kg/m^2 [range: 17.5 to 33.1]	• Main effect of PS: participants in the larger portion condition consumed more food (app. 73 gr.) than those in the smaller condition (p = 0.024). • Most participants were aware of whether they had eaten more or less than their prospective consumption (p = 0.003). • There was a significant difference in perceived and actual intake based on which portion of food participants had received (p = 0.005). Participants in the small condition did not appear to perceive having consumed less or more than their actual intake; by contrast, participants in the large condition tended to perceive their meal as smaller than the actual amount (p = 0.008) and underestimated their intake by 25%. This tendency to underestimate meal size was especially evident in participants who received a larger portion and who also consumed more than they intended (p = 0.003).

PERSPECTIVE NOTES: tested the proposition that participants are aware that they have consumed a larger (than intended) meal after being offered a large portion to consume. Hypothesis: if participants are aware that PS influences intake, then 1) the number who accurately report having consumed more/less than the amount they intended to eat should be greater than chance; and 2) participants will be able to estimate accurately the degree to which their intake deviated from their initial intended amount.

Other measures: prospective consumption (intended intake) measured in the beginning of the experiment; restrain measures and eating behaviour questionnaire; pleasantness of food; weight and height.

Conclusions: Participants who receive a large portion of food and consume more than initially intended systematically underestimate their intake, suggesting they are not aware of the amount they have eaten. There was a tendency for participants to be aware of how their intake compared to a pre-selected (intended) amount, or at least to become aware when prompted. Participants who eat more when receiving a larger portion are generally aware of having done so. Accuracy levels were lower for the small portion condition (though not significant). When individuals eat more than they intended in response to receiving a larger portion, they may be aware that they have done so but underestimate by how much. The apparent absence of awareness of additional intake suggests that interventions

	aimed at modifying responses to larger portions might only achieve partial success and that concern about the availability of large servings and large pre-packaged PSs might only be fully addressed by downsizing current product offerings. Limitations: 2 participants were dieting; huge portions (even the small one is a lot of pasta - 300 gr. dried pasta, and a total meal weight of almost 1kg!) although participants were allowed to serve themselves the amount they thought they would eat. Researchers weighed the amount of food selected by participants in front of them - might have influenced intake.			
Kerameas & Vartanian 2015 (6) Australia?	Study 1 - Unit bias 2 x 2 design: portion size x unit size of cookies Portion size (small 30 gr. vs. large 90 gr.) x Unit size (single vs. 3 smaller units)	RCT Between subjects	N = 87 18-25 years old Normal weight females	• Main effect of unit number: participants served 3 small cookies ate less (in gr.) than those served a single larger cookie ($p = 0.01$). Participants served 3 small cookies also reported a lower perceived norm of appropriate intake ($p < 0.001$). • Main effect of portion size: participants served a larger portion of cookies ate more (in gr.) than those served a smaller portion of cookies ($p < 0.001$) (almost 70% more). Participants served a small portion also reported a lower perceived norm of appropriate intake ($p < 0.001$). • No interaction between unit number and portion size.
	PERSPECTIVE NOTES: The purpose is to compare the unit-bias and segmentation-effect explanations for people's food intake and to determine whether these effects explain the PS effect or operate independently of it. Only study 1 is presented here, as the design of study 2 was deemed not to fit the inclusion criteria of this review. In study 1 the cookies were individually wrapped to signify to participants that these cookies were discrete units. Hypothesis: If a unit bias is driving food intake, then participants should consume a single unit of food regardless of its size and regardless of how many units were provided. If the segmentation effect is driving food intake, then participants served 3 smaller cookies should eat less than participants served a single larger cookie, but they may eat more than a single cookie. Thesis: if the increased effort needed to access the cookies explains the segmentation effect observed in Study 1, then participants in Study 2 should eat the same amount regardless of whether they are given 1 or 3 cookies. Measures: recent food intake; hunger level; tasting experience parameters; liking of cookie; norm of appropriate intake; demographics (age, ethnicity, weight and height). Main conclusions: Study 1 - No support for the notion that the unit bias can explain the portion-size effect. Results suggest that separating a portion of food into smaller subunits can reduce overall food intake (segmentation effect). This effect did not explain the portion size effect, though. People appear to integrate information about the overall portion size and the individual units in determining how much to eat. No evidence that people eat a single unit of food. However, there is evidence that people ate less when the portion of food was divided up into smaller subunits. This segmentation effect appears to be driven by a norm of appropriate intake that is created by the way the food is presented. Limitations: laboratory; the segmentation effect might differ when individuals pay for their own food; hunger assessment with single-item self-report measure; only female undergraduate students (no generalizability of effects).			
Lewis et al. 2015 (26) UK	3 conditions of compulsory breakfast: - control (25% of daily energy requirements for M/W). M: 791 kcal, W: 607 Kcal - 20% smaller portion size (PS). M: 633 kcal, W: 485 kcal. - 40% smaller portion size. M: 476 kcal, W: 363 kcal.	Within-subjects, Crossover RCT	N = 33 18-60 years old BMI ≥25 to <35 Mean BMI: 29 kg/m^2	• EI at lunch and over the whole day did not differ across conditions. • Gastrointestinal hormone responses & fullness profiles were lower for 40% smaller PS condition compared to control. • Hunger, desire to eat, and prospective consumption higher for 40% smaller PS condition compared to control.

	EI measured at ad libitum lunch and later snack + weighed diet diary for the remainder of the day			

PERSPECTIVE NOTES: investigated the impact of reducing breakfast portion size on subsequent EI, postprandial gastrointestinal hormone responses, and appetite ratings.

Other measures: Also ran VAS questionnaires about hunger, fullness, desire to eat, and prospective consumption.

Main conclusion: Smaller portions at breakfast led to reductions in gastrointestinal hormone secretion but did not affect subsequent EI, suggesting small reductions in PS may be a useful strategy to constrain EI. Reducing PS at a single meal altered biological markers of appetite and appetite ratings, but there was no energy compensation later in the day. The effect on gastrointestinal hormones and appetite ratings, particularly after the 40% reduction in PS, questions the sustainability of this strategy to constrain EI.

Limitations to notice: This setting prevented any self-initiated eating episodes between breakfast and lunch.

Marchiori & Papies 2014 (7) Netherlands	2 x 2 design Portion size (small - 10 cookies 51 gr. (247.5 kcal) vs. large - 30 cookies, 153 gr. (742.5 kcal)) x Intervention (mindfulness vs. control)	RCT Between subjects	N = 110 young (22.9), normal weight adults	• Main effect of PS present ($p < 0.01$). Participants who were served the larger portion of cookies consumed more calories (83 kcal = 60% more). • No main effect of the mindfulness intervention on calorie intake. • The mindfulness interaction did not reduce the portion size effect. • The mindfulness moderated the effect of hunger on consumption ($p = 0.045$): hunger had an effect on the control condition (67 kcal more) but not on the mindfulness intervention condition. This effect was independent of portion size. The mindfulness intervention then reduced the effects of hunger on unhealthy overeating, for participants offered both the large and the small portion of cookies. • Participants in both PS conditions reported similar levels of comfort in their satiety. • Gender did not interact with PS nor the mindfulness intervention. • Participants served the smaller portion of cookies reported their portion to be a lot smaller ($p < 0.001$) and more appropriate ($p < 0.001$) than participants who were served the larger portion.

PERSPECTIVE NOTES: Tested whether a brief mindfulness manipulation can prevent the portion size effect, and reduce overeating on unhealthy snacks when hungry.

Also measured: current levels of hunger and thirst; tendency to clean plate; ratings of the snacks (satiety feeling, comparison of portion served to their normal portion size, appropriateness of amount for an afternoon snack); rating of attentional foci (focus on eating, body sensations, something else besides these two); measures of restraint and perceived self-regulatory success in dieting. No differences between participants in the groups except for concern for dieting, and guilt and shame.

Main conclusions: Confirm the robustness of the PS effect and suggest that it may be independent from awareness of internal cues. Mindfulness-based interventions may be effective to reduce effects of hunger on unhealthy food consumption. Hunger typically promotes a motivation to approach high-energy food and to consume it, even without conscious awareness. Mindfulness may reduce the impulsive response under a hungry situation.

Limitations: homogeneous group (lean and young, highly educated); only one type of food offered.

McCrickerd et al. 2017 (8) Singapore	Study 1 2 x 2 design: eating rate (slow/thin porridge vs. fast/thick porridge) vs. ED (low vs. high)	RCT Within subjects (between for comparisons M/F)	Study 1 N = 58 Males: Mean age: 25.6y Mean BMI: 23.1 kg/m^2 Females: Mean age: 23.5y Mean BMI: 21.0 kg/m^2	• Thicker porridges were rated as more pleasant ($p = 0.001$), and participants expected them to be more caloric ($p < 0.001$). • Thick porridges were consumed at a slower rate than the thin versions ($p < 0.001$), 41% reduction in ER. No impact of ED on eating rate. • Participants consumed more of the thin porridges than the thick ones ($p < 0.001$; app. 62 gr.). ED had no effect on the amount consumed. • Participants consumed more calories from the thin porridges ($p = 0.001$; app. 45 kcal); also an effect of ED: participants consumed more energy from HD-porridges than from low-ED ones ($p < 0.001$; app. 229 kcal). • Texture and ED influenced fullness ratings: participants were least full when they consumed thin HD-porridge, and most full after the thick HD-porridge ($p = 0.028$). Also, higher hunger ratings reported across the 90 min post-consumption of the thin porridge versions ($p = 0.034$). Desire to eat ($p = 0.009$) and prospective consumption were lower when the thick porridge was consumed, regardless of ED - small effects though. • No effect of porridge texture nor ED on subsequent consumption outside of the laboratory.
	Study 2 2 x 2 design: eating rate (slow/thin porridge vs. fast/thick porridge) vs. PS (regular 100% vs. large 150%)	RCT Within subjects	Study 2 N = 51 (F) Females: Mean age: 25.4y Mean BMI: 21.1 kg/m^2	• Thicker porridges were rated as more pleasant ($p = 0.004$), more filling ($p < 0.001$), and participants expected them to be more caloric ($p < 0.001$). PS had no impact on these ratings. • Participants consumed more when the porridge was presented in larger PS ($p < 0.001$, app. 62 gr.), and consumed less of the thick version ($p < 0.001$, app. 63 gr.). • Fullness was higher when the thick porridge was consumed ($p = 0.004$), independent of PS. Desire to eat and prospective consumption tended to be lower on these days. • No significant effect of PS on the change in appetite over time. • No effect of porridge texture or PS on subsequent consumption reported in the food diaries.

PERSPECTIVE NOTES: Tested whether reductions in meal size could be achieved through combining changes to ED and PS with food-based manipulations (e.g. thick vs. thin) and a fast rate of eating. "Slow-foods" (chewy, thick, hard, and crunchy) are naturally chewed for longer time than softer-textured foods (largest difference between solid and liquid); they remain in the mouth longer and are often consumed in smaller quantities; they might also be experienced as more satiating post-consumption (calorie for calorie). Hypothesis: participants will consume more calories during a breakfast with a higher ED (study 1) and served in a larger portion (study 2), but both of these effects will be reduced by an equally like and sensory-matched breakfast that requires greater oral processing and promotes a slower rate of eating.

Other measures: Pre-breakfast ratings of appetite - VAS-scales for hunger, fullness, thirst, desire to eat, and prospective consumption; Post-1st spoonful of breakfast - VAS-scales for pleasantness, thickness, familiarity with the porridge, filling expectation, and calorie expectation: Post-breakfast ratings of appetite every 15 min for 90 min post meal. Food diary record for the rest of the day.

Conclusions: Natural variations in food texture can be used to design palatable foods that increase oral processing and moderate EI during a meal. Increasing ED by 77% was associated with a 80% increase in EI (study 1). Increasing PS by 50% led to a 13% increase in EI (Study 2). Decreasing eating rate led to an 11-13% decrease in EI, and the independent effects were additive: the fewest calories were consumed when the thicker ("slow") porridge was served in the low-ED version or in a smaller portion. Participants consumed a similar weight across the high-ED and low-ED porridges, but almost twice the calories from the high-ED version; this aligns with research that shows that EI at a meal often varies directly as a function of the ED of the food being consumed, with little impact on the weight consumed and rate of eating. The difference in EI at breakfast had little impact on subsequent rated appetite and food intake recorded the rest of the day. Humans are relatively insensitive to disguised variations in ED. This study suggests that texture-based differences in oral processing can reduce meal size while concurrently promoting the experience of satiety. These data highlight the opportunity to use a combination of ED dilution, smaller portions, and palatable natural variations in food texture to design foods and meals that promote reductions in EI at a meal while maintaining satiety.				
Reily & Vartanian 2016 (12) Australia	Study 1 Design 2 x 3: PS of pasta at lunch (small 300 gr. / 748 kal vs. large 600 gr. / 1496 kcal) x Contextual size information (no label x label only x label + visual comparison)	Study 1 RCT between subjects	Study 1 N = 154 (F) Mean: 19.9 years Mean BMI = 22.1 kg/m^2	Study 1 • Main effect of PS confirmed ($p < 0.001$; consumption: 57 gr. more for the large portion). • No main effect of context and no effect of interaction between PS and context. • PS was a predictor of perceived appropriateness ($p < 0.001$): larger portions led to larger estimates of how much was appropriate to eat. Even though those having the larger PS ate 26% more pasta, there were no group differences in self-reported intake estimates. • No differences in hunger levels between PS conditions.
	Study 2 Design 2 x 3: PS (small 238 gr. vs. large 477 gr.) x context condition (no label x label + visual comparison x choice)	Study 2 RCT between subjects	Study 2 N = 350 (F) Mean: 25.9 years Mean BMI = 25.5 kg/m^2	Study 2 • Main effect of PS confirmed ($p < 0.001$; prospective consumption: 158 gr. more for the large portion) (357.5 g. vs. 199.1 g). • No effect of context and no interaction between context and PS. • PS was a predictor of perceived appropriateness ($p < 0.001$): larger portions led to larger estimates of how much was appropriate to eat.
PERSPECTIVE NOTES: The purpose was to examine whether contextual size information associated with PS moderates the PS effect. Mechanism research: tested whether perceptions of the appropriate amount to eat explained any PS and context effects on food intake (Study 1) and on prospective intake (Study 2). Study 1 hypothesis: 1.1) participants who receive the large portion will eat more than the ones given the small portion; 1.2) the strength of the PS effect will be diminished for those shown contextual size information; 1.3) perceptions of how much is appropriate to eat will mediate the effect of PS. Study 2 hypothesis: 2.1) participants in the large PS condition will report a higher prospective intake; 2.2) the contextual size information will attenuate the PS effect for those who choose their portion, but not for those who are randomly allocated to a PS condition. Other measures: For both studies, VAS-scales for hunger ratings (before & after); number of hours since last meal; taste ratings (1st and last mouthful) (included properties of food and liking); estimates of how much participants had to eat and how much was appropriate; perception of PS compared to participants regular meals; dietary restraint; attention check (did participants see the labels); demographics. Conclusions: Study 1 - PS was mediated by participants' perceptions of how much was an appropriate amount to eat (norms of appropriateness may be the underlying mechanism for the PS effect). Contextual size information did not attenuate the magnitude of the PS effect. Study 2 - contextual size information did not attenuate the PS effect even for those who chose their preferred PS. There was no evidence that contextual size information influences the PS effect on prospective intake. Overall: The PS effect was robust to context. Perceived appropriateness mediated the PS effect.				

Limitations: Study 1 - those who received the large portion size reported a larger discrepancy between the portion they were served and their usual lunch than those who were served the small portion. Participants did not choose the PS they were to eat (it might have influenced results regarding the effect of contextual information). Both studies: relatively homogeneous groups (can not extrapolate to broader groups); only one type of food.				
Reinders et al. 2017 (13) Netherlands	Design: crossover on 3 restaurants of the same chain 6 weeks control + 6 weeks intervention Intervention: double portion of vegetables (150 g vs. 75 g) and 12,5% reduction in meat reduction	RCT crossover between restaurants	N = 12 observations pr. location Total of 1006 questionnaires and observations, n=536 for control period, n=470 for intervention period. 9 - 88 years Mean age: 48.6 y. 54% females, 46% males	• Vegetable consumption from main dishes was higher during the intervention ($p < 0.001$; app. 87%) (115 g. vs. 61.7 g.). • Total vegetable consumption (main + side dishes) was higher during the intervention (pp < 0.001; app. 30%) - participants ate fewer vegetables from the side dishes during the intervention period. • Meat consumption was lower during the intervention period ($p < 0.001$; app.13%) - in accordance with the 12.5% decrease in meat served during the intervention (183.1 g vs. 211.1 g). • There were differences between locations, both for vegetables and for meat. • Participants evaluated the amount of vegetables during the intervention as higher ($p < 0.01$), but to be still acceptable. • Participants evaluated the amount of meat during the intervention as lower ($p < 0.05$), but to be still acceptable. • Satisfaction with the main dish was lower during the intervention period ($p < 0.01$), but participants were still (very) satisfied with their meal. • Men consumed more meat than women during the control period ($p < 0.01$). • Participants with children ate more vegetables from the main dish (115.7 g vs. 106.7 g) ($p < 0.05$) and overall (177.2 vs. 161.2 g) ($p < 0.01$) during the intervention period than participants with no children. • Positive correlations between age and the amount of vegetables were found during both control and intervention ($p < 0.01$). • Participants who visited the restaurants more frequently tended to eat less vegetables. • Strong positive correlations between reported importance of eating vegetables when dining out and the amount consumed from both main dishes and overall, during both control and intervention ($p < 0.001$). • Knowledge of the amount of vegetables one has to eat during the day was positively correlated with the amount of vegetables consumed from main dishes and overall during the intervention period ($p < 0.05$).
PERSPECTIVE NOTES: Aim was to investigate whether increased PS of vegetables and decreased PS of meat in a main dish increase the amount of vegetables consumed in a real-life restaurant setting without affecting customers' satisfaction. Hypothesis: 1) increasing the PS of healthy food (i.e. vegetables) leads to a higher consumption of these healthy food products and that decreasing the PS of meat will leat to a lower consumption of meat; 2) the adaption of PS will not lead to a decrease in customer satisfaction.				

Other measures: Questionnaire - menu choice; reasons for visiting the restaurant; frequency of visits; frequency of dining out; satisfaction with main dish and visit to restaurant; opinion about amount of vegetables and meat served (5-point scale); importance of vegetables when dining; food involvement (?); linking of vegetables; subjective knowledge about vegetables (?); demographics (gender, age, level of education and having children).

Conclusions: Participants ate 30% mores vegetables in total during the intervention. Partial support was found for the hypothesis that increasing the PS of vegetables and decreasing the PS of meat would not lead to a decrease in customer satisfaction. Participants who already had a positive attitude towards vegetables were more likely to eat more vegetables. The PS effect is also true for healthy foods like vegetables.

Limitations: Measurements took place on Saturdays (weekend bias). Research assistants might not have managed to measure all returned plates to the kitchen. Location was a strong moderator of the results - the intervention seemed to work better in some restaurants than others. The importance of eating vegetables when dining out was rated differently during the intervention and control periods, which might be a translation of considerable differences between subjects during the two periods. Did not measure consumption of appetizers, desserts and beverages (could have affected consumption of main dishes). Did not measure/weighted all the components of the main and side dishes before serving (averages for each evening were used).

Robinson & Kersbergen 2018 (9) UK	Studies 1 & 2 Design: quiche PS day 1 (small 100 gr./220 kcal vs. large 200 gr./440 kcal) vs. PS day 2 (small 400 gr./880 kcal) only quiche + salad for women; bag of chips included also for men	RCT Between subjects	N1 = 75 (F) Mean age 31.9±9.4 y Mean BMI 24.7±4.8 kg/m^2 N2 = 78 (M) Mean age 24.5±7.0 y Mean BMI 25.2±4.5 kg/m^2	• Main effect of PS on day 1 for both F and M participants (ps < 0.001); no differences for salad nor chips consumption on day 1. • Also main effect of PS on day 2 for both F (p < 0.003) and M (p < 0.001) participants. • Both F and M participants' perception of a normal-sized portion was smaller on day 2 if they had eaten the smaller as opposed to the larger PS during day 1 (ps < 0.001). • No effects of PS condition on post-meal hunger or reduced post-meal fullness during either session.
	Study 3 Similar design but 1 week after day 1 prospective PS selection was measured online	RCT Between subjects	N3 = 124 Mean age 27.7±9.6y Mean BMI 23.6±4.1 kg/m^2	• Main effect of PS on day 1 (p < 0.001); no differences for salad nor chips consumption on day 1. • Participants' perception of a normal-sized portion was smaller 1 wk later if they had eaten the smaller as opposed to larger PS during session 1 (p = 0.001). • Participants who ate the smaller as opposed to the larger PS during day 1 tended to select a smaller size PS at follow-up 1 week later (NS). • No effects of PS condition on self-reported appetite.

PERSPECTIVE NOTES: tested whether providing participants with smaller portion sizes of a food might recalibrate their perceptions of what constitutes a "normal" PS and, in doing so, reduce the amount of that food that they choose to eat in the future. Hypothesis: the provision of a smaller as opposed to larger PS of quiche will result in participants choosing to eat less quiche in the future (day after or one week later) and that this will be explained by changes in the perception of the size of a "normal" serving of quiche.

Other measures: Studies 1 & 2 - before and after mood questionnaires (decoy), including hunger and fullness ratings; palatability of food and liking; perception of PS on day 2; demographic information, eating habits; demand characteristics; weight and height. Study 3 - similar but without ratings about food post consumption on day 1; questionnaire about food selection and eating habits

Conclusions: In 3 experimental studies that served participants a smaller as opposed to a larger PS of food resulted in them later perceiving a "normal"-sized portion of that food to be smaller. In studies 1 & 2 this also resulted in selection and consumption of less food the next day. In study 3 it resulted in participants tending to select a smaller ideal PS of the same food 1 wk later. We reasoned that because humans will base perceptions of stimulus normality on what they encounter in their environment, downsizing the PS of a food product should result in consumers adjusting their perceptions of what a normal-sized serving of that food is and this would affect future behaviour.

Limitations: homogeneous groups (young, white, middle-class); unknown whether there could have been measurement bias on the prospective selection of quiche due to fewer response options at the upper end of the scale; no measure of how long the effect could last.

Robinson et al. 2015 (10) UK	Studies 1 & 2 Internet questionnaire: standard vs. larger portions (50% more) + rating of intention to consume Study 1: spaghetti bolognese (400 gr./470 kcal vs. 600 gr./705 kcal). Study 2: chicken curry + rice (500 gr./740 kcal vs. 750 gr./1110 kcal).	RCT Between subjects	Study 1 N = 124 (M) Mean BMI = 27.1 kg/m^2 Mean age: 30 y	Study 1 • Intended consumption in proportion of meal not different between conditions (82.7% vs. 84%), but different in terms of energy (more energy from the larger portion, app. 203 kcal) ($p < 0.001$) (592.1 vs. 389.1 kcal). • Participants in both conditions believed the portion they were shown was a relatively normal size.
			Study 2 N = 117 (M) Mean BMI = 26.4 kg/m^2 Mean age: 29.7 y	Study 2 • Intended consumption in proportion of meal not different between conditions (82.3% vs. 78.5%), but different in terms of energy (more energy from the larger portion, app. 262 kcal) ($p < 0.01$). • Participants in both conditions believed the portion they were shown was a relatively normal size.
	Study 3 Laboratory consumption: serving of a standard (75 gr./ 62 kcal) vs. larger portion (175 gr./145 kcal) of ice cream followed by rating of intention to consume, followed by consumption 2 x 2 design: portion size (standard vs. large) x gender (M vs. F)	RCT Between subjects	Study 3 N = 88 (M & F) Mean BMI = 25.3 kg/m^2 Mean age: 33.1 y	Study 3 • No differences for BMI, age, hunger, plate clearing or restraint. • No interactions between PS and gender for any variables. • No gender differences for baseline hunger, BMI or age. Males scored lower for dietary restraint ($p = 0.03$) and had higher plate clearing tendencies ($p < 0.001$). • No main effect of PS on the intended consumption percentage. Main effect of gender ($p < 0.01$) and interaction between condition and gender ($p = 0.004$) for intended consumption in kcal. • Main effect of PS ($p < 0.001$) and gender ($p < 0.001$) on actual consumption. Significant interaction between gender and portion size ($p < 0.001$). As in Studies 1 & 2, no difference for males in intended consumption for portion size conditions (participants intended to consume the majority of the portion served). This meant a significant difference in intended energy intake ($p < 0.001$). Males in the larger size condition consumed more calories than participants in the standard size condition ($p < 0.001$; almost 100% increase).

				Females differed in intended consumption: in the larger size condition females intended to consume less than females in the standard condition (app.27%). Also a pre-consumption PS effect on intended amount of calories (app.25 kcal more for the larger size) ($p = 0.009$), but no effect of condition on actual kcal consumption between the two size conditions. No differences in intended % of portion to be consumed and actual consumption, for both genders.
PERSPECTIVE NOTES: examined the amount of food individuals intend to eat when served standard vs. larger portion sizes of food. In study 3 participants had a sandwich for lunch before the test with ice cream. Other measures: Studies 1 & 2 - rating of normality of the portion size served; estimation of calories in the meal; liking of meal; satiety; frequency of eating spaghetti bolognese; tendency to clear plate; hunger level; age; self-reported weight & height. Study 3 did not measure rating of normality of portion size, but measured pre-meal hunger (pre-sandwich) and mood measures (post-sandwich), plate clearing tendency and restraint measures. Conclusions: Studies 1 & 2 show evidence for an intended "pre-consumption" PS effect. Regardless of condition, participants evaluated both standard and larger portion sizes of the meals tested as being relatively normal in size. All studies suggest a "pre-consumption PS effect" for males. A PS effect on actual consumption was also registered. Females intended to eat proportionally less of the larger portion of ice cream, and there was no evidence of a portion PS on actual energy intake. These results are consistent with the idea that pre-meal planning plays an important role in EI. The authors hypothesize that PS effects on intended consumption are likely to be observed only when meal portions are deemed to appear relatively "normal" or appropriate in size. Limitations: in study 3 no appropriateness of size was rated, so females might have considered the large portion too big, but we can not know it. The use of a sandwich of the same size prior to testing with the ice cream might also have affected satiety, leading to a lower intended and actual consumption from the large portion, as females have lower energy requirements than males.				
Roe et al. 2016 (11) USA	Crossover design: with repeated measures (lunch on 4 occasions) Portion size variations: 100%, 133%, 167% or 200% (medium ED foods = 60% of meal; low ED = 40%) Outcome in grams and kJ for: entire meal; groups of low-ED and medium-ED; individual foods	RCT Within subjects	N = 48 (F) 20-45 years BMI = 18-40 kg/m^2 (mean: 24.4 kg/m^2)	• Increasing the PS of all foods led to significant increases in the mean weight consumed of the entire meal ($p < 0.0001$) as well as of each food ($p < 0.003$). An increase of 33% in size led to an increase of 25% in meal intake (67% or 100% PS increase → 34% increase in meal size). • Increases in meal intake for both low and medium-ED foods considered in groups ($p < 0.0001$). • Hunger, prospective consumption and fullness did not differ as food PS increased, despite the substantial increase in intake. • Increasing the PS of all foods increased mean EI of the entire meal ($p < 0.0001$) and of each food ($p < 0.003$). 33% PS → 24% increase in meal; 67% or 100% PS → 34% increase in EI. The increase was observed for both low-ED and medium-ED foods. As PS increased the best liked foods at the meal showed the greatest increase in consumption. • There was variation between individuals in both baseline meal intake (weight) and in the proportion of additional food consumed as portions were increased.

				• Pre-meal ratings of prospective consumption and the level of disinhibition explained 7% of variability in the weight of food consumed at meals, beyond that explained by the weight served. E.g. subjects with higher disinhibition showed a stronger response to larger portions (ate more). • Pre-meal ratings of prospective consumption, the level of disinhibition, and individual energy requirements together explained 15% of variability in the ED consumed, beyond that explained by weight served. • Awareness of healthfulness of the foods did not affect intake of the foods in response to larger portions.

PERSPECTIVE NOTES: Varied the PS of all foods at a meal to investigate the influence of food ED on the PS effect as well as that of palatability and subject characteristics.

Other measures: VAS-scales for hunger, prospective consumption, and fullness (before and after); taste of the test foods (before). Also, ranking of test foods by taste, healthfulness and amount of energy (at discharge).

Conclusions: The PS effect is complex. While the response to PS can vary between individuals, the effect depends primarily on the amounts of foods offered and their palatability compared to other available foods. Serving larger portions of all foods at a meal led to increased intake of the entire meal and of each food. The ED of the foods did not influence the weight consumed (larger portions promoted higher intake of both low-ED and medium-ED foods). The results show there is no adjustment of food intake to an increase in ED - as portions were increased, both low-ED and medium-ED food intake increased as well. The effect of PS on intake depended primarily on the amounts of foods served at the meal and was greatest for the foods that were liked the best. This finding suggests that interventions to moderate the effect of PS on energy intake should focus primarily on changes in the composition of meals, for example, by moderating portions of higher-ED foods in order to reduce meal ED.

Important: The apparent magnitude of the portion size response is highly dependent on the portions that researchers choose to serve. E.g. in this study, if only the two smallest portions of broccoli had been served, a 30-g increase in portion size would have led to a 28% increase in broccoli intake; in contrast, if only the two largest portions had been served, the effect of the same increase in serving weight would have been 6% and not significantly different from zero.

Rosenthal & Raynor 2017 (14) USA	4 x 2 x 2 design: meal of macaroni and cheese order of the conditions x television watching (yes vs. no) x portion size (small vs. large)	RCT Within subjects	N = 20 18 - 35 years only normal weight all unrestrained eaters	• Main effect of PS present: participants ate more both in gr. (577,9 ± 150,5 g vs. 453,1 ± 96,6 g) and in kcal (903.9 vs. 734.6 kcal), $p < 0.001$ for both) when they were in the large portion size conditions. • No main effect of television watching was found, nor any interaction with PS. • No differences in hunger or fullness levels post-consumption for any of the conditions

PERSPECTIVE NOTES: tested whether television watching had an effect on portion size. The assumption is that a reduced awareness leads to an increase in consumption.

Other measures: 24h dietary recall prior to intervention; physical activity 7 days before; consumption of morning meal; consumption (other than water) 3 hours up to the test; current levels of hunger, fullness and liking of the foods (before AND after test); liking of TV show; height and weight; demographics (age, gender, race, ethnicity, education level); dietary restraint.

Conclusions: PS effect confirmed; no effect of television watching found, in contrast to previous studies. Possible explanations: previous studies conducted without a time limit (longer time, longer exposure to eating opportunities); not clear whether food cues were present in the TV shows presented; use of snack foods (more palatable, hence higher consumption); small sample size of present study.

The present study further strengthens the evidence that increased PS increases consumption in all situations outside of awareness. The increased consumption with larger PS did not produce different internal sensations of hunger or fullness. Limitations: 24h dietary recall prior to intervention, could have led to increased awareness of intake among participants.				
Spanos et al. 2015 (15) Australia	Design: PS (small x large) x serving-size information (no-label x 2 servings x 4 servings) - but only 4 groups (as small PS was always no-label)	RCT Between subjects	N = 100 (F) 18-28 years Mean age: 20.85y Mean BMI = 21.5 kg/m^2 [16.1-34.7]	• Main effect of PS was present: participants in the small condition ate less than those in the unlabelled large condition (p = 0.04; 27% more), and in the L2 condition (p = 0.004). No difference between participants in the small and the L4 condition. • The serving-size information also had an effect: participants in the L4 condition ate less than participants in the L2 condition (p = 0.04)
PERSPECTIVE NOTES: examined whether providing objective serving-size information would reduce the effect of PS on the amount of food consumed. Hypothesis: 1) the main PS effect will be observed, with participants eating more in the unlabelled large portion condition than in the unlabelled small portion condition; 2) providing objective serving-size information will reduce the PS effect on participants' food intake, with participants given the large portion labelled "contains 4 servings" eating less than those given the large portion labelled "contains 2 servings". Other measures: assessment of pizza packaging (colour, font, style, aesthetic appeal) in order to expose participants in the labelled conditions to the serving-size information; initial hunger; taste ratings; questionnaire checking awareness of serving-size information presented and some demographics (age, weight, height; ethnicity). Conclusions: The nature of the information provided influenced how much participants ate; labelling the pizza with a higher number of servings decreased food intake relative to labelling the pizza with a lower number of servings. Making judgements about serving size, the number of servings contained within food products, or the appropriate amount to eat can be a challenging task, and providing objective serving-size information could aide consumers in those decisions, as long as people notice, recognize and understand the labels. Limitations: The difference between the unlabelled large condition and the two labelled large conditions was not significant, which might have been due to low power. Participants were not perfectly accurate in their reports of how many servings of pizza were provided.			
Vartanian et al. 2017 (16) Australia	2 x 3 design: PS (small 300 gr. / 748 kal vs. large 600 gr. / 1496 kcal) x intake evaluation (less x the same x more than usual)	Trial between subjects	N = 157 (F) 18 - 30 years Mean age: 19.9 Mean BMI: 22.1 kg/m^2	• Main effect of PS (p < 0.001): given a larger portion, participants ate more. • Main effect of intake evaluation (p < 0.001): "ate less" participants did in fact eat less than participants in the two other intake evaluation groups. • No interaction between PS and intake evaluation; the magnitude of the PS effect did not depend on the participants' evaluations. • "Ate less" participants were less prone to point the amount of food available as an explanation for their food intake, followed by "ate the same" and then by "ate more" participants (ps < 0.04). • "Ate more" participants in the large PS condition rated the amount of food available as more influential than did participants in any other group (ps < 0.005). • "Ate less" participants rated the influence of hunger on their food intake lower than the other groups (p < 0.003). On average all groups reported that hunger influenced their food intake. Hunger was rated as a more powerful influence than the amount of food available for most groups, except for "ate more" participants in the large PS condition, where the two factors were rated equally.

PERSPECTIVE NOTES: The purpose was to assess whether peoples' attributions for their eating behaviour differ according to the extent to which they believe they have overeaten relative to the amount that they typically eat.

Other measures: VAS-scales for hunger ratings (before & after); number of hours since last meal; taste ratings (1st and last mouthful) (included properties of food and liking); evaluation of intake compared to usual intake at lunch; 18 different factors influencing eating behaviour; demographics; probing for suspicion.

Conclusions: Participants who reported eating the same amount or more than they normally do rated hunger as a stronger influence on their food intake than did those who reported eating less than they normally do (even though initial hunger ratings were similar across conditions). Hunger appears to be a stock explanation that is applicable in most circumstances, regardless of how much was eaten, and with the fact that people consider hunger to be an appropriate/acceptable reason for their eating behaviour. People may be willing to explain their food intake in terms of external eating cues when they are motivated to do so - that is, when they judge that they have overeaten and may be looking for an excuse. Participants attributed their overeating to a social model when in fact the social model had little effect on their food intake - Although people are more likely to blame external cues when they believe that they have overeaten, they are not particularly accurate when they invoke external cues to exculpate themselves. The salience of the external cue can in part determine whether or not that cue is acknowledged.

Limitations: Only asked for perceptions, but did not manipulate the extent to which participants believed they had eaten more than normal. Simplistic definition of overeating (what people believed it to be). Homogeneous groups of participants; no eating disorder assessment

Williams et al. 2014 (17) USA	Design: crossover, repeated measures (6 weeks): Low-ED preload (4 x salad vs. 2 x absent): 2 x 2 design - ED (100% = 1.25 kcal/g vs. 133% = 1.66 kcal/g) x PS (450 gr. vs. 600 gr.).	RCT Within subjects	N = 46 (F) 20-44 years Mean age: 25.4 y. Mean BMI 23.6 kg/m^2 (0.5) [18.6 - 33.5] 33 normal weight 11 overweight 2 obese	• After consumption of the preload salad, EI at the test meal was influenced by both higher ED (153 kcal higher) and PS (40 kcal higher) ($p < 0.02$). Together this increased EI in the test meal by 187 kcal. Only PS affected weight of food consumed ($p < 0.01$). • Consumption of salad preload decreased EI of the test meal ($p < 0.0001$; 123 kcal) - the salad enhanced satiety. It also decreased weight of food consumed at meal ($p < 0.0001$; 86 gr.). • No differences between conditions of preload (salad/no salad) and total lunch EI for the same test meal - participants compensated for the added energy from the salad by reducing intake at the test meal; even though eating the salad increased the weight consumed for the total meal ($p < 0.0001$; 214 gr.). • For the pasta meals, participants rated calorie contents as approximately the same, even though there was 33% difference in ED between versions. • When the salad preload was eaten, ratings of hunger and fullness were not influenced by PS.

PERSPECTIVE NOTES: explored how alterations in the ED and PS of the test meal affect EI after consumption of a salad preload that has been shown to enhance satiety. Hypothesis: 1) after consumption of a satiating preload, increases in the ED and PS of the following test meal will independently influence EI at the test meal; 2) compared to having no preload, consumption of a satiating salad will reduce EI at both the test meal and the total lunch.

Other measures: VAS-scales to rate hunger and fullness (before and after both salad and pasta); pleasantness of taste and texture; filling; comparison of size to a portion they would normally eat; also evaluation of amount of calories served.

Conclusions: The effect of satiety-enhancing foods can be influenced by the ED and PS of other foods at the meal. Following a salad preload, increases in the ED or PS of the test meal led to independent increases in EI at the test meal and at the entire lunch. Compared to having no salad, consuming the preload decreased EI of the test meal (enhanced satiety), but it did not affect total EI at lunch. Participant ratings of fullness were not affected by the ED or PS of the test meal.

Limitations: Subjects had to wait 20 min. between eating the whole salad and being served with the test meal - not very realistic on free-living conditions. Differences in subject characteristics and the in the test meal could have influenced the compensatory response.

Zuraikat et al. 2016 (18) USA	Design: crossover, 3 x repeated measures (3 sets of PS): Set 1 - 300 g vs. 375 g vs. 450 Set 2 - 375 g vs. 450 g vs. 525 g Set 3 - 450 g vs. 525 g vs. 600 g (Women PS, 75% of Men PS)	RCT Within subjects	N = 50 18 - 45 years 23 overweight subject 2 obese subjects and 25 normal weight	• Increasing the size of the set of portions offered to subjects did not affect the relative PS that were selected for the meal across sets. • Many subjects consistently chose the same relative portion in relation to the other sizes available within the set ($p < 0.0001$). • Main effect of PS: increasing the size of the portions across the sets led to an increase in the mean weight of the selected portions ($p < 0.0001$), e.g. the small portion in set 3 also led to an increase in weight intake, even though it was the same absolute portion as the large in set 1. • Increasing the size of the set of portions offered to subjects led to an increased EI at the meal ($p < 0.0001$); 16% increase for set 3 (2767 kJ) compared to both set 1 and 2 (2377 kJ). • No differences in ratings of hunger, fullness, and prospective consumption after portion selection (before consumption). • As all available portions became larger, subjects viewed their selected portion as both larger in general and larger than their usual portion. • Subjects did not rate their hunger or satiety differently, despite having consumed more energy from the meal in the larger set.

PERSPECTIVE NOTES: tested how both selection and intake from a range of PSs is affected when the size of all available portions is increased. Offering subjects a range of portions could modify the PS effect by providing visual cues that help consumers assess the amount of food most appropriate to meet their particular needs or to match their personal norms. Hypothesis: subjects will choose their portions in relation to the sizes of the other available portions, rather than by the absolute magnitude.

Other measures: Before and after VAS-scales for hunger, fullness, and prospective consumption; pleasantness of taste (after 1st bite), PS in general, size in comparison to usual portion at lunch.

Conclusions: Systematically increasing the size of three portion options at a meal had no significant influence on the relative PS selected. Participants often selected the same relative size across all sets of portions, even when they had the opportunity to select smaller options. As a consequence, both the weight of the selected portion and EI from that portion increased significantly as all the portion options increased in size. Although offering options allows consumers to compare portion sizes in making a choice, the absolute size of the available portions is a critical determinant of EI. Subjects chose their portion in relation to the other available sizes at the meal, and the consistency of portion selection demonstrated by many of them implies the use of an anchoring and adjustment heuristic to determine meal choice. The current study provides further evidence that the amount of food offered has a robust effect on intake, and indicates that in the context of large PSs, offering a choice of portions may not mitigate intake.

Limitations: only one type of food tested.

Zuraikat et al. 2018 (19) USA	crossover design 3 groups: trained (from the Portion-Control trial) vs. overweight controls vs. normal-weight controls 4 eating occasions with variable PS: 100% vs. 125% vs. 150% vs. 175%	RCT Within subjects	N = 102 (F) 20-65 years Mean BMI Trained participants: 32.3 kg/m^2 Mean BMI, controls with overweight: 29.5 kg/m^2 Controls with normal weight: 22.3 kg/m^2	• Main effect of PS confirmed ($p < 0.0001$). • No difference between groups: all consumed a greater weight of food when meal sizes increased (app. 26% more per additional 100 gr. served). • Larger portions increased EI at the meal for all groups ($p < 0.0001$). Independent of the effect of PS, the magnitude of meal EI differed between groups ($p < 0.026$): across all meals, trained participants consumed less energy than controls (no difference between controls). • Across all meals, trained participants had lower energy intake (506 ±15 kcal vs. 601 ±12 kcal, as well as lower ED (1.09 ±0.02 vs. 1.27 ± 0.02 kcal/g). The lower ED was because they consumed less garlic bread than all controls ($p = 0.004$), and less pasta ($p < 0.0001$) but more salad ($p < 0.0001$) than normal-weight controls. • Post-meal fullness ratings did not differ as PS increased. • Post-meal hunger ratings were marginally lower ($p = 0.048$) for the biggest PS condition. • Trained participants rated the meals as more healthful than did normal-weight controls ($p = 0.014$). • Positive effect of food liking: the higher liking, the higher intake of foods ($p < 0.0001$), but this effect was smaller for trained participants than for controls. Across all groups, items ranked higher in taste had a greater increase in intake as portions were increased ($p < 0.0001$).

PERSPECTIVE NOTES: The purpose was to determine whether individuals with extended training in portion-control strategies were less responsive to the PS effect than those without training. Hypothesized that the effect of PS on the weight and energy content of food consumed would be attenuated in participants who were trained in portion control, compared to untrained controls. Also hypothesized that the effect of PS on intake differed between the untrained controls with overweight/obesity and the controls with normal weight.

Other measures: eating behaviour (dietary restraint, disinhibition, tendency towards hunger); energy requirements estimated from age, sex, height, weight, and activity level. VAS-scales for hunger, fullness, thirst, prospective consumption, and nausea (on test occasions). VAS-scales for liking and healthfulness of foods (at discharge).

Conclusions: These results further demonstrate the robust nature of the PS effect and reinforce that reducing meal ED is an effective way to moderate EI in the presence of large portions. The lower ED of the meals consumed by trained participants compared to controls was attributable to eating less of the higher-ED items (garlic bread and pasta), and more of the very-low-ED salad. Trained participants moderated their EI at all meals. This was achieved not by limiting the overall amount eaten at meals, but by consuming a greater proportion of lower-ED foods. Thus, contrary to expectation, individuals trained in portion control did not resist the PS effect; they did, however, reduce their EI compared to untrained controls through their food choices at meals. Although measured EI increased 25% between the meals with the smallest and largest portions, participant estimates of their EI only increased 7%. We also found that across meals, trained participants ate a similar weight of food to untrained controls, despite differences in training and weight status. These findings provide further evidence that the portion served is a primary determinant of the amount consumed, and indicate that even prolonged training in standard portion-control strategies, such as using scales and measuring tools, using pre-portioned foods, or instruction to eat less, may not be powerful enough to counteract the influence of cues from the amount of food available. More innovative strategies are needed that provide immediate awareness of the energy content of the portions of food served, along with ways to sustain the salience of this knowledge. Findings also suggest that trained participants placed greater importance on healthfulness in determining food choice than did controls. Results suggest that it may be easier or more sustainable to moderate EI by consuming healthy, low-ED foods than to try to resist eating large portions. The PS effect on individual foods was greater for better-liked foods. Thus, methods to increase the liking of low-ED foods, in particular fruits and vegetables, have the potential to encourage preferential intake of these foods in the presence of large portions (e.g. increasing the palatability of

	low-ED options; repeated exposure to these foods). Furthermore, serving larger portions can be used strategically to increase intake of healthful low-ED foods if they are well-liked and relatively more palatable than the other foods available. Differences in PS can be difficult to detect, but differences in food healthfulness and ED are often more obvious. Trained participants applied their knowledge of healthfulness to reduce meal ED and moderate EI from larger portions, compared to controls. Thus, strategies to counteract the effect of PS on EI should encourage preferential selection of healthful, lower-ED foods as well as awareness of PS. Limitations: trained participants were older and had higher BMI than participants in both control groups. Energy requirements of normal-weight controls were significantly lower than those of the other groups.

Table D2 Summary of results – pack size effect

Reference	Intervention	Design	Subjects	Results
Haire & Raynor 2014 (22) USA	2x2x2 design (unrestrained/restrained) vs. (normal weight/overweight) vs. (SSP 22 small packages /STP 2 standard packages = in all 5.9 dL pretzels for both conditions)	RCT Between-subjects	N = 64 18-35 years old	• Significant interaction between package size and weight status: overweight/obese participants in the SSP condition ate fewer grams of pretzels ($p < 0.05$), compared to those in the STP condition. • In the STP condition, overweight/obese participants ate more grams of pretzels (app. 92 gr. difference) than normal-weight participants ($p < 0.05$). • Overweight/obese participants in the SSP condition had fewer pretzel eating occasions than overweight/obese participants in the STP condition ($p < 0.05$). • No effect of package size observed for normal-weight participants. • No effect of restraint status found.
PERSPECTIVE NOTES: hypothesizes that single-serving packages reduce intake in overweight/obese individuals and individuals practicing dietary restraint compared with standard packages. Main conclusion: Replacing STPs with SSPs may assist with reducing consumption in some overweight/obese individuals. No effect of restraint found. "Package size may have served as an external cue in this study prompting more eating bouts and/or by suggesting a normative amount of food to consume when eating." Limitations: some differences between subjects in the 8 groups (age, gender, restraining level); small homogeneous population (young, non-Hispanic white); individual factors (socioeconomic status; mental health issues; eating behaviour tendencies) not accounted for. No register of potential compensation effects (very important in a naturalistic setting).				
Versluis & Papies 2016 (21) Netherlands	Study 1 Online: 4 snacks (chocolate; M&M's; chips; cocktail nuts) 2 PS (small vs. large) x 2 prime (dieting goal vs. control) x 2 dietary restraint (high vs. low)	Study 1 RCT Between subjects	Study 1 N = 477 18 - 55 years old	• Both prime ($p = 0.02$) and PS ($p = 0.03$) had a main effect on expected consumption. • Interaction of prime and PS was also significant ($p = 0.04$). PS effect was present in the control condition ($p < 0.01$) but not in the diet prime condition. • Participants with higher restraint scores expected to eat less of the snacks ($p < 0.01$). But restraint did not moderate the effect of PS, prime or their interaction. Expected consumption of restrained eaters in the large pack condition was lower in the diet prime condition than in the control condition ($p = 0.04$). • Perceived self-regulatory success showed a significant interaction with PS, such that the PS effect was only significant at low perceived self-regulatory success ($p < 0.01$).
	Study 2 Laboratory: M&M's 2 PS (small vs. large) x 2 prime (dieting goal vs. control) x 2 dietary restraint (high vs. low)	RCT Between subjects	N = 224 18 - 26 years old	• No main effect of PS, and only a trend for participants in the diet prime condition to consume less than controls. • Interaction of prime and PS not significant • Restraint did not moderate the effect of PS, prime or their interaction, and also did not have a main effect on consumption, on average eating 156 calories less in the large pack condition. • The consumption of restrained eaters in the large pack condition was lower in the diet prime condition ($p < 0.01$). Unrestrained eaters eating from large packs were not

				affected by the prime. Both restrained and unrestrained eaters eating from the small packs were not affected by the diet prime. • Hunger and fullness did not moderate the pack size effect post consumption.
PERSPECTIVE NOTES: tested if exposure to a diet goal prime can help individuals with a dieting goal to keep their consumption under control and as a result, diminish the pack size effect. Hypothesis: for restrained eaters a diet prime will reduce consumption from large packs and diminish the magnitude of the pack size effect; for unrestrained eaters dieting is not a relevant goal, so they will not be affected by the diet prime. Other measures: Study 1 - size impression of the packs (very small to very big); difficulty of assessing expected consumption; PS preferences; current attempt at losing weight; perceived self-regulation (tendency to eat whole pack or restrain); frequency of consumption and liking of the test snacks; hunger; gender; weight and height. Study 2 - hunger and fullness; feelings/moods; liking; consumption frequency of M&M's; general PS preference; current dieting behaviour; dietary restraint; perceived self-regulatory success; tendency to eat whole pack; gender, height and weight. Conclusions: Study 1 - The diet prime reduced the PS effect. A diet prime might motivate consumers to keep their consumption under control, and as a result they rely less on the PS to determine the appropriate consumption amount. The diet prime was not moderated by dietary restraint, maybe because a health goal had been activated and communicated the social norm of keeping consumption under control, so to prevent coming across as excessive eaters, both restrained and unrestrained eaters might have limited their consumption after exposure to the diet prime. Study 2 - Restrained eaters reduced their consumption from large packs when primed with a dieting goal and therefore displayed a smaller PS effect, while unrestrained eaters were not influenced by the prime. The diet prime reduced restrained eaters' consumption from large packs, and diminished the PS effect. The diet prime was not effective for unrestrained eaters. Overall - activating the goal of dieting can help dieters control their intake even in the presence of large quantities of tempting snacks. Limitations: Study 2 - time of day had an effect on consumption and interacted with PS (ate more in the afternoon than earlier in the day). Small effect sizes.				
Versluis et al. 2015 (23) Netherlands	Study 1 2 x 2 design: pack size of a chocolate bar (small 75 gr./14 pieces vs. large 180 gr./30 pieces) x pictorial serving size recommendation* (present vs. absent) * 4 pieces (20 gr.)	RCT Between-subjects	N = 317 18-65 years old	• Participants in the absent serving size recommendation condition were more positive about the appropriateness of the size (4 pieces) when they had just seen a small pack than when they had just seen a large pack ($p = 0.02$). Corresponding to a 56 kcal difference (39.9 g vs. 51.2 g). • Pack size main effect: expected consumption from the small bar was lower than from the large one ($p < 0.01$) • After controlling for the notion of the appropriate serving size, both the pack size ($p = 0.01$) and the effect of the presence of the recommendation ($p = 0.01$) were significant. Expected consumption was lower when the recommendation was present. (see fig.1) • Although the recommendation had beneficial effects, it did not prevent the pack size effect. • Gender had a significant effect on consumption, men consumed more than women, and the pack size effect were only sign. for men.
	Study 2 2 x 3 design: pack size (small vs. large) x recommendation (pictorial vs. numerical vs. absent)	Between-subjects, RCT	N = 324 18-55 years old	• Main effect of pack size present ($p < 0.01$): expected consumption from small packs lower than from large packs (app. 22 gr.). Considerably larger effect for men ($p = 0.04$). • No main effect for the recommendation regardless of format. No effect either after controlling for the notion of the appropriateness of the serving size.

4 types of snacks tested: chocolate bar (small 75 gr./14 pieces vs. large 180 gr./30 pieces); M&M's (small 165 gr. vs. large 400 gr.); crackers (small 60 gr. vs. large 120 gr.); peanuts (small 125 gr. vs. large 300 gr.) recommendations: chocolate (4 pieces = 20 gr.), M&M's (1 hand = 15 gr.), crackers (4 pieces = 15 gr.), peanuts (1 hand = 12 gr.)			• When covariates for the evaluation of the recommendation and for the tendency to eat the whole pack were included, there were significant effects for expected consumption ($p < 0.01$), main effect of pack size ($p < 0.01$), and interaction between pack size and recommendation ($p = 0.02$) (see fig.2). Confirmation that the pictorial serving size recommendation can diminish the pack size effect (but only for the large pack, app. 23 gr.). The pictorial recommendation only lowered the expected consumption for the large pack ($p = 0.01$). And it lowered consumption most for those who find it difficult to control their weight. It also lowered consumption when participants had a high liking for the snacks ($p = 0.05$). • The serving size recommendation, the pack size, and their interaction did not have a significant impact on the odds of eating the whole pack for any of the foods. • Participants evaluated the recommended serving sizes as appropriate.
Study 3 2-group (pictorial serving size recommendation: present vs. absent) between-participants design - only large packs (400 gr.)	RCT Between-subjects	N = 89 17-25 years	• The presence of the serving size recommendation did not influence the amount of M&M's participants served themselves. • The amount served was lower among participants who had noticed the serving size recommendation compared to control participants who received a package without serving size recommendation ($p = 0.03$). Participants who did not notice the serving size recommendation did not take less than control participants. A non-pictorial serving size recommendation in grams was not effective in reducing expected consumption. • Participants found the serving size recommendation of 30 gr. to be appropriate. • No differences between conditions in post eating hunger nor satiety.

PERSPECTIVE NOTES: based on the hypothesis that a serving size recommendation that is smaller than the pack will reduce consumption. Also hypothesizes that a pictorial recommendation will be more effective than a numerical (grams) based one. It assumes that consumers are uncertain of how much they should eat and as a result rely on the portion or pack size to determine it.
Participants were also asked if they could remember the recommended serving size; and to evaluate the appropriateness of the size of the recommendation (7-point scale); in Experiment 2 they were additionally given an "I would eat the whole pack option".

Other measures: tendency to eat whole package; frequency of snacking in the afternoon; frequency of chocolate consumption; current hunger status; weight and height; demographic questions (education, household income, living situation) - no differences between participants across conditions in neither Experiment 1 nor Experiment 2. Experiment 3 - hunger and satiety ratings (before and after); liking and frequency of consumption of M&M's; tendency to eat the whole pack; dietary restraint, current dieting behaviour, perceived self-regulatory success, preferred size of the recommended serving (as in 1 & 2). No differences between participants.

Conclusion: These findings suggest that providing a clear and noticeable reference amount for the consumption decision in the form of a pictorial serving size recommendation can reduce the pack size effect. Providing consumers with an alternative reference point for the amount of snack to consume can be an effective way of reducing the pack size effect. For the recommendation to be effective, consumers need to be aware of its presence (high salience) and need to process it. A non-pictorial serving size recommendation in grams was not effective in reducing expected consumption.

APPENDIX E – TABLE OF RELATIVE PORTION AND PACK SIZES

Studies on Portion Size

Reference (no.)	Intervention/food type	Intervention	Control condition
Berkowitz et al 2016 (25)	Intervention: reduced sized entrees	The reduced-size entrees provided about half of the energy and nutrient content of the full size entrees: 275,5 kcal for lasagna to353,5 kcal for meatloaf 306 kcal for salmon to 654,5 kcal *(33%)** for lamb chops.	Full size entrees at the worksite cafeteria ranged from 551 kcal for lasagna to 707 kcal *(35%)** for meatloaf Full size entrees at the restaurant ranged from: 612 kcal for salmon to 1309 kcal *(65%)** for lamb chops
Brunstrom et al. 2016 (20)		Pictures of portions ranging from 20 kcal to 1000 kcal.	
Cavanagh et al 2014 (3)	Pasta meal	Large portion size: 600 g. pasta, app. 750 kcal *(37%)**	Small portion size 350g of pasta app. 440 kcal
French et al 2014 (4)	Three free lunch sizes	400 kcal 800 kcal *(40%)** 1600 kcal *(80%)**	Control condition, no free lunch
Just & Wansink 2014 (27)		No information of portion sizes in calories	
Keenan et al 2018 (5)	People served themselves from either a large or small bowl of pasta and tomato sauce with an ED;1.33 kcal/g	Large pasta: **1900 g** pasta and tomato sauce: 2527 kcal *(126%)**	Small pasta: **950 g** pasta and tomato sauce, 1264 kcal *(63%)**
Kerameas & Vartanian 2015 (6)	No information on how many calories pr. portion of the cookies or pr. 100 g	Large portion: 90 g. of cookies	Small portion: 30 g of cookies
Lewis et al. 2015 (26)	Reduction in breakfast	20 % smaller: M: 633 kcal, F: 485 kcal 40% smaller: M: 476 kcal, F: 363 kcal	M:791 kcal *(40%)** F: 607 kcal *(30%)**
Marchiori & Papies 2014 (7)		Large portion cookies, 742 kcal, 153 g.	Smaller portion, 247,5 kcal, 51 g
McCrickerd et al 2017 (8)	Study 2: regular and large portion sizes	Study 1: Thin and thick porridges in **1000 g.** portions (with low and high ED). eq. 570 kcal and 1010 kcal Study 2: Larger portion size: 1050 g. 150%	 Study 2: **700 gr.** regular 100 % portion size
Reinders et al 2017 (13)	Increased portion sizes of vegetables and decreased portion size of meat	During intervention period the veg. were doubled from 75 g to 150 g. The portion size of meat were reduced by an average of 12.5 %	
Reily & Vartanian 2016 (12)	Macaroni with tomato sauce.	Study 1: Large portion size 600 g. 1496 kcal *(75%)** Study 2: Portion increased with 75 g. and portion ranged from 119 g. to 953 g *(48%)**	Study 1: Small portion size: 300 gr. 748 kcal *(37,4%)**
Robinson & Kersbergen 2018 (9)		Studies 1 and 2: Day 1: Large quiche: 200 g., 440 kcal.	Studies 1 and 2: Day 1: small quiche: 100 g. 220 kcal. Day 2: 400 gr. 880 kcal *(44%)**
Robinson et al 2015 (10)	Study 1 and 2; intended consumption Study 3: actual consumption	Study 1: large portion: 600 g. eq. 705 kcal *(37%)** spaghetti bolognaise Study 2: 750 g. 1110 kcal. *(50%)** chicken curry	Study 1: small portion: 400 g. 470 kcal. Study 2: 500 g. 740 kcal. *(37%)** Study 3: standard portion of ice cream: 75 g. 62 kcal.

		Study 3: Larger portion of ice cream: 175 g. 145 kcal)	
Roe et al 2016 (11)	A lunch consisting of six foods; three medium energy density (60% of meal) and three low in energy density (40% of meal).	Increasing portion sizes: 133% eq. 1408 kcal *(70%)** 167% eq. 1760 kcal *(88%)** 200% eq. 2112 kcal *(105%)** of baseline amounts.	100 % portion of all foods eq. 1056 kcal *(50%)**
Rosenthal & Raynor 2017 (14)	Macaroni and cheese plus salad with dressing	Large portion: 200% of small portion: 2166 kcal *(108%)**	Small portion: 1083 kcal *(50%)**
Spanos et al 2015 (15)		Large portion: 400 g. cheese pizza	Small portion: 200 g. cheese pizza
Vartanian et al et al 2017 (16)		Large portion size: 600 g. 1496 kcal *(75%)**	Small 300 gr. 748 kcal *(37,4%)**
Williams et al 2014 (17)	On four days a compulsory salad (300 g. 0,33 kcal/g) eq. 99 kcal.	100% ED: PS, 450 g eq. 563 kcal PS, 600 g eq. 750 kcal *(37,5%)** 133% ED: 450 g. eq. 747 kcal *(37,5%)** 600 g. eq. 996 kcal *(50%)**	
Zuraikat et al 2016 (18)	Test food: macharoni and cheese: with an ED of 1.6 kcal/g	Set 1: 300 g.(480 kcal) / 375 g. (600 kcal *30%**) / 450 g (720 kcal *36%**) Set 2: 375 g. (600 kcal *30%**) / 450 g. (720 kcal *36%**) / 525 g. (840 kcal *42%**) Set 3: 450 g. (720 kcal *36%**) / 525 g. (840 kcal *42%**) / 600 g. (960 kcal *48%**) Women Portion size: 75 % of men.	
Zuraikat et al 2018 (19)	4 eating occasions with variable portion sizes	Increasing portion size: 125% eq. 1010 kcal *(50%)** 150% eq. 1212 kcal *(60%)** 175% eq. 1414 kcal *(71%)**	100 % portion size eq. 808 kcal *(40%)**

* Calorie contents marked highlight single meals that account for more than 25-30% of the standard daily energy recommendation for women (2000 kcal).
Quantities (in weight) highlighted in **bold** are considered extremely large for the amount available/offered for *ad libitum* consumption in a single meal situation.

Studies on Pack Size

Study number	Intervention comments	Intervention	Control condition
Haire & Raynor 2014 (22)		Single serving packages. 22 0.9 oz. packages of pretzels	Standard packages, 2x10-oz packages
Versluis et al 2015 (23)		Study 1: Large pack size, chocolate bar: 180 gr. Study 2: 4 types of large snacks: chocolate bar: 180 gr. M&Ms: 400 gr. Crackers: 120 gr. Peanuts: 300 gr. Study 3: only large packs	Study 1: Small pack size 75g Study 2: small pack size 4 types of snacks chocolate bar: 75 gr. M&Ms: 165 gr. Crackers: 60 gr. Peanuts: 125 gr
Versluis & Papies 2016 (21)		Study 1: large pack size: Milk chocolate: 180 g. M&M peanuts:400 g. Chips paprika: 300 gr. Cocktail nuts: 300 gr. Study 2: M&Ms large: 400 g.	Study 1: small pack size: Milk chocolate: 75 g. M&M peanuts: 165 g. Chips paprika: 120 gr. Cocktail nuts: 120 gr. Study 2: M&Ms small: 200 g.