Testing an online measure of ideal portion size: A pilot study.

Rochelle Embling¹, Michelle D. Lee¹, Menna Price¹, & Laura L. Wilkinson¹

¹Department of Psychology, College of Human and Health Sciences, Swansea University, Swansea, SA2 8PP, UK.

Corresponding author: Rochelle Embling, Department of Psychology, College of Human and Health Sciences, Swansea University, Swansea, SA2 8PP, UK. Phone: 01792 29 5279. Email: rochelle.embling@outlook.com.

Short title: Online measure of ideal portion size

Abstract

Background

Portion size is known to be a key driver of food intake. As consumed portions are often pre-planned, ‘ideal portion size’ – an individual’s preferred meal size selected prior to eating – has been identified as a strong predictor of actual consumption. However, assessments of ideal portion size have predominantly relied on laboratory-based computer tasks, limiting use online. Therefore, this study sought to pilot test the validity of a web-based tool to measure ideal portion size.

Methods

In an online study ($N = 48$), participants responded to images of a range of foods. Each food was photographed in a series of different portions, and loaded into an ‘image carousel’ that would allow participants to change the size of the displayed portion by moving a slider left-to-right. Using this image carousel, participants selected their ideal portion size. They also completed measures of expected satiety and expected satiation, and self-reported their age and body mass index (BMI). A non-parametric correlation matrix was used to explore associations between ideal portion size and identified predictors of food intake.

Results

Supporting convergent validity of this measure, ideal portion size was significantly correlated with expected satiety and expected satiation (after controlling for effects of baseline hunger and fullness), consistent with past research. Similarly, supporting divergent validity of this measure, ideal portion size was not significantly correlated with age or BMI.

Conclusions

- 24 Pilot results support the validity of this web-based tool to measure ideal portion size, though
25 further research is needed to validate use with comparisons to actual food intake.

Keywords: portion size, meal size, expected satiety, expected satiation, online, survey, pilot

1. Introduction

‘Portion size’ is known to have an important influence on food intake. Larger portions encourage greater meal consumption, with people consuming 35% more food on average when offered portions that are doubled in size (1). Across studies, this effect has been shown to occur for multiple food types, in different meal settings, and irrespective of individual characteristics (e.g. age, body mass index [BMI], and gender) (2–6). In light of increasing portion sizes in the food industry (7,8), portion size is one factor that has been highlighted as a potential contributing factor to overweight and obesity (9,10).

Consumer decisions around portion size are likely to occur *before* eating when planning meals (11). In a large online study, most individuals self-reported that they ‘cleared’ all foods on their plate, that they did so both when portions were self-selected and when offered fixed servings, and plate-clearing was found to have occurred most frequently when meals were planned (12). Similar results have been found when measuring intended and consumed portions in the laboratory. For example, Robinson et al. (13) reported little difference between planned (74.2% eaten) and consumed (71.3% eaten) meal size when participants were served an ice-cream dessert. As such, ‘ideal portion size’ – an individual’s preferred portion of a food that is selected prior to a meal – has been identified as a strong predictor of actual food intake (14).

To measure ideal portion size, studies typically use a computer-based task [for the original task, see (15)]. Participants are presented with an array of photographs for each food item, with each image representing an incremental increase (or decrease) in portion size. Photographs are then presented consecutively onscreen so that keyboard responses give rise to an ‘animated’ effect, as the displayed portion of food appears to grow or shrink with each keyboard press. Using this measure, past studies have shown that ideal portion size is consistently and significantly associated with expected satiety [i.e., the expectation that a food

will stave off hunger between meals (14,16,17)], as well as expected satiation [i.e., the feeling of fullness a food is expected to deliver immediately after eating (15,18,19)]. Typically, larger portions are selected when foods are expected to be less satiating and less filling, though multiple factors can influence the direction of these relationships [e.g. familiarity, energy density and palatability (20)].

In contrast, no associations have been found between ideal portion size and age (19,21). This may be due to studies focussing on a ‘healthy’ adult population, as research has shown that older adults tend to consume smaller meals (22). In addition, no associations have been found between ideal portion size and BMI (14,19,21,23). In this case, it is important to note that whilst larger portions have been identified as a driver of food intake (1), and has been linked to overweight and obesity due to corresponding upwards trends overtime (9,10,24), ideal portion size measures are concerned with a single eating session which in and of itself would not be expected to predict BMI (indeed, portion size has similar effects on meal consumption irrespective of BMI in both adults and children (2,3,5,6)). There is also some evidence to suggest that fat-free mass, rather than BMI, is positively associated with *ad libitum* food intake (25,26).

In light of the COVID-19 pandemic and the necessary suspension of face-to-face testing, ideal portion size may be used as a ‘proxy’ measure of food intake in eating behaviour research. However, to our knowledge, current tasks are unable to be used remotely as part of a web-based survey. In a previous online study, we asked participants to scroll through several portion size photographs as part of a Likert-scale type measure, but noted that functionality from the original task was lost, predominantly due to a need to present smaller-scale images simultaneously rather than consecutively onscreen (21). We also note that a more recent study used a screen-share service to allow some participants to complete a computer-based task to measure ideal portion size from home (17), but this method is not ideal when recruiting larger

77 samples given that individuals will need access to (and be willing and able to use) specific
78 video conferencing software on a one-to-one basis with a researcher.

79 Therefore, the aim of this study was to pilot test the validity of an online tool to measure
80 participants' ideal portion size, that can be used remotely as part of a web-based survey. To
81 test convergent validity, consistent with past studies using a laboratory-based computer task,
82 we hypothesised that ideal portion size (measured using an online tool) would be significantly
83 correlated with expected satiety and expected satiation (as strong predictors of food intake).
84 Similarly, to test divergent validity, we hypothesised that ideal portion size would not be
85 significantly correlated with age or BMI. Hypotheses were preregistered before data collection
86 had begun (see the method section below for more details).

87 Internal consistency was not measured, as we were interested in piloting single items
88 that can be included within large-scale online surveys, that are not necessarily expected to
89 relate to each other. Test re-test reliability was not measured, as to our knowledge, there is no
90 evidence to support or theoretical justification for the notion that ideal portion size is a stable
91 trait measured over time [e.g. expectations for satiety and satiation, as identified drivers of
92 ideal portion size, are believed to be learned overtime and influenced by external cues in the
93 eating environment (20)].

95 2. Method

97 2.1. Participants

98
99 Participants were recruited online using the database 'Prolific'
100 (<https://www.prolific.co/>). Using the software program 'G*Power v.3.1.9.7', it was estimated

that 42 participants were required to detect a correlation ρ of 0.50 ($1-\beta = 0.80$, $p = .01$, two-tailed), as previous research suggests that expected satiety and expected satiation are ‘moderately’ associated with ideal portion size (14–17). Data collection was stopped when 56 responses had been recorded to account for unusable data (e.g. incomplete responses, multiple responses from the same participant ID). Participants were included if they had normal or corrected-to-normal vision, and if they were 18 – 55 years old [to recruit a ‘healthy’ population, in line with procedures reported in (19)]. Participants were excluded if they had dietary restrictions (i.e. a vegetarian or vegan diet, food allergies or intolerances), to ensure that realistic judgments could be given in response to test foods. Participants were also excluded if they were currently on a diet, or if they self-identified as having a current or historical diagnosis of eating disorders. This meant that 49 responses were eligible for the study. Participants were compensated for their time with a payment of £3.13 on Prolific in accordance with platform guidelines on fair pay. The study was approved by the Department of Psychology Research Ethics Committee at Swansea University, and preregistered on the Open Science Framework [OSF; (27)].

2.2. Stimuli

Photographs of seven test foods were presented to participants, including one food that was only presented as part of a demonstration of the tool (see **Table 1** for macronutrient information). All test foods were selected on the basis that they would be familiar to participants, as examples of commonly consumed meals and snacks, and were photographed from a top-down view against a plain background using a high-resolution digital camera and tripod with lateral arm. Chicken chow mein and crisps were photographed on a white dinner

plate (271-mm diameter), and granola was photographed in a shallow white bowl (204-mm diameter, 36-mm depth). All other foods were photographed on a smaller white dessert plate (230-mm diameter). Each food was photographed 50 times, with each successive photograph displaying a portion that incrementally increased in size by ≈ 20 kcal (kilocalories). This meant that the smallest portion shown for each food was ≈ 20 kcal, and the largest ≈ 1000 kcal. Photographs were edited using Microsoft Photos for Windows 10 and PhotoScape v3.7. When included in the online survey, digital dimensions for all images were 460 x 345. Food photographs used are available on the OSF (27).

Table 1. Test foods used for photographs in ideal portion size tool.

	Kcal/ 100 g	Fat/ 100 g	Sugars/ 100 g	Salt/ 100 g
Granola	433.5	13.3	20.5	0.0
Chicken chow mein ¹	96.0	2.5	2.4	0.6
Salted Crisps (potato chips)	476.0	21.0	1.6	1.8
Madeira sponge cake	382.0	14.6	33.0	0.6
Chocolate buttons	535.0	30.0	56.0	0.2
Skittles (fruit-flavoured candy)	404.0	4.2	89.9	0.0
Jam doughnut ²	317.4	14.4	13.2	0.4

¹ This food was low energy density [<2.5 kcal/g (28)].

² This food was only presented to participants as part of a demonstration of the portion size tool, and test responses were not included in data analyses.

2.3. Measures

2.3.1. Ideal portion size and expected satiety

To create a web-based measure of portion size, we used JavaScript code (29) posted to an opensource community board to adapt the slider question format in the survey software

‘Qualtrics’ (Qualtrics, Provo, UT). This would allow photographs to be loaded into a type of ‘image carousel’, whereby moving the slider from left to right changes the displayed image onscreen (for the full JavaScript code and source, see Additional file 1). Slider size was modified to have a minimum value of ‘1’ and a maximum value of ‘50’ to allow a photograph to be added for each point of the scale, grid lines and labels were removed, and a custom start position was used to set the cursor at the midpoint (≈ 500 kcal portion). For each test food, 50 photographs were then loaded into the slider question in successive order, from the smallest to the largest portion size. As photographs were loaded simultaneously into the slider, with each consecutive point displaying a new photograph (and incrementally smaller or larger portion), moving the cursor of the slider generated an ‘animated’ effect by which the portion of food appeared to grow or shrink with each interaction. This visual effect appears to be comparable to that achieved using a laboratory-based computer task to measure ideal portion size [see previous description in the introduction above, (15)].

To use the measure, participants were instructed to click or drag the cursor to the left of the scale to decrease the portion displayed, and to click or drag the cursor to the right of the scale to increase the portion displayed. For each test food, participants were instructed to “select your ideal portion size to eat right now”, or to select the portion that they would “need to eat right now in order to prevent hunger until your next meal” to measure expected satiety. The name of the presented food was included in the question. The point at which participants set the cursor was automatically recorded by Qualtrics; this could be used to identify the selected photograph number, corresponding weight of food displayed (in grams), and the portion size selected (in kcal). A video demonstration of this web-based tool can be viewed on the OSF (27).

2.3.2. Food ratings

To provide food ratings, participants responded to a photograph of the median portion size for each test food (≈ 500 kcal portion), using a series of 100mm visual analogue scales with the anchors ‘Not at all’– ‘Extremely’. Participants were asked to provide ratings of expected satiation (‘how full would you expect to feel after eating the portion of food displayed above?’), liking (‘how much do you like the taste of this food?’), desire to eat (‘how much would you like to eat this food right now?’), and familiarity (‘how familiar is this food?’). Participants also rated their baseline hunger (‘how hungry do you feel right now?’) and baseline fullness (‘how full do you feel right now?’).

2.3.3. Questionnaires

Following a similar approach to past studies (30,31), the three-factor eating questionnaire-R18 [TFEQ-R18; (32)] was used to characterise the overall sample and assess dietary restraint, uncontrolled eating, and emotional eating traits. Responses were recorded using a 4-point Likert scale (e.g., definitely false/ mostly false/ mostly true/ definitely true), and 4 items were reverse-scored. For each subscale, the sum of coded items was calculated, and raw scores were converted to a 0-100 scale ($((\text{raw score} - \text{lowest possible raw score}) / \text{possible raw score range}) \times 100$). Higher subscale scores suggest greater tendencies for dietary restraint, uncontrolled eating, and emotional eating.

2.4. Procedure

Participants were directed to the study via an anonymous link to Qualtrics. Before completing a consent form, participants were presented with an online information sheet and informed that the aim of the research was to “collect consumer beliefs about different food products”. Participants were asked to provide demographic information including their age, gender, country of residence, and time since last eating, and they rated their baseline hunger and fullness.

For the main portion of the study, participants completed three task blocks. In the first task block, participants provided ratings of liking, desire to eat, expected satiation, and familiarity for each food in turn. An additional two questions were included as attention checks (participants were asked to ‘drag the slider all the way to the left’). In the second and third task blocks, participants completed ideal portion size and expected satiety tasks respectively for each food. Before completing these tasks, participants practiced using the portion size tool with a dummy test food (jam doughnut); they were instructed to decrease the portion size displayed by slowly dragging the cursor to the left, and increase the portion size displayed by slowly dragging the cursor to the right. Participants were only able to continue with the study once they had successfully completed the demonstration. Presentation order of foods within each task block was randomised using the randomiser function in Qualtrics.

After responding to all foods, participants completed the TFEQ-R18, and self-reported their height and weight using dropdown lists to enable calculations of BMI (kg/m^2). To evaluate potential demand awareness, participants had an opportunity to explain their beliefs about the aim of the study using an open-text field, before viewing a debrief form. The study was completed in approximately 20 minutes.

2.5. Data analysis

2.5.1. Planned analyses

For main data analyses, ideal portion size and expected satiety ratings were converted to kcal, and all ratings were collapsed across foods by calculating the mean. A Shapiro-Wilk test showed that data for age ($p < .001$), BMI ($p = .001$), ideal portion size ($p = .008$), and expected satiety ($p = .002$) were not normally distributed. As log transformation did not correct the data, an appropriate non-parametric test was used to calculate coefficients in a bivariate correlation matrix (Spearman's Rho). Outliers were identified and removed from data analyses ($1.5 \times \text{IQR}$); a single participant was excluded from all data analyses, as they had a mean liking score of 7.2. Additionally, three participants were excluded from pairwise analyses; one participant self-reported a BMI of $> 40.0 \text{ kg/m}^2$, and two participants had a mean ideal portion size of 634.6 kcal and 737.1 kcal respectively. Significance was determined using the standard $p < .05$. Data were analysed using IBM SPSS v26.

2.5.2. Exploratory analyses

To check that results were robust, non-parametric (Spearman's Rho) partial correlation coefficients were calculated to account for effects of baseline hunger and fullness, and the main analysis was repeated with individual test foods to calculate separate coefficients (following the same procedure as above). For the latter, significance was determined using the Bonferroni-corrected $p = .008$. A Bayesian non-parametric correlation matrix (Kendall's tau-b) was used to explore strength of evidence for associations in the main analysis. Bayes factors were interpreted using the descriptors 'anecdotal', 'substantial', 'strong', and 'very strong', to indicate support for alternative and null hypotheses (33), and

95% Credible Intervals (CI) are reported. Bayesian analyses were conducted using the open source software JASP v.0.11.1.0, with a default prior setting of 1.

3. Results

3.1. Participant characteristics

Participants included 24 females and 24 males. Most participants self-reported a country of residence in Europe ($N = 37$), 5 participants South America, 3 participants North America, and 3 participants South Africa. For the overall sample, mean scores on subscales of the TFEQ-R18 suggest trait levels of dietary restraint, uncontrolled eating, and emotional eating were comparable to past studies from our laboratory (30,31,34). When asked to report beliefs about the aim of the study, 7 participants mentioned an interest in portion size, but no participant commented on the relationship between predictor variables and portion size specifically. No participant failed both attention checks (to warrant exclusion from the study); however, 4 participants failed a single attention check. See **Table 2** for all other participant characteristics. For average food ratings for individual foods, see Additional file 1.

Table 2. Sample characteristics ($N = 48$)

Demographics	Range	M (SD)
Age (years)	18.0 – 55.0	29.0 (10.7)
BMI (kg/m^2)	17.7 – 34.4	23.5 (4.4)
Baseline hunger (100mm)	0.0 – 100.0	33.0 (31.3)

Baseline fullness (100mm)	0.0 – 94.0	52.5 (28.0)
Time since eating (mins)	0.0 – 943.0	173.7 (205.7)
Food liking (100mm) ^a	35.2 – 92.2	67.6 (12.3)
Food familiarity (100mm) ^a	31.3 – 100.0	70.4 (17.3)
Desire to eat (100mm) ^a	11.3 – 72.5	43.7 (17.2)
Expected satiation (100mm) ^a	17.2 – 94.2	53.9 (17.5)
Expected satiety (kcal) ^a	22.9 – 813.3	460.3 (233.7)
Ideal portion size (kcal) ^a	64.5 – 613.2	281.7 (133.5)
Restraint ^b	0.0 – 77.8	38.2 (21.5)
Uncontrolled eating ^b	3.7 – 85.2	42.0 (19.5)
Emotional eating ^b	0.0 – 100.0	43.8 (34.5)

^aCollapsed across foods by averaging scores for individual items.

^bSubscale score of the TFEQ-R18, reported on a 0 – 100 scale.

3.2. Associations between ideal portion size and identified predictors of food intake

When collapsed across foods, there was a significant positive association between ideal portion size and expected satiety ($r_s(47) = .480$, $p = .001$). There were no significant associations between ideal portion size and expected satiation ($r_s(44) = -.287$, $p = .053$), age ($r_s(44) = -.032$, $p = .835$), or BMI ($r_s(43) = -.111$, $p = .835$). However, after controlling for effects of baseline hunger and fullness, there was a significant, negative association between ideal portion size and expected satiation, whereby a larger ideal portion size was selected when expected satiation was reduced ($r_s(42) = -.309$, $p = .041$). All other results were

unchanged. See **Table 3** for correlations with individual foods.

Bayesian analyses showed that there was ‘substantial’ evidence in favour of no association between ideal portion size and age ($BF_{10} = 0.196$, 95% CI: -0.212, 0.168), and BMI ($BF_{10} = 0.277$, 95% CI: -0.277, 0.108). There was ‘anecdotal’ evidence in favour of a significant association between ideal portion size and expected satiation ($BF_{10} = 1.591$, 95% CI: -0.391, -0.010), and ‘very strong’ evidence in favour of a significant association between ideal portion size and expected satiety ($BF_{10} = 50.172$, 95% CI: 0.132, 0.511).

Table 3. Correlations (r_s) between ideal portion size and predictors of food intake, for individual test foods.

Predictor variable	Granola	Chicken chow mein	Salted crisps	Madeira sponge cake	Chocolate buttons	Skittles
Age (years)	-.317	.047	.270	-.014	-.025	-.195
BMI (kg/m ²)	.008	.106	.106	-.051	-.002	.016
Expected satiation (100mm)	-.004	.158	-.032	-.247	-.211	.020
Expected satiety (kcal)	.237	.391*	.461*	.508**	.393*	.556**

** Correlation is significant, $p < 0.001$; * Correlation is significant, $p < 0.008$ (Bonferroni-correction applied)

4. Discussion

This pilot study provides preliminary evidence for the validation of a Qualtrics tool to measure ideal portion size. As predicted, ideal portion size significantly correlated with expected satiety, and did not significantly correlate with age or BMI. There was also some

evidence in favour of an association between ideal portion size and expected satiation, though this was weaker and less consistent compared to expected satiety. These results are generally comparable to those found in past studies using laboratory-based computer assessments of ideal portion size; in this context, moderate associations ($r > 0.50$) have been observed for expected satiety (14,16,17) and expected satiation (15), whilst very weak associations ($r < 0.12$) have been observed for age (21) and BMI (14,21). This provides support for the convergent and divergent validity of the current measure.

These results highlight the potential of using web-based survey software to develop a dynamic, photograph-based tool to measure aspects of eating relating to meal size and consumption. Compared to our previous attempt to measure ideal portion size within an online survey (21), this tool appears to have greater success in preserving key elements of laboratory-based computer tasks; 1) images are presented consecutively when participants interact with stimuli, giving rise to an ‘animated’ change in portion size, and 2) as a single photograph is displayed on screen at any time, images can be relatively large in size, allowing participants to perceive smaller changes between consecutive portions. As a ‘simplified’ continuous-scale measure of portion size, this tool may be particularly useful for the assessment of self-reported food intake in wider research, given that it consists of fewer trials and is less effortful compared to previous tasks.

However, there is scope to further develop the complexity of this approach to assess ideal portion size and related measures. For example, to implement a ‘matched fullness task’ (15,18), a fixed-portion for a ‘standard’ food may be placed to the left of the ‘comparison’ food within the portion size tool by combining images into a single file to load on each point of the scale. The image of the standard can then be kept the same at each point, whilst the image of the comparison food can be varied, allowing participants to select the portion of the comparison food that would leave them ‘feeling equally full’. This may be particularly

important when evaluating expected satiation, given that previous studies using a psychophysical measurement have reported stronger associations with ideal portion size [for a discussion, see (20)]. However, in an online setting, the potential trade-off between study length/complexity and data quality should be considered (35,36).

This tool has practical advantages. As identified for laboratory-based computer assessments of ideal portion size (14), a photograph-based measure can remove barriers associated with testing effects on ad libitum food intake (e.g. relating to products being discontinued or becoming difficult to source, time needed to prepare foods in advance of multiple test sessions, and food waste). In addition, online testing is known to significantly reduce the time needed for data collection, meaning larger samples are more likely to be viable (e.g. participation is no longer restricted by a need to arrange one-to-one timeslots at a specified location, participants are free to take part at their own convenience, and multiple participants may complete the study in parallel). As paradigms consisting of many trials can often be difficult to implement for online research, the use of this tool may be considered a more accessible, alternative approach to developing such a task; Qualtrics has an intuitive user interface, allowing for the seamless integration of the tool into a large-scale online survey with additional questions of multiple formats, and this approach does not require users to have an advanced understanding of coding language. However, as this pilot study was limited to an online-only setting, future research is needed to validate this tool with direct comparisons to laboratory-based computer assessments, as well as actual food intake.

The use of this tool may also be limited by the type of food used. In this study, exploratory analyses showed that ideal portion size failed to correlate with expected satiety and expected satiation for granola. A possible explanation for this is that, as a breakfast food, individuals may be more likely to select their habitual rather than ideal portion size (16). For instance, though not significantly different, McLeod et al. (17) recently reported that the

association between ideal portion size and expected satiety was weaker when breakfast foods were presented at lunch compared to breakfast time, suggesting that ideal portions may be driven less by current expectations for satiety (as meal size is associated with expectations that are learned in the usual eating context). However, more generally, some foods photograph better than others. For example, the ability to distinguish encased fillings or layers in a food is often lost when photographing stimuli from a top-down view in order to show changes in portion size. Consideration should also be given to whether or not the experience of the food would align with expectations derived from photographs. For example, without additional information, it can be difficult for participants to perceive differences in flavour and texture that they would otherwise perceive when tasting a food, meaning highly familiar products are likely to be most appropriate for use.

5. Conclusions

Overall, data from this pilot study support convergent and divergent validity of a web-based tool to measure ideal portion size. Results suggest that this measure may be used to assess decisions focussed on meal size prior to eating, and as an indicator of food intake. This has wider implications for use in online research studies concerned with eating behaviour. However, given the relatively small scale of this pilot study, and limitations around the assessment of validity in an online-only setting, further research is needed to assess efficacy as it relates to actual consumption.

6. List of abbreviations

BMI: Body mass index (kg/m²)

Kcal: Kilocalories

OSF: Open Science Framework

TFEQ-R18: Three factor eating questionnaire-R18

7. Declarations

Ethics approval and consent to participate: The study was approved by the Department of Psychology Research Ethics Committee at Swansea University. Informed consent was obtained from all participants via an online form at the beginning of the survey.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated and analysed during the current study are available in the Open Science Framework repository, <https://osf.io/yq9fk/>. Project DOI: 10.17605/OSF.IO/YQ9FK.

Competing interests: The authors declare that they have no competing interests.

Funding: RE receives funding from the ESRC Wales Doctoral Training Partnership. The organisation had no role in the design, analysis or writing of this article. Project Reference: ES/P00069X/1, Studentship 197139.

Authors' contributions: RE developed study materials, completed data collection and analysed the data. RE and LLW drafted the paper. LLW, MDL, and MP provided editorial comments. All authors contributed to the study design. All authors read and approved the final manuscript.

386 **Acknowledgements:** Not applicable.

- 387 • Additional file 1
- 388 • PDF file format, .pdf
- 389 • Online supplementary material
- 390 • Includes the full JavaScript code used to create the portion size tool (and cited original
- 391 source), and descriptive statistics for ratings of individual foods.

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