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How neutral coloured backgrounds affect the attractiveness and expensiveness of fresh produce

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ABSTRACT

The colour of the background on which products are presented may affect their perceived attractiveness. In order to find out on which type of background various fresh food products look most attractive, we presented five different vegetables (tomato, carrot, yellow bell pepper, eggplant, mushroom) on five different backgrounds with neutral grey colours varying in degree of blackness: 5, 30, 50, 65, and 90%. Forty-six participants provided colour matches for the vegetables and evaluated them on 10 attributes.

Overall, the blackness of the backgrounds had little or no effect on the perceived colour of the vegetable. Only for carrots we found a small but significant difference, mainly between the 5% and 90% blackness backgrounds. On the darkest background, the carrot would be perceived as a bit lighter, more saturated, and more yellow rather than red, compared to the lightest background.

Differences in perceived attractiveness on the grey backgrounds varied between 0.3 and 1.0 units on a 9-point scale. Attractiveness and expensiveness ratings for most vegetables were highest on the 90% blackness background. In comparison to our previous study where we presented vegetables on hued backgrounds, differences between mean attractiveness ratings were smaller. Because mean attractiveness ratings in the current study were higher, we expect that grey backgrounds are more likely to present vegetable assortments with a variety of hues in an attractive way than hued backgrounds.

1. Introduction

In order to stimulate the sales of fresh produce in retail stores, it is salient that vendors present them in an attractive and appetizing manner. One important aspect of attractive presentation concerns the colour of the materials on which products are presented. In a previous study, results showed that cool, warm, light and dark, orange and blue hued backgrounds were not suitable to present vegetables with different colours in an optimal fashion. In fact, backgrounds that optimally paired with a particular vegetable colour differed substantially between vegetables species (Schifferstein, Howell, & Pont, 2017). In the present study, we continue our search for a background colour or a mechanism that can predict how a variety of vegetables can be presented in an attractive, optimized way.

Appropriateness of colour application for achieving a specific goal such as increased attractiveness or preference has shown to be both dependent on the nature of the object and the context in which it is presented and such effects can be difficult to predict. First of all, although exact colour preferences may differ between individuals, they have been shown to be highly product-specific. This is already the case for many kinds of industrial products for which colours may be chosen arbitrarily (Holmes & Buchanan, 1984; Siple & Springer, 1983), and it is certainly the case for unprocessed agricultural products, where products colours may serve as indicators of freshness, ripeness and decay that all relate to the product's sensory properties, safety and nutritional quality (De Groote & Kimenju, 2008; Lee, Lee, Lee, & Song, 2013; Schifferstein, Wehrle, & Carbon, 2019).

Furthermore, the attractiveness of products is influenced by the backgrounds on which they are presented and the context in which they occur (Howell, Marin, & Kook, 2014). In this case, the mechanisms by which background affects product attractiveness is also dependent on the characteristics of the product displayed. Mechanisms operating with 2D stimuli do not seem to apply to 3D objects. For instance, a study on cool and warm hue preferences in 2D stimuli reported that all foreground colours were liked when presented on a cool coloured background, while only the cool figure colours were liked when presented on a warm coloured background (Schloss & Palmer, 2011). When we tried to replicate these findings in a more realistic setting with

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vegetables presented on blue and orange backgrounds, these expected outcomes were fragmented into a variety of preferred hue combinations. Some of the discrepancies may be due to the occurrence of interreflections between 3D objects and their background, an effect that might even be larger if the objects were presented in a box painted in the background colour (Schifferstein et al., 2017).

Other studies have shown that background colours can also affect the perceived taste properties of the products presented. For instance, serving popcorn from red, blue, green and white bowls influenced the perceived saltiness and sweetness of the popcorn. Salty popcorn was rated sweeter when taken from a blue or red coloured bowl, while sweet popcorn was rated saltier when taken from a blue bowl (Harrar, Piqueras-Fiszman, & Spence, 2011). A restaurant-oriented study found that lighter coloured desserts tasted sweeter when served on white plates, while darker coloured desserts tasted sweeter when paired with black plates (Piqueras-Fiszman, Alcaide, Roura, & Spence, 2012). Hence, it is understood that colour can also exert significant influence on how foods are perceived. Researchers suggest that these effects on product attractiveness and product perception cannot be explained solely in terms of colour contrast and suggest further studies to understand these phenomena (Adams, 2013; Harrar et al., 2011; Piqueras-Fiszman et al., 2012; Piqueras-Fiszman, Giboreau, & Spence, 2013).

To understand colour preferences and the mechanisms that affect them, it is important to understand the basic mechanisms of colour perception. Understanding colour preferences is complex, as is the human visual system. Physiological and cognitive processes collaborate, in ways not yet fully understood, to enable colour vision. In 1878 Hering observed that colour perceptions could not be simultaneously yellowish and blueish or reddish and greenish (see Hering, 1964). Therefore, he posited that humans have four fundamental colour perceptions: red, green, blue and yellow. The colour pairs red-green and yellow-blue are called opponent colours, currently known as complementary colours. He also defined a third opponent pair – black and white – and found that they could veil or influence perceptions of the four fundamental hues (Kuehni & Schwarz, 2008).

Hering's theory aligns with the contemporary physiological understanding of human colour vision, which depends on three classes of chromatic receptors, the short (S), medium (M), and long (L) wavelength-sensitive cones. These cones convert wavelengths into neural signals that travel through the optic nerve to the brain's primary visual cortex. These neural signals are processed into three colour-opponent channels designated red-green, yellow-blue (chromatic channels), and black-white (lightness channel), which enables colour vision. Interestingly, while each cone class is tuned to receive certain wavelengths (S, M, L) all cones, no matter the class, read lightness or black and white (Ware, 2008). In the black and white channel, the difference between stimulus perceptions is called blackness, lightness or brightness contrast. In the red-green and yellow-blue colour channels, this is called chromatic contrast. That all channels register luminance differences enables people to see considerably more detail in black and white and conversely considerably less detail where differences are purely chromatic.

The eye consists of two different types of light energy receptors, cones as discussed above, and rods. Rods are low light receptors that operate at lower visible wavelengths than cones do and cannot mediate colour vision. In contemporary artificially lit society rods are rarely utilized. Colour vision relies solely on cones to convert light energy into neural signals, which enable full chromatic perception (Ware, 2008).

If we want to understand how context may affect the perception of focal objects, it is important to realize that the visual distinctness of colour is controlled as much by the characteristics of the environment as it is by the object itself. Colour studies often present colour swatches on backgrounds of neutral grey. Neutral grey is considered a characterless, indifferent, achromatic colour, of which the perceived colour can be easily influenced by contrasting shade and hue (Itten, 1970), while having little to no colour effect on neighbouring colours. To accurately assess a hue's distinctness, it would be prudent to isolate the colour with a neutral grey border (Ware, 2008). Artists and designers have demonstrated that coloured and neutral line work between unique hues in a composition reduces the effects of simultaneous contrast or the perceived influence adjacent hues have on each other. Also, outlining an area of colour with black tends to deepen it, making it richer and more jewel-like (Feisner & Reed, 2014).

In order for objects to stand out against their background, it is important that their colour contrasts with that of the background. For instance, type legibility has long been shown to be most effective when the lettering colour is in strong contrast with the background colour. Researchers have also shown that colour viewed against backgrounds with strongly contrasting hues are perceived as more saturated than when they are viewed against a background with similar hues (Lotto & Purves, 2000). Furthermore, objects appear more vivid and richly coloured against low-contrast, grey surroundings over high-contrast multi-coloured surroundings (Brown & MacLeod, 1997).

However, contrast not only determines whether the object stands out and its colour becomes more vivid, but it can also have an effect on its attractiveness. Helson and Lansford (1970) asked participants to rate the pleasantness of 125 colour samples that were presented on 25 coloured backgrounds in five sources of illumination. In this study, the white background turned out to generate the highest mean pleasantness ratings for the 125 foreground colours in 4 out of 5 sources of illumination. The overall mean pleasantness rating for the samples on the white background was 6.24 on a 9-point scale. Other background colours on which the colour samples looked good were either very light or very dark, and mostly had low saturation. The samples presented on the black and grey backgrounds in this study obtained a mean rating of 5.89 and 5.86, respectively, which were among the ten best performing backgrounds. From evaluating individual foreground-background pairs the authors concluded that the principle factor determining the pleasantness of the colour samples was the amount of brightness contrast: The most pleasant combinations involved large brightness differences between colour sample and background, whereas the least pleasant combinations involved little or no difference.

Our previous study (Schifferstein et al., 2017) focused on chromatic contrasts between hued vegetables and their hued backgrounds with limited success. Based on the discussion above, we believe that focusing on blackness contrast is more likely to yield a mechanism which can reliably predict attractiveness ratings for the presented vegetables. According to the blackness contrast hypothesis, we expect to find the lowest attractiveness ratings when vegetables are presented on backgrounds that exactly match their own blackness values. The larger the difference between the blackness values of the vegetable and its background, the larger the attractiveness rating will be.

Reynolds-McIlnay, Morrin, and Nordfält (2017) studied the relevance of brightness contrast in a retail environment by showing three stacks of towels (about 24, 55 and 91% brightness) on various grey backgrounds (26, 50 and 82% brightness). They found that products were chosen more often when their brightness levels contrasted more with those of the environment if the products were neatly displayed. Possibly, there is a direct relationship between the degree to which objects stand out and their attractiveness. Marketing studies have pointed out that objects to which shoppers devote more visual attention are preferred and more likely to be chosen (Milosavljevic, Navalpakkam, Koch, & Rangel, 2012).

The present study focuses on how respondents perceive vegetable attractiveness when placed on grey backgrounds. It exchanges the coloured backgrounds of the previous study for a range of grey backgrounds while keeping the assessment methods nearly identical. Furthermore, in the present study we do not only look at the attractiveness of the focal object (the vegetable), but since our context is situated in a marketing environment, we also look at the effects on the perceived expensiveness and premiumness of the vegetable in relation to their attractiveness values. Expensiveness is defined as the ability of

an artefact to "command a high price that is not based on its intrinsic worth". Premiumness is defined as "a value in excess of what is normally or usually expected". Attractiveness is defined as "arousing interest or pleasure" (Merriam-Webster, 2004).

Food marketers are increasingly aiming at product advantage and influence in consumer choice by optimizing product appearance. Colour communicates quality, aesthetic, symbolic and category values (Creusen & Schoormans, 2005) and is an important attribute of a product's visual equity, which can be defined as the value derived from a product's visual elements (Bottomley & Doyle, 2006). Product colour is recognized as the silent salesman that attracts attention and transmits product-specific messaging that defines premiumness (Mastropietro von Rautenkrantz, 2016). In particular, the colour black has been associated with expensive, high quality, trustworthy, luxurious and elegant attributes in various contexts (Amsteus, Al-Shaaban, Wallin, & Sjöqvist, 2015). Incorporating expensiveness ratings into the study will hopefully expose insights into how blackness values affect consumer perceptions of vegetables in terms of their premiumness (Lyons & Wien, 2018; Mastropietro von Rautenkrantz, 2016).

The present study will explore how various light to dark neutral grey backgrounds may assist retailers in presenting a range of vegetables in an attractive and appetizing manner. We predict that:

Hypothesis 1 –The perception of vegetable colours will not be significantly influenced by the vegetable's proximity to neutral grey background colours on which they are placed.
Hypothesis 2 – Vegetable colours with blackness measurements that are increasingly similar to the blackness measurements of the backgrounds colours will be perceived as the least attractive.
Hypothesis 3 – Vegetable colours with blackness measurements that have increasingly greater differences to the blackness measurements of the background colours will be perceived as more attractive.

2. Method

The experimental procedures followed here are described in detail in the previous study (Schifferstein et al., 2017). Important deviations are described below.

2.1. Participants

Forty-six volunteers, 22 females and 24 males, participated in the study. The females varied in age between 18 and 24, with a mean age of 21.2 years. The males varied in age from 18 to 26, with a mean age of 21.8 years. Participants were informed that they would perform a colour vision test and subsequently be asked to match the colour of five vegetables with different colour swatches and then provide attractiveness responses to those same vegetables in different colour contexts. Only a couple of them (< 10%) had participated in the previous study. All respondents were undergraduate students of Brigham Young University (BYU), with the majority studying industrial design (41%), life sciences (15%), or engineering (9%). All participants were screened privately for colour vision deficiencies using a printed Ishihara test. All participants, including those asked to withdraw due to colour deficiency, received slices of pizza as compensation after the study. The experiment was approved by the BYU Institutional Review Board (IRB) for Human Subjects (study number E15416).

2.2. Stimuli

The study was performed with five different vegetables, each in a different colour: mushroom (white), bell pepper (yellow), carrot (orange), tomato (red) and eggplant (purple). These products were chosen, because they were prototypical examples of vegetables that included a broad range of hue and lightness values, had similar smooth skin textures, and fairly homogeneous colours over their whole surface. The five chosen vegetables correlated with a range of neutral grey lightness values varying from very light (mushroom) to very dark (eggplant). The dark cucumber from the previous study was replaced with a light grey white mushroom to enable a full complement of blackness contrasts.

One sample of each vegetable was used in all tests over three days of testing. The samples were purchased the day the study began and were kept refrigerated before and after each session. All vegetables remained visually fresh and consistent in appearance, except perhaps for the carrot, which showed some minor traces of dryness after the second day. Because all statistical tests involved within-participant comparisons, we assume that any possibly observable change in appearance would have affected the ratings in all conditions to the same degree.

Participants were asked to report on how often they ate the vegetables used in the study (rarely or never, 1–2 times per month, 1–2 times per week, 3–4 times per week, or daily). These responses were converted to a weekly average indicating that mushrooms were eaten 0.4 times per week, yellow peppers 0.6 times, carrots 1.6 times, tomatoes 1.0 times and eggplant 0.1 times per week. Participants were also asked to rate how much they liked the taste of the study vegetables on a scale of 1 "don't like" to 9 "like very much". On average, the mushrooms were rated 5.3, yellow peppers 6.5, orange carrots 6.8, and tomatoes 6.2. The eggplant was the least liked at 4.2. These data indicate that all vegetables used in the study are fairly familiar to most participants, except perhaps for the eggplant, which was not particularly liked and consumed only occasionally.

The Natural Colour System (NCS) is a logical, perception-based colour notation system that describes colour by hue, blackness and chromaticness values (Hård & Sivik, 1981). Pages from the NCS colour atlas were used to standardize assessments of stimuli. To determine the approximate NCS colour matches of the five vegetables, three designers assessed NCS colour swatches held in close proximity to the vegetables under the same lighting situation as the final experiment. They varied the comparison location over the sample considering colour variations caused by reflection. After stepping back and forth through the swatches, the best hue page match was determined for each vegetable. The hue page selections made for the study consisted of: C = 00/C = 02-mushroom, Y10R – bell pepper, Y50R – carrot, Y80R – tomato, and R – eggplant.

2.3. Backgrounds

In the process of selecting the five background colours, each vegetable was photographed using lamps specified at 30 W with a colour-rendering index of 90+ and a colour temperature of 5500 K. The lamps were standard E26 size screw sockets and mounted close together in a group of five inside a fabric light box with translucent white front covers. Each vegetable was photographed at the same distance and angle.

Adobe Photoshop CC version 2017.1.1 was used to convert the colour images to greyscale using a "custom proof" setup used in high quality printing, because the designers determined this setup to be more visually accurate than using either the "black and white" or "desaturate" tools more commonly used to convert colour images to grey scale. For "device to simulate" we selected "working grey – dot gain, 20% proof condition" and for "rendering intent" we selected "relative colorimetric", which is the standard rendering intent for printing in North America and Europe.

To collect blackness percentages for each vegetable colour the Photoshop "eye dropper" tool, scaled to a "5 by 5 average" sample size was used. "5 by 5" was selected to increase precision on the thinner vegetables and to identify accurately when the tool was reading either reflections or shadows. Blackness percentages were measured by clicking the eye dropper tool between the two light box reflections on spherical vegetables and to the left and right of the highlight on tubular vegetables. Readings were taken around the highlights to understand what pixels represented reflections or shadows and what best

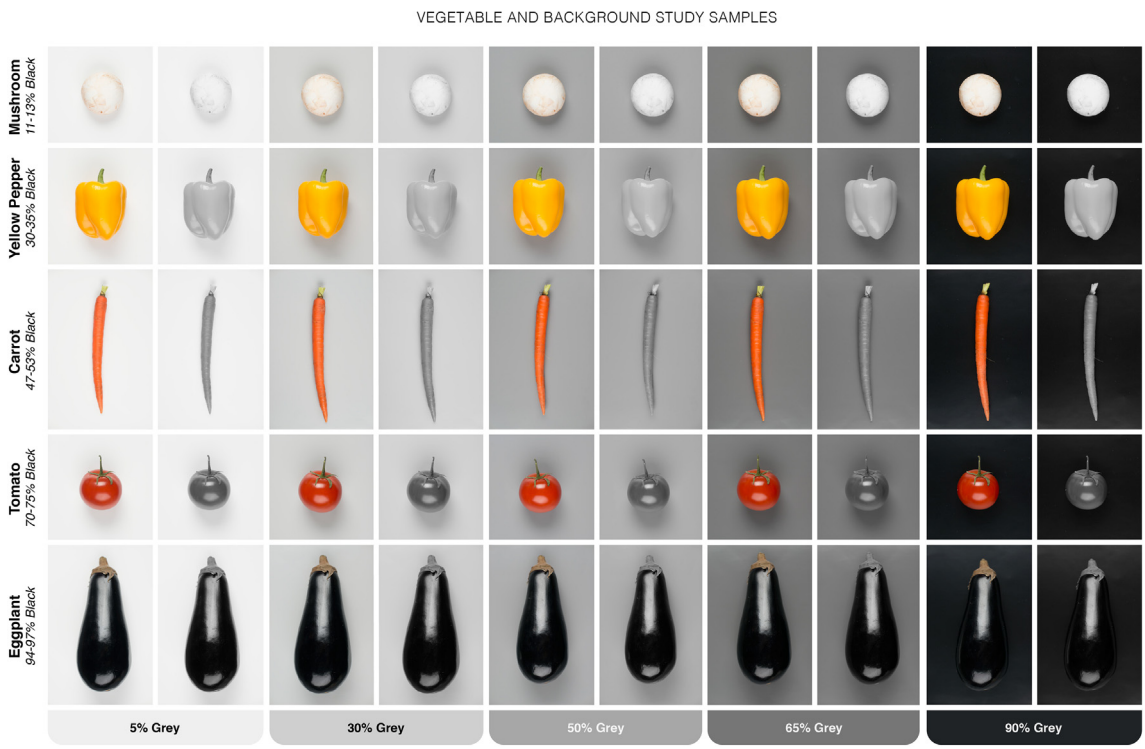

Fig. 1. Images of all 25 vegetable and background pairings. Shown in colour on the left and black & white on the right of each column.

represented the vegetable colour.

The mushroom measured between 7 and 11% blackness, the yellow pepper between 30 and 35%, the carrot between 47 and 53%, the tomato between 70 and 75%, and the eggplant between 94 and 97% blackness. The five NCS A4 paper colour samples were also measured using the method outlined above to understand the difference between Photoshop and NCS blackness values. The Photoshop blackness values measured 3–4% higher than NCS values.

The background colours selected for this study approximately aligned with the vegetable blackness measurements. These were NCS samples S 0500-N or 5% blackness to align with the mushroom, S 3000-N or 30% grey aligned with the bell pepper, S 5000-N or 50% grey aligned with the carrot, S 6500-N or 65% grey aligned with the tomato and S 9000-N or 90% grey aligned with the eggplant (see Fig. 1). Ideally, we would have liked to make perfect matches, but this was not possible because of difficulty in accurately measuring blackness levels on spherical and tubular translucent skinned vegetables using standard Photoshop tools, the innate blackness specification differences between NCS and Photoshop technologies, and limitations in the number of NCS colours available. As a consequence, the viewer may perceive differences in blackness levels between vegetable and their background match. What further complicates the comparison is that vegetables are 3D and produce highlights and shadows, while the background is 2D without any details. As a consequence, a strong visual border with a product shadow occurs between the vegetable and its background. These highlights, shadows and borders make it difficult to determine visually whether the blackness of vegetable and background are the same.

2.4. Procedure

The experimental study was conducted in a darkened room on BYU campus with blacked out windows and no peripheral lighting. The only light sources were artificial lights setup in the testing cubicles which measured at 1150 lm at the centre of the booth. One sample of each vegetable was presented on a semi-matte A4 NCS paper, placed against the back wall of the viewing booth at a distance of about 50–60 cm. Participants were instructed to only look at the samples without touching either the vegetables, the background or the hue pages. Complete cubicle and luminance details can be found in Schifferstein et al. (2017).

Sessions were conducted in nine groups of four or five participants simultaneously over three days. Each session consisted of five rounds of a colour matching task that were alternated with five rounds of a product evaluation task. In each round all five products were evaluated. Whether the session started with a colour matching task or a product evaluation task was determined by chance. In addition, the sequence of the five background colours within each task was determined by chance and was different for each group of participants.

2.4.1. Colour matching

In the colour matching task, it was determined whether potential changes in product attractiveness were based on shifts in a vegetable's perceived colour. Vegetable samples were presented on semi-matte A4 NCS paper backgrounds and respondents were asked to identify the colour that best represented the colour of the vegetable from any of the designated NCS swatch pages.

Each vegetable, except the mushroom, had three NCS atlas pages to choose from. On each of these pages, the approximately 50 unique colour swatches exhibit many variations in blackness and chromaticness, but the hue is constant. One was the matching colour page, as determined by the designer's judgment, and two were adjacent hue pages. The bell pepper was presented with hue pages Y, Y10R (target page) and Y20R, the carrot with Y40R, Y50R (target page) and Y60R, the tomato with Y70R, Y80R (target page) and Y90R, and the eggplant with R (a pure hue and the target page), R10B, and R20B. With the mushroom sample only one page of grey colour swatches, labelled C = 00/C = 02, was presented. This page had a different legend style than the hue pages, because the NCS atlas deals with neutral and subtle greys in a different way. All 71 NCS grey swatches are included on this single page. The swatches labelled C = 00 are the neutral greys, which start at 5% light grey and step up in 5% increments to 90% dark grey.

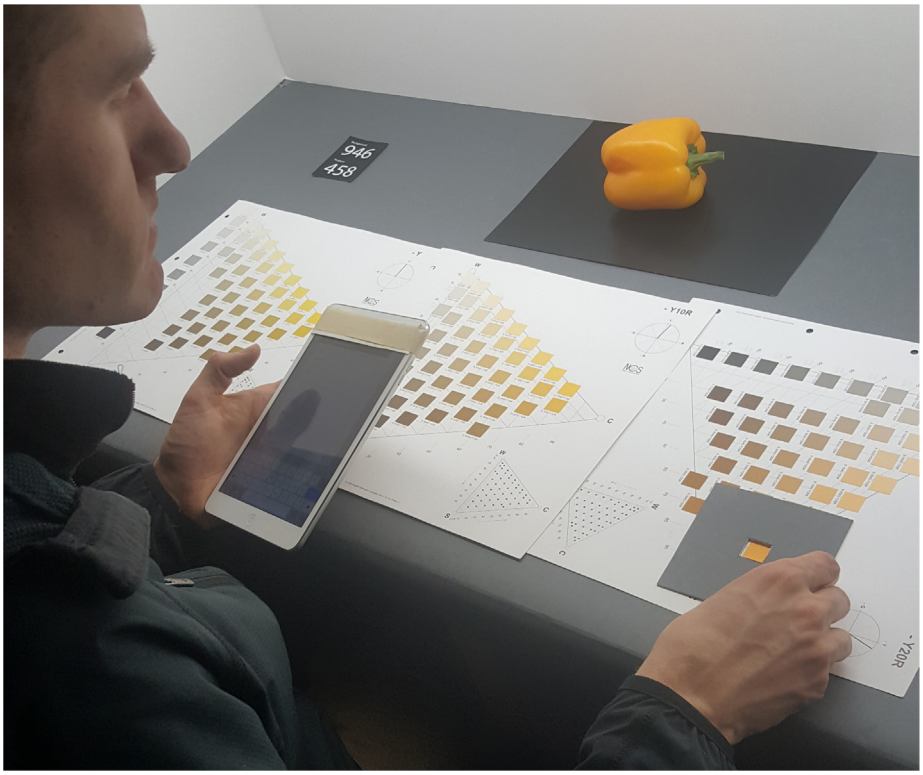

Fig. 2. Participant using the mask to isolate a colour sample during the colour assessment task.

The swatches labelled C = 02 are tinted greys including the pure hues of yellow (Y), red (R), blue (B) and green (G) as well as the mixed hues of Y50R, R50B, B50G, G50Y. The NCS pages were presented to the participants in different orientations for each sample and participants were not allowed to adjust or move them during assessment.

Participants were provided with a 10 × 10 cm NCS S 6500N (65%) grey coloured hand-held mask with a 1.8 × 1.8 cm square hole through the centre of the mask that could be put on the NCS forms to view each colour sample swatch in isolation from other swatches (Fig. 2). This mask matched the grey colour of the cubicle's presentation and working surface. Participants were asked to input the NCS colour code of the matching colour in a Google form displayed on an iPad Mini 2 with a 7.9″, 2048 × 1536 LED backlit display. The Google forms were designed with an S 1000N (10%) grey background and S 5500N (55%) grey instruction header areas with white text. The form response areas were white background with S 5500N text. The iPad's backlights were set low in order to minimize possible interference during the assessment. Participants were instructed to hold the iPads parallel to the table top and away from both the vegetable sample and the hue pages as they input their results. This minimized the chance of participants partially blocking their view of the samples or creating reflectance that might inadvertently influence participant judgements. Participants were asked to complete their assessments within 45 s before they advanced to the next cubicle and sample. This timing was established to allow each respondent enough time to complete the task, but also allow follow-on sessions to occur as scheduled. As participants became familiar with the process, they typically completed their assessments in less than 45 s.

2.4.2. Product evaluation

In the product evaluation task, vegetable samples were again presented on semi-matte A4 NCS paper backgrounds. Respondents were asked to judge the attractiveness of the produce samples by ticking a box for each of the response scales listed on the Google form. The response scales measured the degree to which the vegetable sample looked appetizing, healthy, fresh, natural, beautiful, tasty, attractive, expensive, vibrant and vivid on a 9-point scale anchored with end points of 'Not at all' (1) and 'Very' (9). The study plan allowed 80 s to evaluate each sample. As participants became familiar with the process they typically completed their assessments in under 60 s.

After participants evaluated a sample in either the colour matching or product evaluation task, they would then advance, with their assigned iPad, to the adjacent cubicle and assess a new sample. Participants repeated this until all five produce and background pairings were evaluated. During a single round, all five vegetables were presented on the same background colour. After completing each round, participants were requested to stand back from the cubicles while the assistants placed the next round of stimuli in the cubicles and the process would repeat.

2.5. Data analysis

Colour assessments were recorded as NCS codes, which consist of a percentage value for lightness or blackness (from white to black), for chromaticness (from desaturated to saturated), and for hue (selected from the segmented yellow, red, blue, and green colour wheel). These three percentage values were analysed in a doubly multivariate ANOVA with repeated measures for Products and Backgrounds in IBM SPSS version 22. Although the hue percentage values refer to the balance between different hues for different products, this does not hinder demonstrating whether background colour affects the perception of the hue for the various products as the MANOVA accounts for the interdependence between the dependent measures. We used F-values corresponding to Wilks' Lambda to evaluate multivariate effects.

The ratings on the ten product evaluation response scales were also analysed by doubly multivariate ANOVA, following the procedure described above. In case of significant effects in the multivariate analysis, subsequent repeated measures ANOVAs were performed for single response scales. In these analyses the degrees of freedom were corrected with the Greenhouse-Geisser ε if $\varepsilon < 0.7$, and the ε values were averaged from Greenhouse-Geisser and Huynh-Feldt when $\varepsilon > 0.7$ in

accordance with Stevens (2002). Differences between individual stimuli were investigated by a posteriori t-tests with Bonferroni adjustment. To compare the differences between backgrounds for separate vegetables, we also performed repeated measures analyses on single response scales for each vegetable, using the same correction of degrees of freedom and adjustment for multiple comparisons. We used $p = 0.05$ as cut-off value in tests of statistical significance.

3. Results

3.1. Colour matching

In the analysis of the colour matching data, the responses of three participants were deleted, because they had missing data for 10 or more samples. Any other missing responses were supplemented by filling in the mean of the other respondents' responses (5 responses). Hence, these analyses were performed on data of 43 participants.

The multivariate tests of the three percentage values describing the NCS-matched colours showed a significant main effect for Vegetable [$F(12,418) = 3273.7$, $p < 0.001$, $\eta^2 = 0.98$], for Background [$F(12,418) = 2.6$, $p < 0.01$, $\eta^2 = 0.06$] and for the Vegetable × Background interaction [$F(48,1898) = 2.1$, $p < 0.001$, $\eta^2 = 0.05$]. Hence, although the sizes for the effects of the backgrounds are quite small, they are statistically significant.

To investigate these effects further, MANOVAs were performed for each vegetable separately with Background as the only within-subjects variable. A consistent Background main effect in the multivariate tests was found only for carrots [$F(12,418) = 4.5$, $p < 0.001$, $\eta^2 = 0.10$], with significant effects for each of the three colour dimensions blackness [$F(4,160) = 4.5$, $p < 0.001$, $\eta^2 = 0.10$], chromaticness [$F(4,160) = 3.3$, $p < 0.05$, $\eta^2 = 0.08$], and hue [$F(3.1, 123) = 4.6$, $p < 0.01$, $\eta^2 = 0.10$]. These perceived colour differences are very subtle and seem to distinguish mainly the carrots presented on the backgrounds with the highest and lowest blackness values. On the lightest background (5%), the estimated perceived colour would be 9.3 (blackness) 70.5 (chromaticness) Y57.6R (hue), whereas on the darkest background (90%) the estimate would be 6.8 (blackness) 72.7 (chromaticness) and Y52.7R (hue) (see Fig. 3). Hence, on the darkest background, the carrot would be perceived as a bit lighter, more saturated, and have an increase of yellow. The mean value on the three intermediate backgrounds is very close and can be approximated by 7.6 (blackness), 68.6(chromaticness), Y55.6R (hue). While the carrot alone shows a minor effect, the first hypothesis that neutral grey backgrounds would have little effect on the perceived vegetable colours is sustainable.

Because the effects of backgrounds on the perceived colours were either negligible or very small, the perception data were aggregated over the backgrounds and the frequencies with which the various colour swatches were selected was determined. Fig. 4 shows an overview of the colour swatches that were chosen most often for each vegetable in the present study and compares these outcomes to the findings in the previous study. It shows that colour matches in the two studies were quite similar for some vegetables (bell pepper, carrot), but differ substantially for others (tomato, eggplant).

Fig. 3. The nearest NCS colours showing how the different backgrounds influence the perceived carrot colours. The left shows the carrot colour as perceived on the 5% grey background while the right shows the same on the 90% grey background.

3.2. Product evaluations

Participant responses to nine of the ten response scales on the questionnaire were generally highly correlated. The expensiveness responses seemed to follow a different pattern and will be assessed independently below. Principal components analysis of the nine scales yielded a single factor with an Eigenvalue > 1, with this single factor explaining 67% of total variance. This outcome suggests that the response scales tend to measure a single underlying construct. The attribute that loaded highest on this factor was the attractiveness item (0.88). Therefore, we decided to present the analyses here only for this item as the outcomes for the other items are highly similar. Repeated measures ANOVA for the attractiveness ratings showed significant main effects for Product [$F(3.3, 134.0) = 24.5$, $p < 0.001$, $\eta^2 = 0.38$], Background colour [$F(4, 160) = 4.0$, $p < 0.01$, $\eta^2 = 0.09$] and Product × Background interaction [$F(10.0, 399.2) = 3.0$, $p < 0.001$, $\eta^2 = 0.07$].

According to the blackness contrast hypothesis, it was expected that the highest attractiveness ratings would be obtained for vegetables presented on backgrounds whose blackness values are furthest away from the vegetables' own blackness values. For example, the darker vegetables should perform best on the 5% blackness background, while the lighter vegetables should perform best on the 90% blackness background.

Fig. 5 shows the marginal means for the attractiveness ratings of the different background–vegetable combinations. Overall, changes in attractiveness on the grey backgrounds varying in blackness value were relatively small and did not show a consistent pattern of increased or decreased ratings, which contradicted our second and third hypotheses. Although the attractiveness for mushrooms seemed to increase consistently with darkening of the background, we did not see the opposite pattern for the eggplant, which was the vegetable with the darkest colour. For carrots, tomatoes, bell peppers, and mushrooms attractiveness ratings appeared to be highest for the darkest background, but ratings were generally not increased on the lightest background.

The post hoc test comparing the aggregated means for the five backgrounds provided the highest mean for the 90% background (6.7), but the difference was only significant with the 50% background (6.1). In analyses per individual vegetable, differences between backgrounds did not reach significance for the bell pepper and the eggplant [F-test, both $p > 0.09$]. For the carrot, the attractiveness on 90% blackness was significantly higher than on all other backgrounds, while for the tomato it was significantly higher than on 50% and 65% blackness. Due to variations in standard deviation, for the mushroom only the differences between 30% blackness on the one hand and the 50% and 65% blackness on the other hand were significant [$p < 0.05$].

In the present study expensiveness was added as a new attribute to be rated. This attribute correlated the least with the attractiveness ratings (Pearson $r = 0.44$). Therefore, these responses were analysed separately. Repeated measures ANOVA for the expensiveness ratings showed significant main effects for Product [$F(4, 160) = 26.7$, $p < 0.001$, $\eta^2 = 0.40$], Background colour [$F(2.4, 95.7) = 10.6$, $p < 0.001$, $\eta^2 = 0.21$] and Product × Background interaction [$F(9.4, 374.7) = 3.4$, $p < 0.001$, $\eta^2 = 0.08$]. Fig. 6 shows the marginal means for the expensiveness ratings of the different background–vegetable combinations.

When inspecting the mean expensiveness ratings one effect stands out: most vegetables were rated more expensive when presented on 90% blackness. Apparently, participants found that vegetables presented on (almost) black backgrounds looked more expensive than on other backgrounds. The post hoc test comparing the aggregated means for the five backgrounds provided the highest mean for the 90% background (5.0), which was significantly different from all other means (ranging from 4.1 to 4.2). When this analysis was repeated for the individual vegetables, this outcome was replicated for the mushroom and the carrot. For the tomato, expensiveness ratings were highest

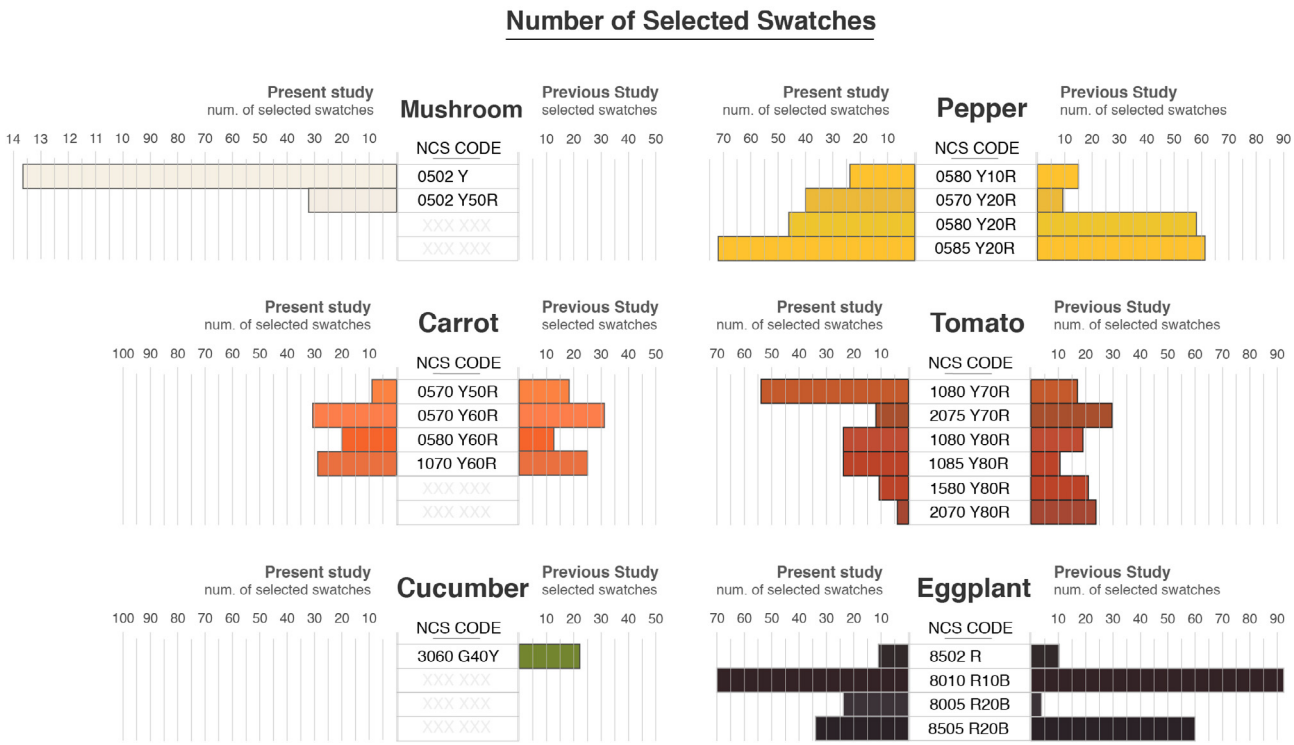

Fig. 4. Colour swatches selected ≥20 times in the present (left) and previous (right) study for the vegetables. Colours of the bars reflect selected NCS colours.

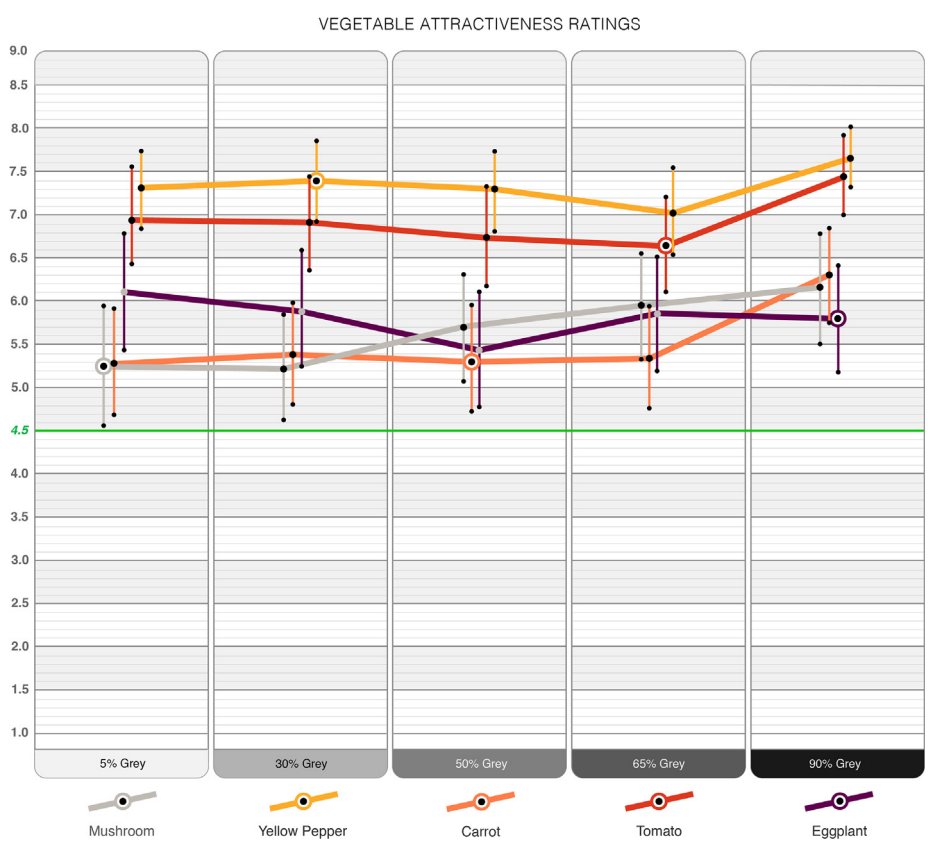

Fig. 5. Mean attractiveness values for five vegetables on five grey backgrounds on a scale of 1–9 with 9 being "very" attractive. Individual coloured circles indicate the vegetables that approximately match the background's blackness value.

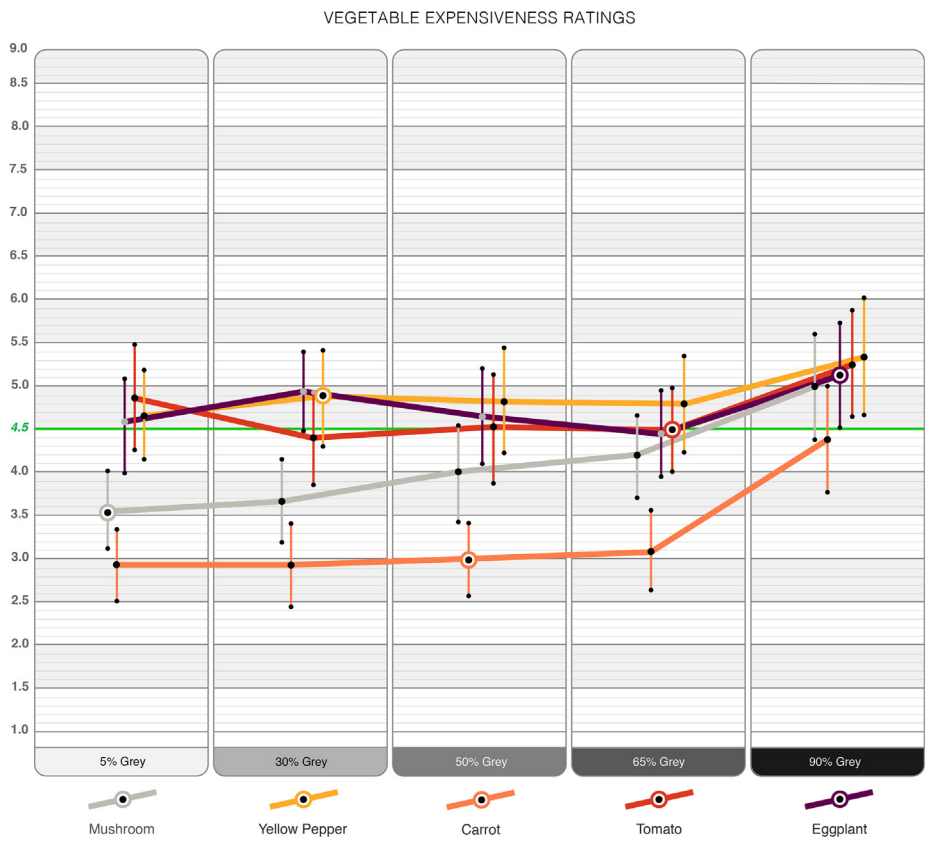

Fig. 6. Mean expensiveness ratings for five vegetables on five grey backgrounds on a scale of 1–9 with 9 being "very" expensive. Individual coloured circles indicate the vegetables that approximately match the background's blackness value.

on the 90% background and differed significantly from 30%, 50% and 65% blackness [$p < 0.05$], but not from the 5% background [$p > 0.20$]. The ratings for the eggplant and the bell pepper did not differ significantly among the five different backgrounds [F-test, $p > 0.15$].

4. Discussion

4.1. Effect of backgrounds on vegetable colour perception

Participants assessed perceived vegetable colours using a colour matching task. In the previous study, it was found that the backgrounds had no effect on vegetable colour perception. In the current study such an effect was only found for the carrot. However, these differences were quite small and subtle and are unlikely to account for the more pronounced effects found in the product evaluation judgments. These outcomes align with expectations that neutral grey backgrounds should have minimal effect on perceived colour of the presented vegetables.

If we compare the colour matches that we obtained for the different vegetables in the two studies, Fig. 4 indicates that the colour matches were quite similar in both studies for the bell pepper, the carrot, and the eggplant. However, for the tomato the differences between the two studies seem to stand out more. These differences are not necessarily due to methodological differences, but may simply reflect natural colour deviations that may be due to geographical or seasonal influences, disparities in ripening stages, or changes in skin moisture content.

4.2. Effect of backgrounds on vegetable attractiveness ratings

For each vegetable, the effects of the light grey to dark grey backgrounds in the present study on the attractiveness scale ratings varied between 0.3 and 1.0, whereas in the previous study the effects of light and dark blue and orange backgrounds were larger and varied between 2.0 and 3.6. This comparison suggests that the effects on perceived attractiveness may be much larger for vegetables presented on backgrounds that include differences in hue and saturation than backgrounds that differ only in blackness.

An important goal of the present study was to find a suitable background colour that multiple different coloured vegetables could be attractively presented on. In both the present and previous study, the attractiveness response scales were identical and four of five of the vegetables were the same species. The primary difference between the two studies were the hued versus neutral grey backgrounds. Assessing the aggregate outcomes from these two studies could demonstrate that multiple vegetables will be found generally more attractive when assessed on neutral grey backgrounds than on hued backgrounds. Therefore, we also calculated the mean attractiveness ratings for the vegetables, averaged over the various backgrounds in the two studies.

Table 1 shows that mean attractiveness ratings were more extreme on the hued backgrounds than on the grey backgrounds, yielding lower minimum values, but also yielding higher maximum values. However, on average over the various backgrounds, the mean attractiveness ratings for the four common vegetables in the studies was 6.0 for the hued background and 6.4 for the grey backgrounds. This suggests that, on average, backgrounds with neutral colours are more likely to present multiple vegetables in an attractive way than hued backgrounds.

In general, the attractiveness of vegetables seems to be highest for the background with the highest blackness level. This finding is in line with previous studies reporting that the colour black was associated with high quality and expensiveness in multiple contexts (Amsteus et al., 2015). Fig. 5 shows that attractiveness ratings for vegetables on grey backgrounds with 5–65% blackness vary somewhat, but do not show a consistent trend; the means aggregated over vegetables ranged

Table 1
Mean attractiveness ratings for multiple vegetables presented on different background colours in two studies with grey (current study) or hued (Schifferstein et al., 2017) backgrounds. We show the smallest value, the mean value, the largest value, and the difference between the two extreme values for each study.

	Grey backgrounds				Hued backgrounds			
	Minimum	Mean of 5	Maximum	Difference	Minimum	Mean of 4	Maximum	Difference
Mushroom	5.2	5.7	6.2	1.0	–	–	–	
Yellow pepper	7.0	7.3	7.7	0.6	4.0	6.2	7.6	3.6
Carrot	5.3	5.5	6.3	1.0	4.4	6.0	7.7	3.3
Cucumber	–	–	–		4.4	6.1	8.0	3.5
Tomato	6.7	7.0	7.5	0.8	5.0	6.1	7.0	2.0
Eggplant	5.8	5.8	6.1	0.3	3.7	5.7	7.3	3.6
Mean of 4 common vegetables	6.2	6.4	6.9	0.7	4.4	6.0	7.4	3.1

between 6.1 and 6.2. For the background with the highest blackness level (90%) the aggregate mean was 6.7, which is a notable increase compared to the previous values. In the previous study with the hued backgrounds, overall attractiveness means increased monotonically from 5.6 (light orange, 24% blackness), 6.0 (light blue, 31%), 6.0 (dark orange, 69%), to 6.4 (dark blue, 78%). This suggests that darker background colours will yield higher attractiveness ratings over a variety of vegetables than lighter colours.

Originally, we started out from the blackness contrast hypothesis suggesting that vegetables would look the least attractive when their colours had blackness levels close to the backgrounds on which they were presented, while expecting higher attractiveness ratings with increasingly lighter or darker backgrounds. Although we found high attractiveness ratings for vegetables presented on the darkest background, we did not obtain high ratings for the lightest background. This outcome deviates from Helson and Lansford's (1970) original study, which reported the highest pleasantness ratings on the white background. Maybe the discrepancy in results may be due to fact that the original colour studies were performed with 2D colour samples, whereas the target stimuli in the current study are 3D objects on a flat surface. Possibly darker backgrounds make the 3D products look more attractive, because dark colours do not reflect or reveal shadows as much as lighter colours. As a consequence, the vegetable's form or silhouette will be easier for the participant to read and understand when it is on a darker background. A vegetable placed on a light background will reveal its single or multiple shadows, as well as its form and colour reflection directly beneath the object. The visual cleanness or purity of form that participants visually perceive with objects on darker backgrounds could contribute to the perceived attractiveness.

Remarkably, white plates tend to be more common for presenting prepared dishes than black plates in restaurants. This makes us wonder whether prepared food perhaps looks better on white plates than on black plates, even though the raw vegetables in our study did not look more attractive on the lighter backgrounds? If so, would this effect be due to differences in size and shape, or the fact that prepared food does not cast so many shadows on plates than raw food? Or is it because the surface textures of prepared foods are less shiny than those of raw foods and that their texture contrasts with the shiny surface of the porcelain plate? This could be an interesting topic for a follow-up study.

The high attractiveness ratings on darker backgrounds may be related to the perceived premiumness of such vegetables, that is reflected in the increased expensiveness ratings on the 90% darkness background. When consumers encounter a package design it elicits cognitive, affective and behavioural responses that causes the consumer to interpret the quality and authenticity of the product. Colour choice in packaging can evoke a premium or generic brand perception and cost correlation (Mastropietro von Rautenkrantz, 2016; Mugge, Massink, Hultink, & van den Berg-Weitzel, 2014). Hence, if premium associations are preferred, designers might explore integrating darker backgrounds in the design. In contrast, if designers develop packaging for a low-cost product, they might explore utilizing a lighter background. The same principles could potentially be incorporated in larger displays of vegetables.

4.3. Differences in attractiveness and expensiveness ratings between vegetables

Fig. 5 shows that certain vegetables generally rate more attractive than others. The bell pepper rates highest on all backgrounds (see Table 1) and is mirrored by the tomato. The other three vegetables are perceived as less attractive, with the carrots obtaining the lowest mean rating. These attractiveness ratings deviate substantially from the consumption frequencies and the taste liking data that the participants reported (see 2.2 Stimuli), which generally showed the highest preference for carrots, followed by yellow peppers and tomatoes, then mushrooms, and the lowest liking for eggplants. Hence it is clear that attractiveness judgments deviate substantially from taste preferences.

Differences in attractiveness ratings are probably related to the visual properties of vegetables and how people tend to evaluate these. The appearance of agricultural products is normally evaluated by considering size, shape, form, colour, freshness, and the absence of visual defects (Costa et al., 2011; Schifferstein et al., 2019). Research has indicated that a food's surface colour is the first sensation a consumer perceives and uses to accept or reject the product (León, Mery, Pedreschi, & León, 2006). Note that the food colours consumers judge as acceptable may depend on their age, ethnicity, and the context in which the products are encountered (Francis, 1995). Although these visual properties could explain differences in attractiveness between product variants of the same species, we think that not all of these properties are likely to account for differences between species.

An explanation that might explain the differences between product species could perhaps be found in the physiology of how the human mind processes colours. The primary colours (saturated red, green, blue, and yellow) have been shown to receive preferential cognitive processing and thereby capture our attention faster. Attention capture studies have shown that red and yellow are tracked fastest, while it takes more time to find orange and purple (Andersen & Maier, 2017). The yellow pepper and red tomato have saturated primary colours, while the orange carrot carries a saturated secondary colour. The eggplant contains a dark, unsaturated red-purple, while the mushroom has a light, unsaturated yellow tinted grey. The hierarchy of colours in attentional capture observations correlates with the attractiveness hierarchy of the vegetables carrying the saturated colours. Hence, it might be interesting to explore this idea further in subsequent studies.

Physical properties such as surface texture and gloss could also have influenced attractiveness ratings. The lower performers have rougher textures and matt finishes (carrot and mushroom), while the top performers (bell pepper, tomato) have smooth textures and glossy surfaces. Human beings are attracted to glossy objects and our preference for shine has been associated with people's basic need for water (Meert, Pandelaere, & Patrick, 2014). Produce that is freshly harvested often

has a bright, glossy surface and is found to be both desirable and preferred to a dried appearance. The brightness of colour and the absence of visual defects or drip also indicate freshness (Pathare, Opara, & Al-Said, 2013). That the higher performing vegetables had both high surface gloss and saturated colours could have influenced the attractiveness ratings.

Another possible factor could involve the inclusion or exclusion of the vegetable stem. The yellow pepper, tomato, and eggplant retained their normal stems, which were easily visible. The carrot's green leaves were removed so the large mass of green would not affect the perception of the orange colour of the carrot, but approximately 1 cm of the stem was left attached to the carrot. The mushroom stem was removed so it would lay flat on the background (Fig. 1). Vegetable stems can add a highlight of complementary colour that could contrast with the main vegetable colour, which could make the whole more attractive.

Besides attractiveness we also studied expensiveness ratings. These ratings may partly reflect the actual retail prices of each piece of vegetable at the time of the study. The mushroom ($ 0.14) and the carrot ($ 0.20) are low in price and received the lowest expensiveness ratings, while the tomato ($ 0.40–0.80), the bell pepper ($ 0.88) and the eggplant ($ 1.49) are more expensive and obtained higher ratings. In addition, the mushroom and the carrot both have rougher, matte surfaces, whereas the other three vegetables all have a shiny, glossy surface. This might also partly be a factor that affects their expensiveness ratings, since many expensive materials like precious metals and stones have shiny surfaces.

Although expensiveness ratings had the lowest correlation with attractiveness ratings of all the variables assessed in the study (Pearson $r = 0.44$), the patterns of means displayed in Figs. 5 and 6 show several similarities. For instance, ratings tend to be highest for vegetables displayed on the darkest background for both dependent variables. However, this effect seems more pronounced in the expensiveness ratings than in the attractiveness ratings. Furthermore, for both measures the eggplant and the bell pepper do not produce significant differences between the five backgrounds, whereas the other vegetables do.

4.4. Methodological limitations and suggestions for future research

Measuring highly reflective 3-dimensional curved surfaces on multiple vegetables and incorporating digital software tools to interpret their blackness values naturally lead to human judgement choices in final measurements. The experimenters were conscientious of this and did their best to be consistent in methods and technology use, but nonetheless, biases may have occurred in some of the measurements (see 2.3 Backgrounds).

Although we mainly focused on the colours of the products we investigated, proportional variations between the various vegetable sizes and shapes and the standardized background sizes could have an impact on participants' perceptions and responses. The eggplant is significantly larger than the mushroom, while all backgrounds were the same size. The smaller vegetables like the carrot allowed the background colour to be seen both behind and in front of the carrot, whereas the eggplant was tall enough that the back wall of the viewing booth was seen on the far side of the vegetable rather than the coloured background.

The present study shows again that theories developed for the colour perception of 2D stimuli do not seem to hold for real world objects that are not only 3D, but also differ on many more aspects, such as size, shape, and surface properties. Hence, investigating the implications of colour evaluations in realistic contexts is necessary to understand the complex world that people live in. In order to investigate the impact of these factors, the current research could be extended with objects in a single colour that differ in size and shape, and possibly also in glossiness, while presenting them on a number of grey backgrounds. In addition, the characteristics of the background (e.g., matte versus glossy) could vary.

Grobelny and Michalski (2015) determined consumer preferences for product packages displaying a black mobile phone on a neutral grey versus a pinkish grey colour. In this study, participants did not judge the attractiveness of the phone by itself, but the attractiveness of the phone and its background simultaneously. These authors found a large effect of gender, with women preferring the pinkish grey and men preferring the neutral grey package colour. The study also suggests that the package background colour factor was markedly more important to men than to women in determining their preferences. Because pink is often associated with femininity, the men probably do not like the pinkish grey, because they do not want to be associated with a feminine package, while for women both packages would be acceptable. In their study, the focus is not so much on the physical properties of the colours, but more on the meaning of these colours to the participants. Just like the evaluations of expensiveness in our study, future studies could focus not only on perceived attractiveness, but could include more aspects that reflect what colours signify to potential consumers.

Although objects that show more blackness contrast stand out more and tend to be preferred, Reynolds-McIlnay et al. (2017) found that this preference tended to be reversed when the target products appeared in disarray. Apparently, sales and purchase likelihood can decrease when attention is drawn to a negative product attribute (Areni, Duhan, & Kiecker, 1999). This suggests that when products stand out more, consumers are also more likely to notice any irregularities or blemishes, which could then affect their evaluation and purchase probability negatively.

In the current study, the participants were mainly students volunteering to participate. In future studies we could expand our participant sample to include consumer groups varying in concerns or eating patterns (e.g., health-conscious, vegetarian, vegan, raw consumption) to determine how their preferences and product evaluations are affected by displaying products on different background colours.

5. Conclusion

It would be commercially interesting to demonstrate that certain background colours would increase attractiveness perceptions of vegetables. This study, while not conclusive, has exposed how light to dark neutral greys could influence how fresh foods are presented by retailers and perceived by consumers in a variety of food related environments. The finding that consumers generally find vegetables more attractive on very dark backgrounds may be of direct relevance to current food retailers. Designers may utilize these insights to improve vegetable packaging or presentation to effectively achieve the marketing goals of food industry managers. As industry and consumers achieve clarity in the effects of visual messaging related to colour, our general well-being could be enhanced by both enabling healthy eating and enhancing the commercial outcomes of food retailers and services.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2019.05.018.

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