# Final Deliverable HAK- The perfect way to serve vegetables 

Literature Review and design guidelines
Dr. Betina Piqueras-Fiszman
Associate Professor Marketing and Consumer Behaviour, WUR

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## Design guidelines

Based on the literature reviewed in the next sections, the following plate design suggestions are proposed.

- Round plate. Social modelling research has shown that the eating behaviour of adults and children can be influenced by the way other diners are eating (Bevelander et al., 2012; Hermans et al., 2009). Parents are thought to be one of the most important social influences on child and adolescent eating behaviour (Salvy et al., 2011), influencing health beliefs, behaviours and dietary intake (Oliveria et al., 1992; Lau et al., 1990). Since this is a way of unconsciously coping with a feeling of belonging, it is expected that a plate that looks similar to that of a model (parent) will facilitate this mimicry behaviour and transition to adolescence, where most likely plates will be the same as those of adults.
- Adult size. The Delboeuf illusion leads to the perception that an area (amount) of food is smaller if placed on a larger (vs. smaller container) and viceversa, due to learnt correct proportions. For this project, it is preferable that the amount of food served is perceived as less rather than too crowded. In addition, the more amount they are served the more they are likely to eat. A normal sized adult plate ( $27-28 \mathrm{~cm}$ ) facilitates this without overcrowding the plate. In addition, many children do not like when food components touch each other, though they do like a bit of disorganisation. A larger size helps picky eaters keep their foods components separated.
- Vegetable compartment/section. Depth can give the impression from the top that it's not very full. In addition, making a compartment for the vegetables can enable serving more, while keeping it visually similar.
- White background. Although behavioural research suggests that lowering the colour contrasts between the food and the plate facilitates mindless eating, this has not been demonstrated in children, and in children this strategy might backfire since it might lead to boredom instead and children's attention to be drawn elsewhere. Colour contrasts enhances the colour of the food, and potentially the flavour intensity (Piqueras-Fiszman \& Spence, 2012 showed this comparing white vs. black plates). When food is displayed in such a way that its colours look vivid, the appeal for the food tends to increase, and this has been more robustly demonstrated, foods that are more visually liked are more likely to be consumed. Since most studies have focused on single-coloured food items, there is no generalisable evidence on a specific colour increasing intake (see p. 5-6). Therefore, since a white background enhances the colour of every food, and different plate colours may lead to different effects depending on the colour of the specific item placed on top, my recommendation is to use a white background to potentially increase the food's appeal.
- No rim. Rims lead to an increase perception of food volume by decreasing the perception of the size of the plate (leading to the Delboeuf Illusion). Rims take a considerable proportion of the plate, decreasing the area where food is served in. Therefore it is not recommended to use a rim.
- No drawings or pictures of food units in the background. Although many children's plates have drawings, a plain white background with no drawings or pictures would be more fitting to a wider age range (4-8 year olds), and more universally accepted. Specific drawings might appeal to a certain gender only, or to a smaller group of children that are fond of it, but not to others. Therefore keeping the background neutral would make the plate more universally appealing when food is served, for longer (i.e., it doesn't become too childish as children grow up).
-It is encouraged that the plate is presented with the vegetables section in the bottom/lower section, closer to the child eating, to facilitate easy access (or to avoid difficult access, which would decrease
chances of consumption). If they start with what is closer to them, this closer area (which can be rotated to bring it closer to their dominant hand) increases the likelihood of that food being consumed (Elder \& Krishna, 2012).


## Literature review

## Introduction

In recent years, many studies have demonstrated the health benefits of a high consumption of vegetables. These health benefits include among others a reduced risk of cardiovascular disease, obesity and adiposity, dementia and cognitive decline, and all-cause mortality (Astrup et al., 2008; Ledoux et al., 2011; Loef \& Walach, 2012; Lamport et al., 2014; Oyebode et al., 2014; Wang et al., 2014). As previous research shows that eating behaviours track from early childhood into adulthood, it is important to establish a healthy level of intake of vegetables already early in life (Mikkilä et al., 2005; Holley et al., 2017). However, in young children the bitter and undesirable taste of vegetables is often described as one of the main barriers to establish this healthy level of vegetable intake (Brug et al., 2008; Di Noia \& Byrd-Bredbenner, 2014). In addition, food neophobia can interfere with young children's acceptance of particularly new vegetables (Dovey et al., 2008; Mustonen et al., 2012). Subsequently, many potential strategies to increase children's vegetable intake have been investigated (Holley et al., 2017; Nekitsing et al., 2018). From these strategies, repeated taste exposure, modelling, flavour enhancement, stealth, and social praise have been shown to promote vegetable intake to varying extents (Cooke et al., 2011; Anzman-Fransca et al., 2012; Caton et al., 2013; Draxten et al., 2014). Furthermore, more attention has been focused on aspects related to the serving of vegetables, for example the variety or portion sizes of vegetables presented to children (Lycett et al., 2017). The results of interventions focusing on these aspects could potentially be used to develop presenting styles, including dishware to (unconsciously) increase vegetable intake of children. Therefore, this literature review will aim to provide an overview of the results of interventions focusing on the link between aspects related to vegetable presentation and vegetable intake among children.

The literature review is subdivided into sections which each describe a separate aspect related to vegetable presentation. These sections will describe the effects of plate design, a visually appealing presentation, serving order, variety/choice, and portion size on children's liking and intake of vegetables.

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## Plate design

As many children's fruit and vegetable intake is lower than the recommended levels, numerous studies have aimed to increase the consumption of these food categories. One of the factors which could potentially influence children's vegetable intake and food intake in general is the design of the plate from which the children eat. In this context, multiple studies have examined the use of photographic images of fruits and vegetables on plates in relation to the children's intake of fruits and vegetables (Reicks et al., 2012; Melnick \& Li, 2018; Sharps et al., 2020). These studies showed that the presence of a carrot image on the plate could increase carrot consumption in children aged 5-11 years old (Reicks et al., 2012; Sharps et al., 2020). A similar result was found for green beans (Reicks et al., 2012). In addition, the portion size shown on the image was found to be of importance, an image of a larger portion size of carrots further increased carrot intake compared to an image showing a small portion size (Sharps et al., 2020). The results of the study and the photographic images used by Sharps et al. (2020) are visualized in Figure 1.

Melnick \& Li (2018) conducted a similar type of research for children aged 3-5 years old, in which plates had sections for fruits and vegetables labelled by pictures. Children ate lunch in their school classrooms and served themselves from bowls of fruits and bowls of vegetables. They found that when these pictures were present children consumed significantly more vegetables compared to a white control plate without the presence of these pictures (Melnick \& Li, 2018, see Figure 2), but only when cucumbers and carrots were present, in Day 2.


Figure 1. Main results and the photographic images used in the study by Sharps et al. (2020).



C Fruit taken



Figure 2. Main results and the photographic images used in the study by (Melnick \& Li, 2018)


These plates (named HealthBeet plates) were an initiative of Super Healthy Kids Inc. (https://www.superhealthykids.com/). MyPlate Divided Kids Plate is 25.4 cm diameter. Other plates from them are shown below.


Choose MyPlate Portion Plate for Adults and Teens, 25.4 cm diameter. This design is a realisation of the new USDA graphic showing a supposed "balanced diet".


Healthy Habits Divided Kids Plate, $24.13 \times 20.32 \times 2.54 \mathrm{~cm}$

In addition, the effects of plate colour on children's vegetable liking and intake has been assessed in two studies (Andersen et al., 2017; Brunk \& Møller, 2019). The study performed by Andersen et al. (2017) found that the amount of bell pepper consumed by children 2-6 years old was dependent on the colour of the plate on which the vegetable was served (Andersen et al., 2017). In more detail, a blue plate colour resulted in a $9 \%$ increase in consumption compared to when the bell pepper was served on a white plate. On the contrary, red and yellow plates resulted in a decrease of respectively $17 \%$ and $19 \%$ in consumption (Andersen et al., 2017). Brunk \& Møller (2019) found that children younger than 10 years were more likely to prefer chromatic plates (green, blue, yellow, or red) compared to children >10 years old. However, white coloured plates were still preferred most often (ranked highest), for all groups of children children when presented empty (Brunk \& Møller, 2019). For more details about these studies, see Table 1. Piqueras-Fiszman and Spence (2012) also showed that a food served on a background which colour contrasts with the colour of the food is likely to be perceived as being more vivid (therefore appealing), and that this in turn might increase liking for the food. For instance, the flavour of a strawberry dessert was perceived to be more intense on a white compared to a black plate, and this likely impacted the liking. Due to colour contrast, the colour of the front object (the food) is perceived to be more vivid, potentially enhancing the flavour intensity (and if liked, increasing the liking too). In addition, when a food's colour is more vivid, it is more appealing to the eye as it's a learnt cue for freshness and safety (Lee, Lee, Lee, \& Song, 2013). The majority of literature exploring colour in plates have done so by using mono-colour foods, and the effect of individual plate colours will depend on the food placed atop, and on how appealing it makes it look.

On the other hand, behaviourally, higher colour contrasts increases one's awareness of the food and leads to less mindless eating behaviour (van Ittersum \& Wansink, 2012) compared to when the food "blends" in with the colour of the plate. Once again, this has been shown with mono-coloured foods (pasta with white sauce, or green vegetables, with white and green plates respectively).

A study by Zampollo et al. (2012) investigated children's preference regarding multiple factors related to the orientation of their plates. Results showed that children aged 5-12 years old liked on average more colours and components on their plates compared to adults. The main component was preferred on the lower right of round plates, and on the left side of oval plates, see Figure 2. Furthermore, children preferred the food in their plates disorganized (compared to neat, or arranged in geometrical patterns) and uncrowded (i.e., with more empty spaces; Zampollo et al., 2012). Finally, the influence of dishware size on children's energy and vegetable intake was examined by DiSantis et al. (2013). They found that although children (6-7 years old) served themselves significantly more energy when using adult-size compared to child-size dishware, probably due to the Delboeuf visual illusion whereby a circle (in this case the area occupied by the food) seems smaller when surrounded by a larger circle (in this case the border of the plate) compared to when surrounded by a smaller circle. However, no significant differences in vegetable intake were present between the conditions. Only liking did influence vegetable intake positively (DiSantis et al., 2013). An overview of the studies looking into the effects of plate design/plate orientation on children's liking and intake of different kinds of vegetables can be found in Table 1.


Figure 2. The different possible positions participating children could indicate they preferred their main components to be on round plates. For the preference on an oval plate, similar positions were used (Zampollo et al., 2012).

So far in this section, studies have exclusively focussed on plate design's influence on children's vegetable intake, revealing only limited available studies concerning this healthy food category. Therefore, several other studies looking into the effects of plate design on intake of all kind of other
food categories will be discussed as well. However, it should be emphasized that caution is required when trying to translate the results of these studies to the intake of vegetables by children.

A study conducted by Carstairs et al. (2019) investigated whether plate colour could be utilised as a strategy to reduce intake of high energy density snacks, and increase the intake of low energy density snacks in pre-school children aged 3-5 years old (Carstairs et al., 2019). No significant differences between the effect of chromatic (green/red) and achromatic (white) on the snack intake of children was found (Carstairs et al., 2019). Therefore, plate colour as a visual cue did not influence snack food intake in this group of pre-school children. In addition, McClain et al. (2014) studied whether a plate's rim width and colouring could influence perceptual bias to affect perceived portion size (McClain et al., 2014). Their study showed that wider and coloured rims could exaggerate perceptions of the amount of food on a plate (McClain et al., 2014). However, in this study the rim significantly reduced the area where the food is served, therefore leading to the same results as the Delboeuf illusion. This may indicate that rim width and colour influence food perceptions, which could potentially result in changes in food consumption. Examples of the stimuli used in this study can be found in Figure 3.


Figure 3. Stimuli used in the study by McClain et al. (2014). The stimuli differ in their rim width, and portion sizes.

Finally, Han and Kang (2017) proposed a smart plate and cup series, in order to effectively stimulate children to have healthy dietary habits (Han \& Kang, 2017). In their designed tableware, they used images, sound kits, and LED lights to attract children's interest. The authors mention that the use of these variables will result in more attention, and encourages children to eat healthy foods (Han \& Kang, 2017).

In general, studies looking into the effects of plate design on children's vegetable intake found that photographic images of vegetables on the plate, or in sections of the plate could increase the intake of these vegetables. In addition, the portion size was found to be of influence, with larger portion sizes shown on the image resulting in a higher intake. For the effects of the plate colour, mixed results were found for children, with a few studies demonstrating a slight increase of vegetable intake or preference
when eating from chromatic coloured plates. However, other studies also including other food categories, did not find significant effects caused by the plate colour. Other research found that the placement of the main component was preferred on the lower right of round plates by children. Furthermore, they preferred their plates mixed up and uncrowded. Results from the effects of plate design on children's food intake of other food categories indicates that also the plate rims could influence perceived portion sizes and potentially even food intake.

Table 1: The effects of plate design/plate orientation on children's liking and intake of different kinds of vegetables.

| Authors + Year | Country/Setting | Population | Design | Exposure | Type of Vegetable/Fruit | Main Findings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sharps et al. (2020) | UK - Primary School | 1) 63 children (6-11 years old) <br> 2) 59 children (5-12 years old) | 1) Betweensubjects <br> 2) Betweensubjects | Photographic image of corresponding vegetable/fruit on plate (1+2), in different portion sizes (on picture) (2) | 1) Grapes <br> 2) Carrots (raw) | Children in the fruit nudge group: intake $\uparrow$ ( 91.5 gram compared to 67.6 gram (control - no image)) <br> Children in the large portion nudge significantly higher intake compared to small portion nudge and control group ( 46.0 gram 29.9 gram - 31.1 gram respectively) |
| Reicks et al. (2012) | US - <br> Elementary School | Approximately 800 children (5-11 years old) | Betweensubjects | Photographic images of carrots and green beans in lunch tray compartments | Carrots <br> Green beans | Increase of children who selected the green beans ( $6.3 \%$-> 14.8\%) and carrots ( $11.6 \%$-> 36.8\%) from the cafeteria at school. <br> Consumption per student exposed for green beans compared to control: $\uparrow$ ( 2.8 gram - 1.2 gram) Consumption per student exposed for carrots compared to control: $\uparrow$ (10.0 gram - 3.6 gram) |
| Zampollo et al. (2011) | US | 23 children <br> (5-12 years old) <br> 46 students | Within- and betweensubjects (groups) | Questions regarding the colour on the plates, number of food elements, position main | - | Children liked more colours and components on their plate compared to adults ( 6 vs 3,7 vs 3 , respectively). |

$\left.\begin{array}{llll} & \begin{array}{ll}\text { (26 years or } \\ \text { older) }\end{array} & \begin{array}{l}\text { component, and fullness } \\ \text { \& organization of plate }\end{array} & \begin{array}{l}\text { Children preferred main } \\ \text { component on the lower right of } \\ \text { their round plate, and on the left } \\ \text { side of an oval plate. }\end{array} \\ \text { Children prefer uncrowded plates }\end{array}\right]$

| DiSantis et al. (2013) | US - <br> Elementary <br> School | 42 children <br> (6-7 years old) | Withinsubject | Children served themselves using childsize dishware ( 7,25 inch diameter plates. 8-oz bowls), or adult-size dishware (10,25 inch diameter plates, $16-\mathrm{oz}$ bowls) | Whole meal (included mixed vegetables) | Adult-size dishware: amount of energy served themselves $\uparrow$ (90.4 kcal more compared to child-size dishware). <br> For vegetables specific: no significant effects, only liking influenced intake positively. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Andersen et al. (2017) | Denmark | 123 children <br> (2-6 years old) | Crossover intervention | Four differently coloured plates (blue, yellow, red, and white) | Bell pepper | Compared to on a white plate (103,4 gram); |
|  |  |  |  |  |  | Blue plate: $\uparrow(9 \%, 112,5$ gram $)$ <br> Red plate: $\downarrow(17 \%, 86,6$ gram $)$ <br> Yellow plate: $\downarrow(19 \%, 84.0$ gram $)$ |
|  |  |  |  |  |  | Only the difference between blue and yellow plate was significant. |
|  |  |  |  |  |  | Plate colour did not influence intake in children below the age of 3,3 years. |
| Piqueras- <br>  <br> Spence (2012) | Spain | Adults | Within- <br> Subjects | Two coloured plates (black and white) | Strawberry (pink) dessert | The same dessert out of a white plate was perceived sweeter, more intense in flavour and more liked. |

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## Visually Appealing Presentation

Next to the design of the plate, also the presentation of fruits and vegetables at the moment of serving could be of importance for children's vegetable liking and intake. In the past, studies have looked into the effects of a visually appealing presentation of different types of fruits and vegetables compared to the same fruits and vegetables presented in a regular way (Olsen et al., 2012b; Zampollo et al., 2012; Correia et al., 2014; Clay, 2016; Chung \& Fong, 2018; Maiz et al., 2019). In general, these studies found that children preferred a nice visual presentation (Olsen et al., 2012b; Zampollo et al., 2012), and that an enhancement of the visual presentation could result in increases in intake of pumpkin, sweet potato, carrot, and aubergine (Chung \& Fong, 2018), and spinach (Chung \& Fong, 2018; Maiz et al., 2019). However, although slight increases were observed, no significant differences in intake were found for cucumber, chive, and olives (Correia et al., 2014), and for green pepper (Clay, 2016) presented in a graphically nice way. Some of the visual enhanced presentations are illustrated in Figure 3 and Figure 4.

Furthermore, the influences of the shape and size of vegetables on children's liking and intake were studied (Olsen et al., 2012b; Liem \& Russell, 2019). A study by Olsen et al. (2012b) found that children preferred having their vegetables cut into pieces of ordinary size, with no differences in preference between sticks and slices (Olsen et al., 2012b). However, Liem \& Russell (2019) showed that when carrots were served as a whole as compared to diced to children aged 6-11 years old while watching a movie, children consumed more of the whole carrots after 10 minutes (significant) and 90 minutes (borderline significant) (Liem \& Russell, 2019). An overview of the main studies conducted in the field of vegetable consumption in relation to their (visually appealing) presentation during serving can be found in Table 2.


Figure 4. Different presentation style of vegetables in the study of Olsen et al. (2012b).


Figure 5. The presentation of fruit and vegetables in the visually appealing condition in the study of Maiz et al. (2019).

In summary, most of the included studies focussing on the effect of a visually appealing presentation of fruit and vegetables on their intake concluded that children preferred a nice visual presentation compared to a normal presentation. On the contrary, the effects of the presenting style on the intake of fruits and vegetables were inconsistent. This could be due to individual differences in presentation styles, or due to the type of fruits and vegetables included in the studies.

Table 2: The effects of a visually appealing presentation on children's liking and intake of different kinds of vegetables.

| Authors + <br> Year | Country/Setting | Population | Design | Exposure | Type of Vegetable/Fruit | Main Findings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Correia et al. (2014) | US - Child Care Center | 1) 43 children (3-5 years old) <br> 2) 42 children <br> (3-5 years old) | Withinsubject | 1) Pizza with either vegetable on top, or on the side <br> 2) Vegetables served in a graphically nice way (as a caterpillar), or normal | 1) Broccoli <br> 2) Cucumber, chive, and olives | 1) No significant differences in broccoli consumption between the conditions ( 18,1 gram on top $-17,8$ gram on the side of pizza). <br> 2) Cucumber served in a graphically appealing manner: consumption and willingness to try $\uparrow$ (34,3 gram compared to 29,0 gram for control). However, not significantly different. |
| Zampollo et al. (2011) | US | 23 children <br> (5-12 years old) <br> 46 students <br> (26 years or older) | Within- and between subjects (groups) | Questions regarding the visual presentation of the meal | - | Children prefer an appealing and nice visual presentation, whereas adults prefer a more casual presentation of the meal. |
| Clay (2016) | US- Preschools | 56 children <br> (3-5 years old) | Between- <br> subjects | Vegetables cut into figures (hearts, stars, flowers) served on placemats that children coloured (same figures) | Green pepper | No significant differences between the intake of vegetables cut into figures and vegetables presented in a 'normal' way. |

## Olsen et al.

 (2012b)Denmark Local Schools

138 children Within-
( $9-12$ years old) subject

Vegetables presented in two different sizes; small and ordinary, and in four shapes; whole/chunk, sticks, slices, and figures (stars).

Fruits and vegetables either enhanced in their visual appeal, or not.
Betweensubjects (groups)

## Liem \& Russell

(2019)

Australia Primary School

60 children
(6-11 years old)

Crossover design

Carrots served to children watching a movie: either diced or whole carrots

Carrots, cucumber, red peppers influential, children preferred having their vegetables cut.

Figures were liked the most by the children, and no differences were observed between sticks and slices.

Size only mattered for the whole/chunk, in which the ordinary size was preferred most.

Mango, apple, For an increased visual appeal orange, banana, (compared to no enhancement) blueberry, consumption of: pumpkin, sweet Pumpkin $\uparrow$ potato, spinach, Sweet potato $\uparrow$
carrot, and Spinach $\uparrow$
aubergine Carrot $\uparrow$
Aubergine $\uparrow$

## Carrots

The consumption of whole carrots was significantly higher than the consumption of diced carrots after 10 minutes (median intake 39 gram -26 gram, p-value $<0.05$ )

After 90 minutes: the consumption of whole carrots trended towards

| Maiz et al. (2019) | Spain - Primary Schools | 165 children <br> (8-12 years old) | Between- <br> subjects <br> (groups) | Children were served either visually appealing fruit and vegetables or regularly served fruit and vegetables. In addition, some children helped with preparing the visually appealing food. | Papaya, apple, strawberries, star fruit, spinach, beet root | Visually appealing fruit and vegetables: willingness to taste new foods $\uparrow$ <br> Furthermore, helping with creating the visually appealing foods creates positive experiences with the foods involved. <br> Some small (approximately 10 gram) increases in vegetable consumption between the visually appealing group and the control group. Small additional effect for the help with creation. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |

## Serving Order

Another aspect which could possibly be related to children's vegetable intake is the order of serving of the components during their meals. There are two studies conducted which illustrate the potential of interventions focusing on this serving order effect (Redden et al., 2015; Elsbernd et al., 2016). Both these studies found that children aged 5-11 years old increased their vegetable intake when a portion of broccoli or carrots (Redden et al., 2015), or peppers (Elsbernd et al., 2016) was served to children while they waited in line to obtain their lunch at school (Redden et al., 2015; Elsbernd et al., 2016). This indicates that children may increase their total vegetable intake when vegetables are presented to them in advance of their actual meal. However, it should be noted that the vegetable intake was very low and below recommended levels, even in the intervention conditions.

Related to this research, Spill et al. (2010) examined the effects of providing different portion sizes of carrots in children's first course on the children's (3-5 years old) total vegetable consumption during the entire meal. The study showed that total vegetable consumption increased when portion sizes of carrots in the first course were larger (Spill et al., 2010). More specifically, doubling the size of the first course increased carrot consumption by $47 \%$, whereas the broccoli consumption during the main meal was not affected by this increase in carrot consumption (Spill et al., 2010). Similarly, Spill et al. (2011b) studied the influence of providing a first course with 150,225 , or 300 grams of tomato soup on children's (3-5 years old) vegetable consumption during the entire meal. They found that total vegetable and soup intake increased for larger portion sizes of tomato soup in the first course (Spill et al., 2011b). In addition, the variations in first course tomato soup portion sizes did not influence broccoli intake during the main meal (Spill et al., 2011b).

Lastly, Savage et al. (2011) assessed whether varying entrée portions (100, 160, 220, 280, 340, and 400 grams) resulted in differences in intake of fixed portions of apple sauce, bread, and green beans served alongside the entrée in children aged 3-6 years old. Results showed that increasing the portion sizes of the entrée lead to a decreased intake of the other foods which were served alongside the entrées (Savage et al., 2011). A summary of the studies described in this section can be seen in Table 3.

In conclusion, the serving order was found to be quite influential in determining the children's intake of vegetables during the meal. In the research looking at the effects of serving a portion of vegetables before the main meal, significant increases in intake of different kinds of vegetables were found for the children. This implies that children may increase their total vegetable intake when vegetables are served to them in advance of their actual meal. However, it should be noted that in most of these studies, vegetable intake was still low and below recommended levels. In addition, the effects could also work the other way around, with a study showing that the vegetable intake during the main meal decreased with increasing entrée portions not containing any vegetables.

## Table 3: The effects of serving order of vegetables on children's intake of different kinds of vegetables.

| Authors + <br> Year | Country/Setting | Population | Design | Exposure | Type of <br> Vegetable/Fruit | Main Findings |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |


| Spill et al. (2011b) | US - Daycare Facilities | 72 children <br> (3-5 years old) | Crossover design | Normal lunch, with or without a first course of 150,225 , or 300 grams of tomato soup. | Tomato (first course) <br> Broccoli (main course) <br> Apple sauce (main course) | Total vegetable and soup intake by increasing the portion sizes: $\uparrow$ (300 grams of soup: 128,9 grams, 150 grams of soup: 108,8 grams, $\mathrm{p}<$ 0.001). |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Broccoli intake of main course not affected by the varying first course tomato soup portion sizes. |
| Savage et al.(2011) | US - Childcare Facility | 17 children <br> (3-6 years old) | Withinsubject | Varying entrée portions (100, 160, 220, 280, 340, and 400 grams), alongside fixed portions of apple sauce, bread and vegetables | Green beans Apple sauce | Increasing portion sizes of entrée resulted in an increased intake of the entrée, and decreased intake of the other foods served alongside the entrée ( $p<0.01$ ). |
|  |  |  |  |  |  | Intake of green beans for ascending portion sizes (7,6-7,8-6,1-7,3-5,6-2,7 grams respectively). Same pattern observed for apple sauce. |
|  |  |  |  |  |  | Children consumed a more energydense lunch as portion sizes of entrée increased ( $\mathrm{p}<0.001$ ). |
| Redden et al. (2015) | US - <br> Elementary <br> School | 1) Approximately 700 children <br> (5-11 years old) <br> 2) Approximately 500 children <br> (5-11 years old) | Withinsubject | When the children waited to enter the line to obtain lunch: they would receive two carrots (1) or broccoli (2) in a small paper cup | Carrots (raw) <br> Broccoli | When carrots were served first: carrots consumption $\uparrow$ (12,7 grams - 2,4 grams (control), $\mathrm{p}<0.01$ ). When broccoli was served first: Broccoli consumption $\uparrow$ ( 3,4 grams - 0,9 grams (control), $\mathrm{p}<0.01$ ). |

## Variety/Choice

In a literature review, fruit and vegetable variety was described as an important determinant of the choice of these foods among children and adolescents (Krølner et al., 2011). In addition, the presence of a variety of vegetables was shown to improve the meal composition in adults (Bucher et al., 2011; Meengs et al., 2012). Based on this information, it could be suggested that providing children with a variety or choice of fruit and vegetables may influence the amount eaten of these healthy foods. Therefore, a number of studies looking into these influences will be discussed in this section.

First of all, Bucher et al. (2014) served children aged 7-10 years old a mix of either carrots and green beans, or one of these vegetables separately. The study found that children who were given the two vegetable choice had a significantly higher energy intake from vegetables compared to children who were offered only one of the two vegetables (Bucher et al., 2014). Similar research was performed by De Wild et al. (2015) among children aged 2-5 years old. In their research, children were presented with either one type of vegetable, or with two types of vegetables from which they could choose during dinner. The vegetables consisted out of peas, broccoli, French beans, cauliflower, and string beans, which are all commonly consumed among children in the Netherlands (De Wild et al., 2015). Results showed that children who had the choice from two different vegetables had an increased vegetable intake compared to children who were presented with one type of vegetable ( $\mathrm{p}=0.09$ ) (De Wild et al., 2015). Zeinstra et al. (2009) and Domínguez et al. (2013) both examined the effects of choice out of two vegetables; either before or during the dinner, compared to no-choice (one type of vegetable) on 4-6 years old children's vegetable consumption. Domínguez et al. (2013) found that children who could choose between zucchini and green beans (either beforehand or during the dinner) consumed significantly more vegetables compared to children who could not choose and were served one of the two vegetables (Domínguez et al., 2013). In more detail, no differences in vegetable consumption were found between the different choice moments, beforehand or during the dinner (Domínguez et al., 2013). The research performed by Zeinstra et al. (2009) looked at carrots, peas, cauliflower, broccoli, red cabbage, beets, French beans, and spinach as vegetables of interest. However, as opposed to Domínguez et al. (2013), they found that children's vegetable consumption did not significantly differ between the choice conditions (Zeinstra et al., 2009). The fact that the study was conducted in a restaurant setting was mentioned as a possible reason why no significant results were observed in this study (Zeinstra et al., 2009).

Furthermore, Roe et al. (2013) investigated the effects of providing either three types of vegetables or fruits simultaneously, or just a single type of vegetable or fruit on vegetable and fruit intake among children aged 3-5 years old. The vegetables and fruits they looked at were sweet pepper, cucumber, tomato, apple, peach, and pineapple. Results indicated that serving a variety of three types of vegetables or fruits significantly increased the consumption of both vegetables and fruits by a mean of 31 grams (Roe et al., 2013). However, it should be taken into account that independently of the variety effect, the mean vegetable intake was substantially less than the mean fruit intake (Roe et al., 2013).

Finally, the effects of providing a mixture of a liked (peas) and either a neutrally liked (sugar snap) or a disliked vegetable (celery), as compared to serving only a neutrally liked vegetable (cauliflower) on children's vegetable intake were assessed by Olsen et al. (2012a). The results of their study showed that the vegetable intake levels were dependent on the vegetable serving condition. More specifically, children consumed significantly more of a neutrally liked vegetable when it was served together with a liked vegetable compared to when it was served alone or in combination with a disliked vegetable.
(Olsen et al., 2012b). For an overview of the studies looking into the influence of variety/choice on children's fruit and vegetable consumption, see Table 4.

In general, the available studies looking into the effects of variety on the intake of fruits and vegetables consistently show that children's intake increases when there is a variety or a choice of fruits and vegetables. In addition, the liking of the vegetables in the mixture appeared to be of influence, from a neutrally liked vegetable a greater amount was consumed when it was served alongside a liked vegetable compared to a disliked vegetable.

## Table 4: The effects of variety or choice on children's liking and intake of different kinds of vegetables.

| Authors + <br> Year | Country/Setting | Population | Design | Exposure | Type of Vegetable/Fruit | Main Findings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Bucher et al. (2014) | Switzerland | 100 children <br> (7-10 years old) | Between- <br> subjects <br> (groups) | A mix of two types of vegetables, or only one of the two vegetables | Carrots <br> Green beans | Children given the two-vegetable choice had a significantly higher energy served from vegetables (64 $\mathrm{kJ})$ compared to children who were offered only carrots ( 37 kJ ), or only green beans ( 38 kJ ). |
| De Wild et al. (2015) | The <br> Netherlands - <br> Day-care <br> Centers | 70 children <br> (2-5 years old) | Between- <br> subjects <br> (groups) | Two types of vegetables from which children could choose (also both possible), or only one type of vegetable present per dinner session | Peas, broccoli, French beans, cauliflower, and string beans | Choice group (two types of vegetables): vegetable intake $\uparrow$ compared to no-choice group (57,7 grams $-48,5$ grams, $p=0.09$ ) |
| Domínguez et al. (2013) | Spain - Primary Schools | 150 children <br> (4-6 years old) | Between- <br> subjects <br> (groups) | Choice out of two vegetables; either before dinner or during dinner (both served), or no choice and only one type of vegetable served | Zucchini Green beans | The conditions in which children could choose between two vegetables (either beforehand or not): vegetable intake $\uparrow$, compared to no-choice condition (approximately 45 grams - 20 grams, $\mathrm{p}<0.05$ ). |

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## Portion size

One of the most well-known findings in eating consumption research constitutes the observation that people tend to eat more when they have more food in front of them (Wansink, 2004). Furthermore, increasing portion size has been shown to promote intake in children in previous research in this area (Fisher, 2007; Fisher \& Kral, 2008). Although most of these studies did find these results for highly liked food, some evidence exists that these results could also apply to less palatable foods (Wansink \& Kim, 2005). This section will describe the studies which looked at the effects of portion size on children's intake of fruits and vegetables.

In a study conducted by Mathias et al. (2012), the same meal was served to children aged 4-6 years old across different days. However, alongside this meal varying portion sizes of fruits (peach) and vegetables (broccoli) were served as side dishes. These portion sizes were either 75 grams or 150 grams. The results showed significant increases in vegetable (37\%) and fruit (70\%) intake when portion sizes doubled (Mathias et al., 2012). Similar results were shown by Miller et al. (2015), in their research portion sizes of carrots, apple sauce, and orange slices were increased by about $50 \%$. When portion sizes were bigger, food and vegetable intake by children aged 5-11 years old was increased with 13 grams for carrots, with 42 grams for apple sauce, and with 16 grams for orange slices (Miller et al., 2015). A study performed by Kral \& Kabay (2010) found similar results for fruits when fruit side dishes (applesauce) were doubled in portion size (Kral \& Kabay, 2010). However, for vegetable side dishes (broccoli and carrots) there was no significant influence of the doubled portion size on the vegetable intake of children aged 5-6 years old.

Furthermore, van Kleef et al. (2015) examined the effects of portion size and unit size on the consumption of cucumber by children of 8-13 years old. In the large portion size condition, two-thirds of a cucumber was served to the children, whereas in the small portion size condition one-third of cucumber was served. The unit size conditions consisted out of the cucumber being served as one piece or cut into small pieces. The study showed that cucumber intake significantly increased by 54\% in the large portion size condition compared to the small portion size condition (Van Kleef et al., 2015). On the contrary no main effect of unit size or interaction effects were found in the study (Van Kleef et al., 2015). As mentioned previously in the section about serving order, Spill et al. (2010) and Spill et al. (2011b) investigated the effects of providing different portion sizes of vegetable servings in the first course with total vegetable intake during the entire meal in children aged 3-5 years old. Both these studies found that increasing the portion sizes of a vegetable serving (carrots, tomato soup) in the first course significantly increased total vegetable consumption (Spill et al., 2010, Spill et al., 2011b). This also indicates that children eat more vegetables when they are presented with bigger portion sizes of these vegetables.

Lastly, Smith et al. (2013) and McCrickerd et al. (2017) assessed whether portion sizes of a meal including vegetables did affect food and vegetable intake in children aged 2-6 years old. Both these studies show that serving larger portion sizes significantly increases food and vegetable intake among children (Smith et al., 2013; McCrickerd et al., 2017). However, it is important to mention that both of these studies conclude that the observed effect was dependent on the age of the children. In more detail, the older children (6 years old) were more responsive to the larger portion sizes than younger children (4 years old) who were non-responsive (McCrickerd et al., 2017), or even decreased their intake when served a large portion size compared to the reference (Smith et al., 2013). An overview of the main results of the studies looking into the effects of portion size on children's fruit and vegetable intake can be found in Table 5.

Summarizing, in most of the studies increasing the portion sizes of fruits and vegetables resulted in an increased intake of these foods by children. However, in a few studies no significant changes in vegetable consumption by children were found when portion sizes increased. These different findings could potentially be explained by the fact that the vegetables included and the age group of the participating children differed between the studies.

## Table 5: The effects of portion size on children's intake of different kinds of vegetables.

| Authors + <br> Year | Country/Setting | Population | Design | Exposure | Type of Vegetable/Fruit | Main Findings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Miller et al. (2015) | US - <br> Elementary School | Approximately 700 children (5-11 years old) | Withinsubjects | Increased portion size of about 50\% compared to normal (regular) portion sizes | Carrots (raw) <br> Apple sauce <br> Orange slices | Increase in portion size by 50\%: <br> Carrots intake $\uparrow$ ( 13 grams, mean change) <br> Apple sauce intake $\uparrow$ (42 grams) <br> Orange slices intake $\uparrow$ (16 grams) |
| Mathias et al. (2012) | US - Laboratory Setting | 30 children <br> (4-6 years old) | Withinsubjects | Same meal, with varied portion sizes of fruits ( 75 - 150 grams) and vegetables (75 grams 150 grams) side dishes | Peach Broccoli | When portion sizes doubled: <br> Vegetable intake 37\% 个 (12 grams, mean change) <br> Fruit intake 70\% 个 (41 grams) <br> Both significant: $p<0.01$. <br> No interaction effects. |
| Kral et al. (2010) | US | 43 children <br> (5-6 years old) | Crossover design | Doubled fruit and vegetables side dishes compared to normal (regular) portion sizes | Broccoli <br> Carrots <br> Apple sauce | Doubling the portion size of the side dishes: <br> Fruit intake $\uparrow(43 \%, \mathrm{p}=0.001)$ Vegetable intake $\leftrightarrow$ |
| Spill et al. (2010) | US - Day Care Center | 51 children <br> (3-5 years old) | Crossover design | Different portion sizes of carrots served in the first course (30, 60, and 90 grams) | Carrot (first course) Broccoli (main meal) | Total vegetable consumption for increasing portion sizes of carrots in first course: $\uparrow$ ( $p<0.001$ ) <br> Doubling the size of the first course increased carrot consumption by $47 \%$ (12 grams). The tripled portion |


| Spill et al. | US - Daycare | 72 children |
| :--- | :--- | :--- |
| (2011b) | Facilities | (3-5 years old) |


| Van Kleef et | The |
| :--- | :--- |
| al. (2015) | Netherlands - |
|  | Primary School |


| McCrickerd et | Singapore - |
| :--- | :--- |
| al. (2017) | Preschool |

## 255 children (8-13 years old)

## Crossover design

Portion size (large; twothirds of a cucumber, small; one-third of a cucumber) $x$ unit size (served in one piece; cut in pieces)

Within-
subject

Between
subjects
(groups)
(n

1) Meal with rice, vegetables and a protein

Normal lunch, with or
without a first course of 150,225 , or 300 grams of tomato soup. source. Either teacher's serving, self-serving, or

Tomato (first course)
Broccoli (main course) Apple sauce (main course) Cucumber

Mixed vegetables

Large portion size conditions: Cucumber intake 54\% 个 (139.4 grams - 90.4 grams, significant)

No main effect of unit size or interaction effects.
size did not further increase carrot intake.

Broccoli consumption not affected by the first course consisting of carrots, regardless of portion size.

Total vegetable and soup intake by increasing the portion sizes: $\uparrow$ (300 grams of soup: 128,9 grams, 150 grams of soup: 108,8 grams, p < 0.001).

Broccoli intake of main course not affected by the varying first course tomato soup portion sizes

Serving size and intake was similar across teacher's serving and selfserving conditions.

| Smith et al. | China - <br> Kindergarten | 173 children <br> (2013) | Crossover <br> design | Small/reference/large <br> portion of a meal <br> consisting of rice, | Mixed <br> vegetables |
| :--- | :--- | :--- | :--- | :--- | :--- |

## Other promising strategies to promote vegetable intake in children

As many other studies which are somewhat related to the topic have aimed to increase children's vegetable intake in the past, this section will describe some other promising strategies involving aspects to increase children's intake of these healthy foods.

First of all, a study performed by Spill et al. (2011a) examined the effects of incorporating puréed vegetables into entrées on the consumption of food and vegetables in children aged 3-5 years old. Their main idea was to decrease relative energy density of the meal to $85 \%$ or $75 \%$ of the standard dish, and children were not aware of these modifications. The vegetables included zucchini, cauliflower, broccoli, tomatoes, and squash. Results of the study indicated that children significantly increased their daily vegetable intake by 52 grams in the $85 \%$ energy density condition, and by 73 grams in the $75 \%$ energy density condition compared to the standard dish condition (Spill et al., 2011a). In addition, the intake of more vegetables in the entrées did not affect the intake of vegetables in the main meals (Spill et al., 2011a). This illustrates that children's vegetable consumption can be (unconsciously) increased by incorporating some form of puréed vegetables into dishes.

Furthermore, a study conducted by Rioux et al. (2018) investigated the influence of visual exposure to placemats with pictures of five unfamiliar vegetables in either one or four different atypical colour(s) on children's ( $3-6$ years old) vegetable intake during lunch in a cafeteria. In addition, a condition was present in which the placemat did not contain vegetable pictures but pictures of stones. The researchers found that children who were exposed to placemats with vegetables increased their consumption of exposed and non-exposed vegetables after the intervention period (Rioux et al., 2018). This indicates that next to the design of the plate, also the design of the placemat could potentially influence children's vegetable liking and intake. However, the condition where vegetables on the placemat were shown in four different atypical colours was not proven to be more effective than the placemat where the vegetables were shown in one colour (Rioux et al., 2018).

Marketing strategies have used characters to promote increased consumption of foods (healthy and unhealthy). There characters are presented in packaging, canteens, advertisements, etc. In a study, researchers worked with 10 elementary school cafeterias to study the impact marketing media using branded vegetable characters have on vegetable uptake, and if boys and girls respond differently to the media. The characters shown in the branded media are vegetables with human attributes such as arms, legs, and a mouth, as well as super-human strength. Compared to conditions where the characters were not present, children ate significantly more vegetables (Hanks, Just, \& Brumberg, 2016; see also Upton, Upton, \& Taylor, 2013). In addition, a systematic review of 11 experimental scientific studies (Kraak \& Story, 2015) that examined the influence of media characters on children's diet-related cognitive, behavioral, and health outcomes found that: 1) Media characters can be used as a promising strategy to increase children's preference, choice, and intake of fruits and vegetables compared to not using characters for branding. 2) Even an unfamiliar cartoon character may increase children's appetite and preference for healthy foods compared to not using a cartoon character at all.

It is also well known that food that is more easily accessible tends to be picked more (Maas, de Ridder, de Vet, de Wit, 2012). "Choice architecture refers to strategic changes in the environment that are anticipated to alter people's behaviour in a predictable way, without forbidding any options or significantly changing their economic incentives" (Bucher et al., 2016). An example of such strategies is to position certain (healthy) foods in a more accessible and available way, to increase their "appeal" to consumers and facilitating their choice. Applying this principle to plate design, placing the vegetables closer to the child would potentially increase their consumption, or at least not decrease it
compared to when placed further away and not so "easily accessible". Elder and Krishna (2012) also showed that in an advertisement, how a product is displayed can result in less or more mental simulation of using the product and consequently affect purchase intention. They demonstrated this with a mug: the handle on the right (versus left) resulted in greater mental simulation and higher purchase intention for right-handed people.

Finally, Nekitsing et al. (2019) studied the effects of providing children (2-5 years old) with a (in)congruent storybook and/or (in)congruent sensory play on their vegetable (celeriac) intake. The storybook included a narrative with either a celeriac (congruent) or a carrot (incongruent) as main character, whereas the sensory play was with the (in)congruent vegetable and included all the senses. The results showed that a congruent story book and sensory play increased children's odds of eating and the intake of celeriac compared to children in the incongruent conditions (Nekitsing et al., 2019). However, the differences between the individual conditions were only small (Nekitsing et al., 2019). An overview of the main findings of the discussed studies is shown in Table 6.

Table 6: Other promising strategies involving sensory aspects to increase children's intake of different kinds of vegetables.

| Authors + <br> Year | Country/Setting | Population | Design | Exposure | Type of Vegetable/Fruit | Main Findings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Spill et al.(2011a) | US - Preschool | 40 children <br> (3-5 years old) | Crossover design | Incorporation of puréed vegetables into entrées to reduce their relative energy density (ED) to $85 \%$ or $75 \%$ of the standard dish | Zucchini <br> Cauliflower <br> Broccoli <br> Tomatoes Squash | Daily vegetable intake compared to standard dish condition: <br> 85\% ED: 50\% 个 (52 grams) <br> 75\% ED: 73\% 个 (73 grams) <br> $p$-values < 0.001. |
|  |  |  |  |  |  | The consumption of more vegetables in the entrées did not influence the intake of vegetable side dishes in the main meals. |
| Rioux et al. (2018) | France Preschools | 70 children <br> (3-6 years old) | Between- <br> subjects <br> (groups) | Placemats with pictures of five unfamiliar vegetables in one or four different atypical colours, or with no vegetable pictures (but stones) during lunch in a cafeteria | Mixed vegetables | Placemats with vegetables on them: consumption of vegetables (on average): $\uparrow$ <br> However, the intervention where vegetables were shown in four different colours was no more effective than just the one colour of vegetables. |
| Nekitsing et al. (2019) | UK - Preschools | 337 children <br> (2-5 years old) | Between- <br> subjects <br> (group) | Storybook with <br> (in)congruent vegetable as main character. Also, sensory play including all senses (with vegetable) | Celeriac | Congruent storybook and congruent sensory play increased the odds of eating celeriac compared to incongruent condition. However, the differences were small. |

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