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## Text highlighting as a new way of measuring consumers' attitudes: A case study on vertical farming

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### ABSTRACT

Attitude measurement occupies a central position in consumer research. Concerns over the validity and reliability of traditional measures have motivated the development of alternative approaches. The present research introduces text highlighting as a method for measurement of explicit attitudes using a case study on vertical farming (VF) with 837 UK consumers. They participated in an online survey, where they read a text about VF and used highlighting functions to mark text as 'like' and 'dislike.' Consumers approached the task in a systematic and logical way and desirable aspects of VF were frequently highlighted as 'like', whereas undesirable aspects were more frequently highlighted as 'dislike'. The text highlighting responses were summarised using word clouds, frequency tables and through sentiment scores to reveal an overall positive attitude to VF among participants. Sentiment scores enabled the identification of consumer segments with interpretable differences in their attitude towards VF. Two approaches to method validation – comparison with direct attitude questions and consumer profiling – further confirmed the potential of the text highlighting method. The sentiment of specific sentences in the text highlighting task matched results from self-reported attitudinal based on Likert scales. Consumer segments with different sentiment in the text highlighting task also differed in their food technology neophobia scores in the expected direction. Future research should investigate methodological aspects of text highlighting and explore its suitability to other applications.

## 1. Introduction

### 1.1. Attitude measurement

Attitudes can be defined as affective associations about an object stored in the mind (Conrey & Smith, 2007). They are basically a predisposition to evaluate an object as positive or negative (Fazio, 2007). Attitudes can be formed through three key processes: i) from cognitions, when the attitude is based on beliefs about the (un)desirable characteristics of an object; ii) from affect, when attitudes are formed from emotional reactions to the object; and iii) from behaviour, when attitudes are based on past experiences (Fazio & Olson, 2007). According to the MODE model (Motivation and Opportunity as Determinants) (e.g., Payne & Gawronski, 2010), attitudes can influence behaviour through both spontaneous and deliberative processing (Fazio & Towles-Schwen, 1999). The MODE model falls into the category of Dual-Process Models of Attitudes (DPMA) (e.g., Gawronski & Brannon, 2018; Ross, Lepper, &

Ward, 2010), which have advanced the understanding of attitudinal and motivational factors associated with human behaviour and have more or less relegated traditional models of attitude (e.g., Theory of Reasoned Action, Theory of Planned Behaviour) to obsolescence.

Measuring attitudes has long been regarded as a key step to understanding consumer behaviour (Conrey & Smith, 2007) and this importance has supported ongoing development and refinement of measurement approaches since the time of Thurstone (1928) (e.g., Krosnick, Judd, & Wittenbrink, 2005). Explicit measurements relying on participants' self-reports of their attitudes are the most common method to measure attitudes (Fazio, 2007). Participants are usually asked to indicate their degree of agreement with written statements about an object or behaviour, or to respond how frequently they engage in a behaviour. Rating scales, including Likert scales, are very popular and generally perform very well (e.g., Willits, Theodori, & Luloff, 2016). However, rating scale response are also expected to be affected by different biases, including social desirability bias (i.e., people's tendency

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to provide socially acceptable responses), demand characteristics (i.e., participants' tendency to provide responses to please the researcher) and consistency motif (i.e., people's tendency to appear consistent and rational in their responses) (Orne, 2009; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). In addition, the use of Likert scales poses several challenges for cross-cultural research due to differences in response style (Ares, 2018).

### 1.2. Text highlighting for attitude measurement

Drawing on the above, the present research focuses on text highlighting as a new method for explicit attitude measurement. Participants are shown a piece of text that they read while making use of highlighting functions to indicate parts of the text that they, respectively, like and dislike (Fig. 1). There are no further instructions or requirements, and participants can highlight as much or as little text as they choose, focusing on positive or negative aspects as suits them. The responses from each person are captured to record the selection made for each word (positive highlight, negative highlight, no highlight) and summarised across participants.

Apart from a lack of reliance on Likert scales, several factors justify the potential of text highlighting for attitude measurement, foremost familiarity, simplicity, diversity and engagement.

Highlighting is a common tool used to mark relevant sections in text. As a study strategy, it is popular among students when trying to make sense of the content of a text (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013), and it is expected to be familiar to most adults who may have used it at some point in their life. People who contribute to crowd sourcing platforms are also likely to have encountered highlighting, which is one of the most frequent human intelligence tasks on these platforms (Strobel, Oelke, Kwon, Schreck, & Pfister, 2015) because of the importance for successful classification in machine learning. The expression of like and dislike is, likewise, commonplace due to its popularity on social media platforms, and in online reviews of products and services.

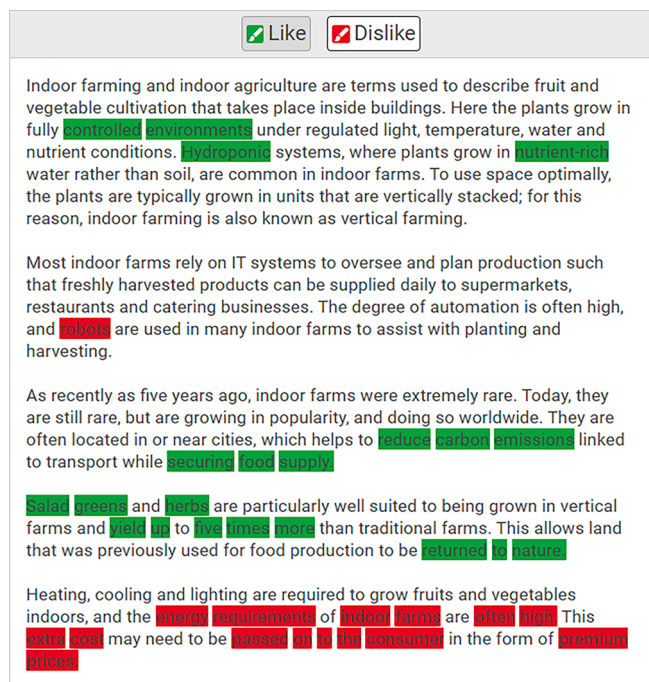


Fig. 1. Illustration of text highlighting task. Participants are instructed to read the text and use the highlight functions to indicate text that they like / feel positive about and text that they dislike / feel negative about. Highlights added by a participant who has completed the task. The shown text is VF-basic + pro/con.

As a task, text highlighting does not require training or extensive explanations. To participants it is a simple and quick task, and these characteristics are desirable in online surveys, where question difficulty and survey length negatively influence completion rates and data quality (e.g., Galesic & Bosnjak, 2009; Ganassali, 2008; Liu & Wronski, 2018; Roßmann, Gummer, & Silber, 2018). Participant boredom is also a factor of concern in survey research (e.g., Brace, 2018; Bradburn, Sudman, & Wansink, 2004), and if a credible alternative to rating scales for attitude measurement, text highlighting could enable survey developers, in a small way, to reduce monotony by using both types of tasks instead of using one method repeatedly. Since text highlighting as a study tool has been found to increase engagement and understanding (Latini, Bråten, Anmarkrud, & Salmerón, 2019; Leroy, Gerjets, Oestermeier, & Kammerer, 2021), a similar effect when used as a research tool may further mitigate survey boredom and fatigue.

### 1.3. Vertical farming

The present study is focused on consumer attitudes towards indoor vertical farming (VF), which on the spectrum of controlled environment agriculture (CEA) technologies is regarded as the most control-intensive high-tech approach (Niu & Masabni, 2018). Briefly, crops are grown indoors in vertically stacked layers under highly controlled conditions that allow for the optimisation of resource use, incl. nutrients, water, energy and space (e.g., De Oliveira, Ferson, & Dyer, 2021). VF has attracted considerable interest in recent decade/s because it is able to produce food crops – to date primarily lettuce, kale, herbs, and microgreens – more sustainably than conventional farming (e.g., Al-Kodmany, 2018). In a broader context, VF is part of a transition from outdoor to indoor agricultural production that is regarded as necessary to feed the world's growing population and manage threats to food supply caused by climate change and urbanisation, among other things (e.g., Benke & Tomkins, 2017; Kalantari, Tahir, Joni, & Fatemi, 2018).

VF is a suitable topic for attitude measurement. Attitudes are important for understanding consumer perception of new food technologies (e.g., Grunert, Søndergaard, & Scholderer, 2004; Lusk, Roosen, & Bieberstein, 2014; Siegrist & Hartmann, 2020), and these likely merge in a bottom-up process with other general attitudes to technology, innovation, nature and science (Deliza & Ares, 2018) when faced with limited topic knowledge such as would be expected in the case of VF. This technology's mix of potential advantages, such as improved security in food supply, shorter supply chains, all-year crop production, higher yields, and less pesticides and herbicides use (e.g., Benke & Tomkins, 2017; De Oliveira et al., 2021; Kalantari et al., 2018), and potential disadvantages, such as high energy use and premium pricing (e.g., Beacham, Vickers, & Monaghan, 2019; Specht, Siebert, & Thomaier, 2016), as well as possible undesirable characteristics from a consumer perspective (e.g., concerns over health risks (Specht et al., 2016), fully automated systems (Jansen, Cila, Kanis, & Slaats, 2016) added to the ability to investigate performance of text highlighting in relation to general, as well as specific attitudes.

A secondary benefit of using VF as a case study is that research into consumers' perceptions and acceptance of this novel way of food production, while increasing, remains limited (e.g., Grebitus, Chenarides, Muenich, & Mahalov, 2020; Jansen et al., 2016; Jürkenbeck, Heumann, & Spiller, 2019; Specht et al., 2016; Specht et al., 2019).

### 1.4. Research aims

The present research had two aims. The first aim was to explore the potential of text highlighting as a method in attitude measurement using vertical farming as case study. For this purpose, two different texts about VF were used, differing in length and content. The resulting data were summarised descriptively, and insights gained regarding consumer attitudes to VF were explored using word clouds, frequency tables and sentiment analysis.

The second aim was to explore the validity of text highlighting data. To have potential as a method for attitude measurement, opinions about VF uncovered through text highlighting should correspond to those expressed in direct attitude questions. For this reason, a first approach to method validation involved comparison of text highlighting data with direct attitude questions. Further, text highlighting should be sensitive to differences in the opinions of different groups of people, and to this end degree of food technology neophobia (FTN) was measured for each participant. This psychometric trait captures the fear of novel technologies used in food production and processing (Cox & Evans, 2008), and it was expected to have relevance for the present research because the products – fruits and vegetables – are well known to consumers but the production systems were novel. Previous research has successfully found that consumers who vary in FTN have different opinions about processing technologies, genetically modified foods, functional foods and food packaging (Chen, Anders, & An, 2013; De Steur, Odongo, & Gellynck, 2016; Evans, Kermarrec, Sable, & Cox, 2010; Martins, Oliveira, Rosenthal, Ares, & Deliza, 2019; Verneau, Caracciolo, Coppola, & Lombardi, 2014). For example, consumers with higher levels of FTN have less positive attitudes about foods processed using emerging technologies, such as high hydrostatic pressure, than those with lower levels of FTN (Martins et al., 2019; Vidigal et al., 2015). On this basis, the second approach to method validation was to compare the characteristics of groups of participants providing different responses in text highlighting, with special emphasis on FTN. It was expected that participants who were more positive toward VF would be less food technology neophobic (i.e., lower in FTN).

## 2. Methodology

### 2.1. Participants

The study took place in the UK (England, Scotland, Wales and Northern Ireland) with participants ( $n = 837$ ) (50% female, 18–65 years old) who had self-registered with an ISO-accredited web panel provider (Lightspeed). To be eligible, participants had to i) identify English as their primary language and ii) be regularly involved in the household grocery shopping and food preparation (more than once per week). Quota sampling with interlocking age group/gender criteria were imposed for all experimental conditions with a 50:50 gender split and a 50:50 split in age group (younger group aged 18–39 years, older group aged 40–65 years old). The sample was diverse across key socio-economic characteristics, but not representative of the UK general population. Part 2 of [Supplementary Material](#) has additional participant details. The UK was a suitable country to conduct the research since VF there are many initiatives to develop the technology (e.g., [Butturini & Marcelis, 2020](#)) and in some parts of the country, produce from VFs are sold in supermarkets (e.g., [www.infarm.com](#)).

#### 2.1.1. Human ethics statement

The study was covered by a general approval for sensory and consumer research from the Human Ethics Committee at The New Zealand Institute for Plant and Food Research Limited (PFR). Participants were assured that their responses would remain confidential and gave voluntary consent to participate. As compensation, participants earned reward points and promotional offers.

### 2.2. Data collection

#### 2.2.1. Texts used in highlighting task

Since the text highlighting task was explained earlier, only details regarding the texts are given here. They were written by the authors and revised by a full-time science editor with a PhD in biological sciences. The intent was that the texts would be suitable for use with a lay audience, while factual and credible.

The first text used in the highlighting task – *VF-basic* – conveyed

descriptive information about VF in a neutral and descriptive tone (125 words, 6 sentences). This text is shown in [Tables 2 and 3](#) (sentence format) and Part 3 of [Supplementary Material](#) (paragraph format). Another text component conveyed additional information about VF with a focus on advantages and disadvantages (*VF-pro/con*: 125 words, 7 sentences). The pro/con information about VF was only used in combination with the *VF-basic* text and combined to create the second text used in the highlighting task: *VF-basic + pro/con* (250 words, 13 sentences). This text is shown in [Tables 2 and 3](#) (sentence format) and Part 3 of [Supplementary Material](#) (paragraph format). For data collection, participants performed the highlighting task for one text only, either *VF-basic* or *VF-basic + pro/con*.

#### 2.2.2. Attitude and behavioural intent questions

Immediately following the text highlighting task participants saw five statements ([Table 4](#)), which were preceded by the instruction: “Please consider the information you have been given about indoor farming (indoor agriculture, vertical farming) and their use to grow fruits and vegetables. Then indicate your level of agreement or disagreement with each of the following statements.” Responses were obtained on 7-pt Likert scales from 1=‘disagree strongly’ to 7=‘agree strongly.’ The text was available for participants to read again if they needed to and accessed by clicking a hyperlink.

#### 2.2.3. FTN and background questions

Contributing to method validation, participants completed the food technology neophobia (FTN) scale from [Cox and Evans \(2008\)](#), which comprises 13 statements that are evaluated on 7-pt Likert scales (1=‘disagree strongly’, 7=‘agree strongly’), for example, “New food technologies are something I am uncertain about” and “It can be risky to switch to new food technologies too quickly.”

Participants were also asked if they had previously heard about indoor / vertical farming (yes, no, don’t know). In relation to fruit and vegetables (F&V) consumption, two questions were used: i) frequency of consumption (9-pt scale from 1=‘never’ to 9=‘4 or more times per day’ and ii) proportion of organic F&V from 0% to > 75% (5-pt scale). Demographic and socio-economic questions were asked last.

#### 2.2.4. Implementation

Data were initially obtained from 10% of participants (evenly across the experimental groups) to allow initial checks for responses fitting expectations. The survey then proceeded to full launch and the remaining data were collected in February 2021. Participants completed the survey in a location of their choosing using a desktop or laptop computer (tablets and mobile phones were restricted since reduced screen size could interfere with ability to perform the text highlighting task). The data were obtained as part of survey sessions that included task other than those described here (not considered further due to lack of relevance).

**Table 1**  
Descriptive summaries for ‘like’ and ‘dislike’ highlighting shown for the two texts about vertical farming (VF) included in the research (*VF-basic* and *VF-basic + pro/con*).

Summary statistic	VF-basic	VF-basic + pro/con
Median of highlighted words (%)	8	8
Percentage of participants who highlighted at least one word in the text as ‘like’ (%)	90	95
Median of words selected as ‘like’ (%)	85	67
Percentage of participants who highlighted at least one word in the text as ‘dislike’	55	72
Median of words selected as ‘dislike’ (%)	15	33
Median of highlighted words in sentences (%)	19	25
Median of highlighted sentences (%)	33	31

**Table 2**

Descriptive summaries for the highlighting task by individual sentences, following aggregate level analysis. They are shown for the two texts about vertical farming (VF) included in the research (*VF-basic* and *VF-basic + pro/con*).

Text and sentences*	Participants (%) highlighting 1 + word within sentence	Participants (%) highlighting 1 + word within sentence as 'like'	Participants (%) highlighting 1 + word within sentence as 'dislike'	D) Sentiment of sentence
<b>Text: <i>VF-basic</i></b>				
1. Indoor farming and indoor agriculture are terms used to describe fruit and vegetable cultivation that takes place inside buildings	32	23	11	12
2. Here the plants grow in fully controlled environments under regulated light temperature water and nutrient conditions	41	34	8	26
3. Hydroponic systems where plants grow in nutrient-rich water rather than soil are common in indoor farms	54	47	8	39
4. To use space optimally the plants are typically grown in units that are vertically stacked for this reason indoor farming is also known as vertical farming	42	33	9	24
5. Most indoor farms rely on IT systems to oversee and plan production such that freshly harvested products can be supplied daily to supermarkets restaurants and catering businesses	48	35	15	20
6. The degree of automation is often high and robots are used in many indoor farms to assist with planting and harvesting	52	17	37	-20
<b>Text: <i>VF-basic + pro/con</i></b>				
1. Indoor farming and indoor agriculture are terms used to describe fruit and vegetable cultivation that takes place inside buildings	23	18	6	12
2. Here the plants grow in fully controlled environments under regulated light temperature water and nutrient conditions	27	22	5	17
3. Hydroponic systems where plants grow in nutrient-rich water rather than soil are common in indoor farms	37	32	6	26
4. To use space optimally the plants are typically grown in units that are vertically stacked for this reason indoor farming is also known as vertical farming	28	23	5	18
5. Most indoor farms rely on IT systems to oversee and plan production such that freshly harvested products can be supplied daily to supermarkets restaurants and catering businesses	31	23	10	13
6. The degree of automation is often high and robots are used in many indoor farms to assist with planting and harvesting	32	12	20	-8
7. As recently as five years ago indoor farms were extremely rare	10	7	3	4
8. Today they are still rare but are growing in popularity and doing so worldwide	18	16	3	13
9. They are often located in or near cities which helps to reduce carbon emissions linked to transport while securing food supply	50	48	4	44
10. Salad greens and herbs are particularly well suited to being grown in vertical farms and yield up to five times more than traditional farms	43	42	2	40
11. This allows land that was previously used for food production to be returned to nature	39	38	1	37
12. Heating cooling and lighting are required to grow fruits and vegetables indoors and the energy requirements of indoor farms are often high	43	10	35	-25
13. This extra cost may need to be passed on to the consumer in the form of premium prices	50	3	47	-44

Note. \*) Sentences are listed in the order they appeared in the texts.

## 2.3. Data analysis

### 2.3.1. Text highlighting data

For each text, categorical coding was used to record whether a participant selected each of the words as 'like' (+1), 'dislike' (-1), or did not select it (0). The percentage of words highlighted by each participant were calculated, as well as the percentage of words highlighted as 'like' and 'dislike'. Histograms were created for each variable. The same analyses were performed for individual sentences.

For each text, word clouds were created to visually represent the percentage of participants who highlighted words as 'like' and 'dislike'. In addition, the percentage of participants who highlighted at least one word in each sentence was calculated, as well as the percentage of participants who selected at least one word as 'like' and 'dislike'.

Average sentiment scores for sentences were calculated as the difference between the percentage of participants highlighting at least one word within the sentence as 'like' and the percentage of participants highlighting at least one word within the sentence as 'dislike'. Positive scores represented a generally positive sentiment toward the information in a sentence, and negative scores represented a generally negative sentiment toward the provided information. The scores could range between -100 and 100, with the former representing that only 'dislike' highlighting was used in sentence and the latter representing only use of 'like' highlighting.

Sentiment scores for individual participants' were calculated as the difference between percentage of sentences with words highlighted as 'like' and the percentage of sentences with words highlighted as 'dislike'. A sentiment score of 100% meant that a participant only used

'like' highlighting, while a sentiment score of  $-100\%$  means that a participant only used 'dislike' highlighting. Consumer segmentation was performed using these scores creating three groups: i) Positive Group for participants with sentiment scores higher than  $0\%$ , ii) Neutral/Ambivalent Group for participants with sentiment scores equal to  $0\%$ , and iii) Negative Group for participants with sentiment scores lower than  $0\%$ .

### 2.3.2. Attitude and behavioural intent questions about VF

These data were collected as part of method validation and summarised for comparison with results from sentiment analysis. The responses were obtained on Likert scales (1='strongly disagree' to 7='strongly agree') and the distributions of responses were summarised and classified as "Disagree" for scale values 1, 2 and 3, "Neutral" for scale value 4 ('neither agree nor disagree') and "Agree" for scale values 5, 6 and 7.

### 2.3.3. FTN and background questions

Following common practise, FTN was expressed as a summed score across the 13 statements (following reverse coding as needed), with higher scores reflecting higher FTN levels (theoretical range: 13 to 91). The value for Cronbach alpha was 0.87 and greater than standard threshold of 0.7 (Tavakol & Dennick, 2011), hereby supporting a summed value as reflective of degree of FTN. Chi-square tests were used to compare the three sentiment groups based on the highlighting task (Section 2.3.1) on background questions.

## 3. Results

### 3.1. Overview of highlighted text

Participants tended to highlight the words that conveyed the key meaning of the sentences, mainly nouns and adjectives. Prepositions and conjunctions were less frequently highlighted (Figs. 2 and 3).

The number of highlighted words differed considerably from participant to participant, with some selecting only a single word in an entire text and others selecting all words. The median percentage of highlighted words corresponded to  $8\%$  (Table 2), with  $75\%$  of the participants highlighting less than  $17\text{--}18\%$  of the words included in the sentences. 'Like' highlighting was more frequently used than 'dislike' highlighting. Most participants ( $90\text{--}95\%$ ) highlighted at least one word as 'like' and the median percentage of words highlighted as 'like' ranged between  $67\%$  and  $85\%$  (Table 1). Conversely,  $55\text{--}72\%$  of participants selected at least one word as 'dislike' and the median percentage of highlighted words was between  $15\%$  and  $33\%$  (Table 1). It had face validity that 'dislike' highlighting was more frequently used in the text which explicitly mentioned disadvantages of VF (*VF-basic + pro/con*). For completeness, distributions of word selection frequencies (total, 'like', 'dislike') are shown in the Supplementary Material.

Considering the nature of the task, the highlighting responses were analysed in the context of whole sentences. As was found for individual words, some participants only highlighted word/s within a single sentence while others highlighted at least one word in every sentence. The median percentage of sentences highlighted by participants was  $19\text{--}25\%$ , whereas the percentage of participants who highlighted at least one word within a sentence ranged between  $10\%$  and  $54\%$  across all sentences included in the two texts (Table 2). As for words, the majority of the sentences were highlighted as 'like'. Across the two texts, the percentage of participants who highlighted at least one word as 'like' ranged between  $3\%$  and  $48\%$  across all sentences, whereas the percentage of participants who highlighted at least one word as 'dislike' ranged between  $1\%$  and  $47\%$  (Table 2). The selection of both liked and disliked words within a sentence was an exception ( $0\text{--}2\%$ ), as participants tended to either highlight words as 'like' or 'dislike'. This is aligned with the content of the texts, which did not frequently include information about advantages and disadvantages of VF in the same sentence.

### 3.2. Insights on vertical farming provided by text highlighting

#### 3.2.1. Word clouds and frequency tabulation

Figs. 2 and 3 show a visual overview of results of the highlighted task for each text using word clouds. Varying colour and font size indicates frequency of highlighting with larger and darker blue font for more frequently highlighted words, and smaller and lighter blue font for less frequently highlighted words.

When providing basic information about VF, 'like' highlighting was used for text that described growing conditions (e.g., controlled environment, regulated light, hydroponic, nutrient-rich water) and consumer benefits (freshly harvested, supplied daily) (Fig. 2a). 'Dislike' highlighting was used less frequently than 'like' highlighting and primarily in relation to technology (e.g., IT systems, automation, robots) and the fact that cultivation took place inside buildings (Fig. 2b). Visual inspection of the word clouds suggested low tendency for words to be frequently highlighted as both 'like' and 'dislike.'

When the basic text was merged with text about pros and cons of VF, word selection was more frequent for the second half of the text, which contained the VF pro/con information, than the top half of the text, which provided the basic information about VF (Fig. 3). Growing conditions remained selected in 'like' highlighting but less frequently than benefits linked to reduced carbon emissions, high yield and returning farmland to nature (Fig. 3a). The result was similar for 'dislike' highlighting in the sense that frequent 'dislike' words in the *VF-basic* text were also selected as 'dislike' in the text where pro/cons were added, but their frequency of use was lower than other negative aspects of VF and consumer disadvantages (high energy costs, premium pricing) (Fig. 3b).

The percentages of participants who highlighted at least one word as 'like' and 'dislike' within each of the sentences of the two texts are shown in Table 2. Confirming the qualitative insights from the word clouds (Figs. 2 and 3), it was also seen that participants frequently highlighted words within sentences describing advantages of VF as 'like', and highlighted words within sentences describing disadvantages of VF as 'dislike.' Table 2 also supported the observation from the word clouds suggesting a contextual influence of other text (content and/or length) on 'like' and 'dislike' highlighting responses. Because the six sentences of the *VF-basic* text featured verbatim in the *VF-basic + pro/con* text, it was possible to compare the highlighting summary statistics. The general pattern was that highlight frequency decreased from the basic VF text (*VF-basic*) to the text that also contained information about VF pros and cons (*VF-basic + pro/con*) (Table 2).

#### 3.2.2. Sentence sentiment scores

Considering the interest in exploring text highlighting as a method to measure attitudes, average sentiment scores for sentences were calculated, and the results quantitatively confirmed the insights gained from the word clouds (Figs. 2 and 3). Overall, it fitted with the earlier findings that most of the sentences had positive or neutral sentiment scores, whereas only 4 of the 19 sentences ( $21\%$ ) had negative sentiment scores (Table 2). For basic information about VF, the same three sentences (2nd, 3rd and 4th sentences) were ranked highest for positive sentiment in the *VF-basic* and *VF-basic + pro/con* texts, and they described specifics of VF cultivation (plants grown in fully controlled environments, use of hydroponic systems and vertical stacking for optimal space use). More extreme sentiment scores were found for the text describing pros and cons of VF, and commensurate with the qualitative insights from word clouds, the most positive sentiment scores were found for sentences describing key VF advantages (being near cities to reduce carbon emissions, securing food supply, high yield and return of agricultural land to nature). Strongest negative sentiment was found for the sentences describing high energy requirements of VF and premium pricing of VF produce (Table 2).

The sentiment scores also confirmed the observation from word clouds that highlighting was influenced by textual context (content and/or length). When comparing the sentiment scores for the six sentences

**Table 3**

Average sentiment scores for individual sentences in each text (*VF-basic* and *VF-basic + pro/con*) by groups of participants with positive, neutral or negative sentiment scores<sup>#</sup>.

Text and sentences*	Positive Group	Neutral Group	Negative Group
<b>Text: <i>VF-basic</i></b>			
1. Indoor farming and indoor agriculture are terms used to describe fruit and vegetable cultivation that takes place inside buildings	25	4	-27
2. Here the plants grow in fully controlled environments under regulated light temperature water and nutrient conditions	41	22	-26
3. Hydroponic systems where plants grow in nutrient-rich water rather than soil are common in indoor farms	58	34	-31
4. To use space optimally the plants are typically grown in units that are vertically stacked for this reason indoor farming is also known as vertical farming	45	-4	-21
5. Most indoor farms rely on IT systems to oversee and plan production such that freshly harvested products can be supplied daily to supermarkets restaurants and catering businesses	39	-7	-21
6. The degree of automation is often high and robots are used in many indoor farms to assist with planting and harvesting	1	-49	-70
<b>Text: <i>VF-basic + pro/con</i></b>			
1. Indoor farming and indoor agriculture are terms used to describe fruit and vegetable cultivation that takes place inside buildings	21	5	-13
2. Here the plants grow in fully controlled environments under regulated light temperature water and nutrient conditions	28	8	-18
3. Hydroponic systems where plants grow in nutrient-rich water rather than soil are common in indoor farms	41	10	-18
4. To use space optimally the plants are typically grown in units that are vertically stacked for this reason indoor farming is also known as vertical farming	32	-1	-16
5. Most indoor farms rely on IT systems to oversee and plan production such that freshly harvested products can be supplied daily to supermarkets restaurants and catering businesses	25	-1	-18
6. The degree of automation is often high and robots are used in many indoor farms to assist with planting and harvesting	5	-23	-44
7. As recently as five years ago indoor farms were extremely rare	7	0	-2
8. Today they are still rare but are growing in popularity and doing so worldwide	21	-4	3
9. They are often located in or near cities which helps to reduce carbon emissions linked to transport while securing food supply	50	38	26
10. Salad greens and herbs are particularly well suited to being grown in vertical farms and yield up to five times more than traditional farms	50	32	13
11. This allows land that was previously used for food production to be returned to nature	45	25	21
12. Heating cooling and lighting are required to grow fruits and vegetables indoors and the energy requirements of indoor farms are often high	-13	-36	-61
13. This extra cost may need to be passed on to the consumer in the form of premium prices	-36	-53	-68

Notes. <sup>#</sup>) For text *VF-basic*, the 417 participants were divided across the three sentiment groups with 63% in the Positive Group, 20% in the Neutral Group and 17% in the Negative Group. For text *VF-basic + pro/con*, the 420 participants were divided across the three sentiment groups with 63% in the Positive Group, 22% in the Neutral Group and 15% in the Negative Group. \*) Sentences are listed in the order they appeared in the texts.

that comprised the *VF-basic* text, it could be seen that these were numerically different. However, sentence valence was not strongly affected, and rank ordering from most to least positive sentence was virtually unaffected (Table 2).

### 3.2.3. Individual sentiment scores and consumer segmentation

The second approach to sentiment analysis used individual level data and calculated sentiment scores for each participant. While the scores ranged between -100% (when the participant only used 'dislike' highlighting) and 100% (when the participant only used 'like' highlighting), the distribution of sentiment scores was skewed towards positive values, corresponding to median scores of 50% and 35% in, respectively in the *VF-basic* and *VF-basic + pro/con* texts (Supplementary Material shows the histograms). This fitted with the earlier results and the evidence pointing to more frequent use of 'like' than 'dislike' highlighting and with the text explicitly mentioning VF disadvantages being perceived less positively.

The individual sentiment scores were used to identify groups of participants with positive sentiment (Positive Group), neutral/ambivalent sentiment (Neutral/Ambivalent Group) and negative sentiment (Negative Group), and fitting with the aggregate level results, the majority of participants fell into the Positive Group (63% for both *VF-basic* and *VF-basic + pro/con*), with the remainder roughly evenly divided between the Neutral/Ambivalent Group (20–22%) and the Negative Group (15–17%).

Differences between the groups were consistent across the two texts and the *VF-basic* text illustrated these well with positive sentiment scores for each sentence in the Positive Group, negative sentiment scores for each sentence in the Negative Group and a mix of positive and negative sentiment scores in the Neutral/Ambivalent Group (Table 3; Sentences 1 to 6). Regarding pros and cons of VF, all participants were negative about high energy use and premium pricing (Table 3; sentences 12 and

13 in text *VF-basic + pro/con*) regardless of group membership, although stronger negative sentiment (more negative values) were seen in the Negative Group than the Positive Group. The reverse was observed for information about benefits of VF (Table 3; sentences 9 to 11 in text *VF-basic + pro/con*); that is, more positive sentiment expressed by members of the Positive Group than members of the Negative Group.

### 3.3. Validation of text highlighting as a method for attitude measurement

#### 3.3.1. Attitude and behavioural intent questions

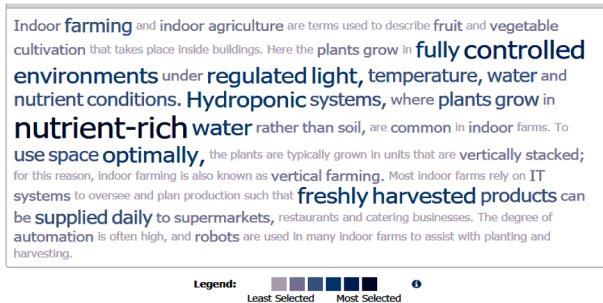
Table 4 shows the results following analysis of the attitude statements considering all participants. The percentages of participants with Agree, Neutral and Disagree attitudinal responses for Statements 1 and 2 in Table 4 were similar to the percentages from consumer segmentation based on individual sentiment scores following text highlighting (Table 3). That is, both approaches revealed a positive opinion about VF being expressed by 62–66% of participants, with a negative opinion about VF being expressed by 11–20% of participants, and the remaining ~ 20% of participants expressing a neutral/ambivalent opinion. Responses to Statement 3, related to premium pricing, reflected disagreement (Table 4), which was consistent with the highlighting results and the negative sentiment for the sentence in the *VF-basic + pro/con* text that referred to cost of VF produce (Table 2). Heterogeneity in consumer responses to the statement related to the potential negative impact of vertical farming on climate change was observed (Table 4), which aligned with the slight negative sentiment of Sentence 12 in the highlighting task performed on the *VF-basic + pro/con* text (Table 2). The last attitude statement in Table 4 addressed an issue that was not mentioned in the highlighting texts – safety of VF produce. Most of the participants agreed with the statement, which fitted with the generally positive attitude towards VF and overall trust in the food supply chain among UK consumers, and thus served as a benchmark for data quality.

**Table 4**

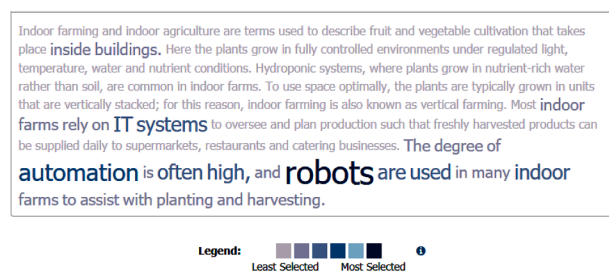
Summary of responses to five attitude and behavioural statements about vertical farming (VF) obtained from participants who completed the highlighting task for the two texts (*VF-basic*, *VF-basic + pro/con*). Responses were obtained on 7-pt Likert scales from 1 = 'strongly disagree' to 7 = 'strongly agree' and classified as Disagree for scale values 1, 2 and 3, Neutral for scale value 4 ('neither agree nor disagree') and Agree for scale values 5, 6 and 7. The shown values are percentages, which for each text sum to 100% within attitude statements.

Attitude and behavioural intent statements about VF	<i>VF-basic</i>			<i>VF-basic + pro/con</i>		
	Agree	Neutral	Disagree	Agree	Neutral	Disagree
1. To me indoor farming sounds like a good idea	62	18	20	66	23	11
2. I would like to try fruits and vegetables grown in indoor farms	66	20	13	65	24	11
3. I would be willing to pay a premium for fruits and vegetables grown in indoor farms	22	18	60	24	23	53
4. It worries me that growing fruits and vegetables indoors will add to the burden of climate change	43	21	36	50	26	23
5. It will be safe to eat fruits and vegetables grown in indoor farms	76	16	8	78	17	5

A) 'Like'

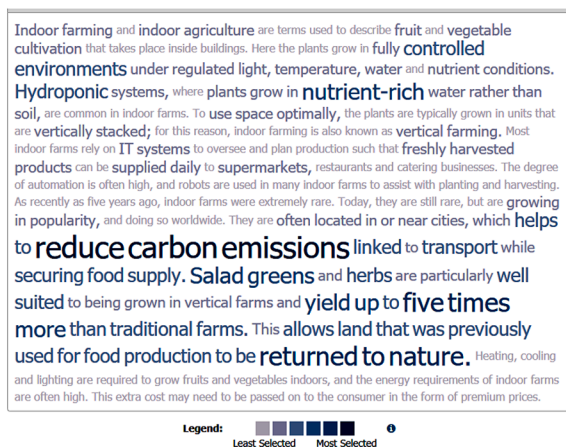


B) 'Dislike'

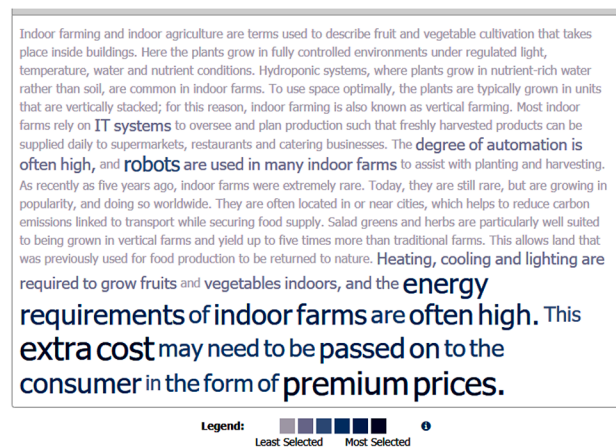


**Fig. 2.** Word clouds for the text that provides basic information about VF (*VF-basic*), shown separately for: A) 'Like' highlights, and B) 'Dislike' highlights.

A) 'Like'



B) 'Dislike'



**Fig. 3.** Word clouds for the text that provides both basic VF information and information about some pros and cons of VF (*VF-basic + pro/con*), shown separately for: A) 'Like' highlights, and B) 'Dislike' highlights.

Differences in responses to the attitude and behavioural intent questions were also found among the groups of consumers who expressed different sentiments towards VF in the text highlighting task. As shown in Fig. 4, participants in the Positive Group (i.e., positive sentiment scores) responded more favourably to the statements describing advantages of VF than participants in the Negative Group (i.e., negative sentiment scores). For example, for the *VF-basic* text, 78% of participants in the Positive Group agreed with the statement "To me indoor farming sounds like a good idea." These percentages were 49% and 20% for the Neutral/Ambivalent Group and Negative Group, respectively (Fig. 4a). The patterns of responses were similar for the two texts, and in all instances fitted expectations with low percentages of participants agreeing with the statement about being willing to pay premium prices for VF produce (e.g., 33%, 10% and 8% for the Positive, Neutral/Ambivalent and Negative Groups; Fig. 4b) and more

participants in the Negative Group agreeing with the statement about the VF adding to the burden of climate change (Fig. 4a, 4b).

### 3.3.2. Characteristics of participants expressing different sentiment to VF in the text highlighting task

*A priori*, it was expected that participants who were more positive toward VF would be lower in FTN, and the results confirmed this. For the *VF-basic* text, average FTN was significantly different for the sentiment groups ( $p < 0.001$ ) with the Negative Group showing the highest FTN scores ( $M = 61.9$ ,  $SD = 9.7$ ), followed by the Neutral/Ambivalent Group ( $M = 55.1$ ,  $SD = 8.2$ ) and finally the Positive Group ( $M = 52.4$ ,  $SD = 9.3$ ). A similar pattern of results was established for the *VF-basic + pro/con* text with the FTN mean score being higher for the Negative Group ( $M = 59.1$ ,  $SD = 9.6$ ) than for the Neutral/Ambivalent Group ( $M = 54.2$ ,  $SD = 7.8$ ) and Positive Group ( $M = 52.1$ ,  $SD = 9.3$ ) ( $p < 0.001$ ).

Frequency of fruit and vegetable (F&V) consumption was not significantly different between the three sentiment groups ( $p > 0.46$ ), but frequency of purchasing organic F&V was, with a greater tendency to do so in the group expressing positive sentiment towards VF in the highlighting task ( $p < 0.001$ ). There was also a significant difference between the sentiment groups in whether or not they had previously heard about VF in the *VF-basic + pro/con* text ( $p = 0.011$ ) and a marginal difference in the *VF-basic* text ( $p = 0.06$ ). The tendency was for people in the groups with positive sentiment to agree that they had previously heard about VF.

There were no systematic differences between the three sentiment groups for gender, age, education and income. Mostly the differences were non-significant with two exceptions for gender in the *VF-basic* text where women were more frequently in the Negative Group than the Positive Group (60% vs 45%,  $p = 0.02$ ) and income in the *VF-basic + pro/con* text (effect not interpretable,  $p = 0.02$ ).

## 4. Discussion

### 4.1. Text highlighting as a new method for attitude measurement

#### 4.1.1. Establishing the potential of text highlighting as a method for attitude measurement

Results from the present work confirmed the potential of text highlighting as a method for attitude measurement. Participants highlighted those aspects of the text that were information rich – nouns and adjectives – and largely ignored prepositions and conjunctions (Figs. 2 and 3). That is, responses were systematic and logical rather than random, a conclusion that was further supported by desirable aspects of VF being most frequently highlighted as ‘like’ (e.g., nutrient-rich, reduced carbon emissions, returned to nature) and undesirable aspects of VF being most frequently highlighted as ‘dislike’ (e.g., robots, high energy requirements, extra cost, premium pricing) (Figs. 2 and 3). These findings were supported by word clouds and numeric summaries of consumer responses (Table 2). Sentiment scores showed positive values for sentences that described desirable aspects and/or consumer benefits and negative values for sentences describing concerns and undesirable aspects. Meanwhile, sentences dominated by non-affective neutral content had sentiment scores closest to zero (e.g., “Indoor farming and indoor agriculture are terms used to describe fruit and vegetable cultivation that takes place inside buildings” and “As recently as five years ago indoor farms were extremely rare”) (Table 2).

Text highlighting responses also made it possible to uncover heterogeneity in consumers’ attitudes, which fits expectations for affective methods in consumer research. The fact that consumers hold different opinions on most topics is well documented, including in the literature on food-related consumer behaviour (Köster, 2003; Næs, Varela, & Berget, 2018). Heterogeneity was evidenced through the percentage of consumers who highlighted words as ‘like’ and ‘dislike’ (Supplementary Material) and the distribution of individual sentiment scores (Supplementary Material). This was the foundation for consumer segmentation based on sentiment analysis (Table 3).

Consumer segmentation based on the overall sentiment towards the texts (positive, neutral/ambivalent, and negative) provided meaningful insights as it enabled identification of groups with different overall attitudes towards VF. Several authors have drawn attention to the importance of segmentation, warning of the inadequacy of aggregate level analyses (Köster, 2003; Næs et al., 2018), and advocating for the additional insights gained by segmentation (Meiselman, 2013). The ability to establish meaningful and interpretable segmentation based on text highlighting data is therefore significant in evaluating its potential as a new method, especially also because consumer segmentation on attitudinal variables is regarded as more informative than segmentation based on demographic and socio-economic variables (Hollywood, Armstrong, & Durkin, 2007; Shepherd & Raats, 1996).

#### 4.1.2. Validating text highlighting responses to confirm methodological potential

To complement the first research aim, which investigated the potential of text highlighting as a method for attitude measurement, the second research aim sought to validate this new method and strengthen the evidence of its potential. For this purpose, two approaches were used. First, a comparison was made with direct attitude questions which are highly popular in attitude research (Fazio, 2007; Krosnick et al., 2005) and therefore can be regarded as a benchmark method. In support of methodological validity, the text highlighting data provided similar results to those from the attitudinal statements rated on Likert scales. This was found both at the aggregate level (Table 4) and for segments of consumers with positive, neutral/ambivalent or negative sentiment towards VF based on the text highlighting task (Fig. 4). Greater direct concordance between the texts and the attitudinal questions would have strengthened this aspect of the research, and to achieve this attitude statements could be worded more similarly to the texts. For example, the statement “It appeals to me that plants grow in stacked layers to save space” could be used to validate ‘like’ and ‘dislike’ highlighting for the partial text sentence “To use space optimally, the plants are typically grown in units that are vertically stacked.”

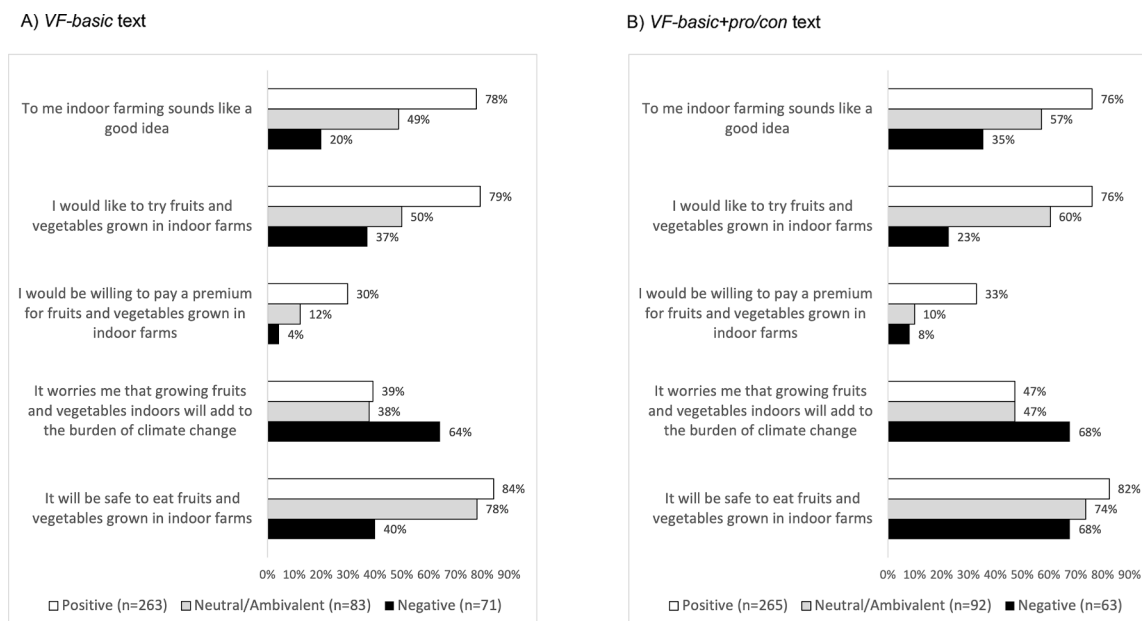
Tentatively, it could be regarded as a limitation of the validation attempt that a within-subjects design was used and always with the text highlighting task preceding direct attitude questions, since a testing bias and order effects could manifest. This possibility cannot be ruled out and future research could use a between-subjects design where one group of participants performed text highlighting and another group read the text and answered direct attitude questions. Certainly, the possibility of testing bias does exist considering the advantages of highlighting in learning, where the act of deciding what to mark and what not to mark may lead students to process textual information at a deeper and more evaluative level than they would when simply reading it (Yue, Storm, Kornell, & Bjork, 2015). Drawing on the Elaboration Likelihood Model of attitude change (Petty & Cacioppo, 1986a), this could imply that text highlighting increases the probability that participants will follow the central route to persuasion, which compared with the peripheral route is associated with attitude change that is more enduring and predictive of behaviour (Petty & Cacioppo, 1986b).

In the second approach to validation, consumer groups with different sentiment towards VF based on the text highlighting task were compared and their differences found to fit expectations. Foremost, we predicted that FTN, which captures fear of novel technologies used in food production and processing (Cox & Evans, 2008), would modulate attitudes, and the results confirmed this with highest average FTN observed in the group with negative sentiment ( $p < 0.001$ ). To extend this approach to method validation, other consumer psychographics could be investigated; for example, concern for the environment (Cruz & Manata, 2020) or trust in science (Bak, 2001). Higher purchase frequency of organic F&V was observed in the Positive Group, which seemed reasonable since consumers who buy organic F&Vs seek natural products that are produced sustainably (e.g., Vukasović, 2015). It also had face validity that participants who stated they had previously heard about VF expressed more positive sentiment in the highlighting task. For F&Bs, unfamiliarity and perceived novelty reduce through exposure, and typically lessen negative impressions.

#### 4.1.3. Future steps in investigating and validating text highlighting as a method for attitude measurement

The present research began the process of investigating and validating text highlighting as a method for attitude measurement. The case study on VF presented evidence that the approach works, which further adds to its desirable characteristics, described in the introduction: familiarity, simplicity, diversity and engagement. Ideally, confirmation of these characteristics with consumers would be obtained, which could be integrated with the required future research to demonstrate that the method works beyond this case study and with diverse consumer





**Fig. 4.** Percentage of participants who stated agreement\* with each of the five attitude and behavioural statements about vertical farming (VF) for groups with Positive, Neutral/Ambivalent and Negative sentiment scores based on the highlighting task. A) Responses from participants who completed highlighting task for the *VF-basic* text and B) Responses from participants who completed highlighting task for the *VF-basic + pro/con* text. *Note.* \*) Values correspond to the percentage of respondents who provided scores equal to 5, 6 or 7 on 7-pt Likert scales from 1='strongly disagree' to 7='strongly agree'.

populations. It can obviously be applied in any written language and may have applicability in cross-cultural research because it is scale-free. The latter, together with familiarity, are positive characteristics it shares in common with emoji, another novel approach that has gained popularity, particularly among children (10 + years old) (Jaeger, Vidal, & Ares, 2021).

A seemingly important topic for future research is to understand the contextual influence that the present results pointed to. Word clouds, frequency tabulations and sentiment scores all suggested that the highlighting responses for the *VF-basic* text changed when this text was combined with the *VF-pro/con* text. Specifically, they changed in the sense of being less frequently highlighted as 'like' and 'dislike' in the *VF-basic + pro/con* text and we speculate that this was due to being presented with text that evoked greater sentiment – positive or negative – among participants. However, since text length changed, this could also have exerted an influence and based on these data these two possible explanations cannot be detangled. Nonetheless, it would not be surprising if textual content influenced attitudes to VF since opinions about food technology are shaped by the available information (e.g., Cattaneo, Lavelli, Proserpio, Laureati, & Pagliarini, 2019). If text length also exerted an influence this would not invalidate text highlighting but rather increase transparency about the fact that the attitudinal responses were obtained in direct response to the presented information.

There is scope to explore data analysis strategies further, including how to create consumer segments. In this research, participants were grouped based on sentiment scores being positive, negative or zero, and we chose this approach based on expectations about how consumers perform the text highlighting task, wherein people may not highlight all of the text that they 'like' and 'dislike' but only text that exceeds an idiosyncratic threshold (Jaeger et al., 2020). Based on this assumption about task completion, sentiment scores do not have interval properties. Yet, it may nonetheless be sensible to make a distinction between consumers with "weak" vs "strong" positive sentiment towards VF, considering the wide range of observed positive scores. Mean ratings on Likert statements for segments created this way could be compared with the expectation that higher means would be found in the "strong" positive sentiment group.

Considering also that consistency and reliability are important in

attitude measurement, future research should investigate this aspect of text highlighting, possibly with inspiration from scale research where multiple-item scales have been used with great success for many decades (e.g., Edwards & Kilpatrick, 1948).

#### 4.2. Insights about consumer acceptance of vertical farming

In addition to its methodological contribution, the present research also contributes new knowledge about consumer acceptance of VF. Since this technology is still in the earlier stages of implementation, the extant literature on consumers' opinions about VF is currently limited.

A unique contribution of the present research was the ability to establish which aspects of VF were responded positively and negatively to, on average (Figs. 2 and 3, Table 2). In regard to the *VF-basic* text, there was no strong sentiment response when reading that plants grown inside buildings and even a moderately positive sentiment on average to information that plants grow in fully controlled environments under regulated light temperature water and nutrient conditions, often in hydroponic systems (Table 2). Juxta positioned to traditional agricultural production, which is soil-based and outdoors, VF has been linked to unnaturalness (e.g., Jürkenbeck et al., 2019; Specht & Sanyé-Mengual, 2017; Yano, Nakamura, Ishitsuka, & Maruyama, 2021) but possibly it is another aspect of VF that consumers react negatively to, such as reliance on IT, automation and robots (Figs. 2 and 3, Table 2). The latter may be viewed unfavourably because of concern for rural workers and communities (Benke & Tomkins, 2017). More in-depth exploration of such perceptions seems warranted and can be achieved with text highlighting by using texts that provide different / additional information about VF. Considering that consumer benefits are important for the adoption of new technologies (e.g., Choi & Ji, 2015; Mather et al., 2012), VF could be described with greater emphasis on these, including low use of pesticides and fertilisers or reduced water requirements (e.g., Beacham et al., 2019). Whether researchers do this when explaining to participants what VF is (e.g., Jürkenbeck et al., 2019), or draw attention to other facts or use more scientific/production focused language (e.g., plant factory with artificial light; Butturini & Marcelis, 2020) will likely influence results and text highlighting can capture and quantify such effects.

The identification of consumer segments with different attitudes towards VF is also a useful knowledge contribution, and although not unexpected that segmentation would exist (since it does for “all” other topics), information about those aspects of VF that consumers responded more similarly to (e.g., premium price, reduced carbon emissions) and those that they had divided opinions about (e.g., IT systems, automation, robots) is valuable. The segments were not systematically different in terms of composition by gender, age, education and income, despite younger age being often mentioned as a factor influencing positive attitude to novel food production methods and consumption behaviours, especially when associated with environmental benefits (e.g., Cardello, Schutz, & Leshner, 2007; Janssen, Busch, Rödiger, & Hamm, 2016). The general positive attitudes to VF found in this research may explain this difference, and possibly the benefit of returning agricultural land to nature appealed more strongly to older consumers, who were therefore also positive toward VF, albeit for a different reason. It would be possible to investigate such explanations by using age group as basis for segmentation of the sentiment scores obtained in text highlighting.

## 5. Conclusions

The present research introduced text highlighting as a new method for explicit attitude measurement. The task is simple with high expected familiarity, and it was successfully implemented with 837 consumers in a case study on vertical farming. Data could be easily summarised using word clouds and processed in greater depth to derive quantitative sentiment scores that enabled consumer segmentation. Comparison with direct attitude questions and consumer profiling validated the highlighting results and thus the method’s potential in attitude research. Replication and extension are needed.

## CRedit authorship contribution statement

**Sara R. Jaeger:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Sok L. Chheang:** Investigation, Data curation. **Gastón Ares:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

## Declaration of Competing Interest

Given her role as Editor at the time of submission, author SRJ was not involved in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another editor, as per the journal guidelines. Authors SLC and GA declare no conflicts of interest.

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## Appendix A. Supplementary data

Supplementary data to this article contains: 1) Summary of participant characteristics for the two text conditions (*VF-basic*, *VF-basic + pro/con*); 2) The two highlighting texts in paragraph format; 3) Histograms for word highlighting (total, ‘like’ and ‘dislike’) in text *VF-basic*; 4) Histograms for word highlighting (total, ‘like’ and ‘dislike’) in text *VF-basic + pro/con*; 5) Histograms for individual sentiment scores in the two texts (*VF-basic*, *VF-basic + pro/con*).

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodqual.2021.104356>.

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