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Analytic-holistic tendencies differentially impact consumer response dependent on measurement method and context: A case study with chocolate

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ABSTRACT

As sensory and consumer researchers work to better understand consumer decision-making, a focus on consumer product evaluation in environments that are closer to the real world than traditional central location tests has emerged. However, not all consumers respond in the same way across different environments. The notion that variations in cognitive styles, namely analytic-holistic tendencies, impact consumer response and susceptibility to context effects has been highlighted in existing literature. This typically sized consumer sensory study (n = 115) investigated whether grouping participants based on analytic-holistic tendencies provided additional insight into consumer response to chocolate in a traditional CLT and an immersive home virtual environment (VE). Whole-sample analysis indicated differences in sensory perception based on context, across both traditional sensory intensity questions and a speeded-response task. Furthermore, based on context, the holistic group (n = 56) exhibited changes in emotional and conceptual product association speeded-responses, whilst the analytic group showed changes in sensory product association speeded-responses. No between-group differences existed when considering liking or sensory perception. However, the analytic group (n = 59) exhibited more significant mean drops in liking than the holistic group when attributes were not Just-About-Right, which was particularly apparent in the VE environment. Findings indicate that the food-related cognitive thinking style tool used may not measure a single coherent construct. Nevertheless, using such a tool can provide insights into consumer decision-making. Results also suggest that context may have differential effects across certain groups of consumers; a consideration for sensory and consumer scientists when deciding on testing methods.

1. Introduction

Sensory and consumer researchers are striving to better understand the consumer experience, with the aim of improving product success in the market (Giacalone, 2018). This is a complex task requiring consideration of factors including the consumer, the product, the environmental context in which the product is consumed, and their interactions (Meiselman, 1996). Considering context, products are often tested in controlled environments, which may not reflect how consumers behave in the real world; therefore, testing in realistic environments is of current interest to the food industry (Bangcuyo et al., 2015; Giezenaar & Hort, 2021; Low et al., 2021). For instance, existing research has found evidence to support cognitively evoked situational contexts can impact consumer expectations and their sensory experience (Lee et al., 2021); and that acceptance testing in an immersive environment is preferrable to a lab-based environment for context-sensitive products, as it offers results that are more in-line with the real world (Lichters et al., 2021). Further research has found consumers are better at discriminating between products on liking in more realistic environments (Bangcuyo et al., 2015) and penalise liking more for non-JAR attributes in personally relevant environments (Man et al., 2023). These results suggest that consumer assessments and the value obtained from a product may differ based on environmental context, which may be due to changes in expectation (Bangcuyo et al., 2015; Man et al., 2023). From a product development perspective, capturing data that is as close to real life as possible is important, but further research is required to understand the full effects of consumption context. It is understood that consumption contexts vary and can be defined by considering many

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factors, including social aspects, event, location and environmental cues such as background noise or props (Stelick & Dando, 2018). In the current study, the term context is used in relation to non-social environmental changes that come from evaluating chocolate with consumers in a digital immersive virtual environment (now referred to as VE) that mimics a typical consumption environment, comparing it with a central location test (CLT).

Consumption experience is likely to differ between consumers depending on factors such as, their previous experience with the product, their likes, differences in sensory perception and their motivations (see Næs et al., 2018 for an interesting discussion on individual differences in consumer sensory research). Therefore, by better understanding the consumer at an individual, rather than aggregate level, there is scope to inform the interpretation of consumer sensory results and enhance knowledge required for practical decision making (Beekman et al., 2022; Feeney et al., 2024; Jaeger et al., 2017; Næs et al., 2018).

Existing research has found links between thinking styles and food choices, including analytic-rational thinking and a deeper search for information on yoghurt labels (Gastón Ares et al., 2014) and a rational decision-making style and positive attitudes to insect based foods (Vanutelli et al., 2024). Cognitive styles, related to analytic-holistic thinking tendencies, have also been investigated to better understand responses to food (for a review see Beekman et al., 2022).

Adopting cognitive style questionnaires, such as the Analysis-Holism Scale (AHS) (Choi et al., 2007) allows consumers to be categorized as having analytic or holistic tendencies. Individuals with holistic tendencies seek varying perspectives and focus on the global context, that is, the relationships between an object and its surroundings (Nisbett et al., 2001). Individuals with analytic tendencies tend to place more focus on the individual aspects of a situation, see separation between objects and their surroundings, and tend to make rules-based categorisations (Nisbett et al., 2001). Research has found that participants from countries characterised by holistic cognitive styles give more attention to contextual cues than participants from countries characterised by analytic thinking styles (Masuda & Nisbett, 2001). Moreover, an association has been found between individuals from a culture characterised by holistic thinking and perception of a focal food item as more satiating when surrounded by foods low in expected satiation (Cheon et al., 2022), which emphasises the relative nature of decision-making. Eye-tracking has also been adopted to investigate attention to background when viewing food images, with findings showing participants from holistically focused cultures give more attention to the background than participants from cultures who tend to view the world more analytically (Zhang & Seo, 2015). An association between holistic thinking and craving indulgent food, when viewing an advertisement with a consumption occasion background, has also been reported (Hildebrand et al., 2019). Therefore, existing individual differences research points to the potential that consumers may be affected differently by context, based on their analytic-holistic tendencies. In fact, there is evidence from a predominantly intracultural consumer sensory study that showed holistic participants gave more attention to contextual elements than analytic participants, who tended to focus on individual attributes of a food situation (Beekman & Seo, 2022).

Furthermore, in a study evaluating sensory perceptions of different products, individuals with more holistic tendencies gave higher hedonic ratings and showed lower mean drops in liking when sensory attributes were not considered to be ideal, when compared with individuals with analytic tendencies, who were more critical and sample-focused (Beekman & Seo, 2024). These findings suggest consumer responses can be influenced by cognitive style. This may also be true for emotion-related responses, as individuals from a holistic thinking culture have been found to rely on contextual cues more than individuals from an analytic thinking culture when interpreting facial emotions (Masuda et al., 2008). Therefore, it is prudent to understand whether emotion-related responses to food products are also influenced to a varying degree, based on analytic-holistic tendencies. This is especially important given the continued focus on understanding food-evoked emotions for a clearer insight into consumer decision-making (see the following reviews for relevant literature Lagast et al., 2017; Low et al., 2022).

Studies by the developers of a food-related analysis-holism scale (F-AHS) have investigated this to some extent (Beekman & Seo, 2022, 2023, 2024), but more work is needed to enable the industry to better understand if collecting information on cognitive styles is worthwhile and practical for standard consumer sensory testing. Such cognitive styles have also been noted for their relationship to culture, and research has highlighted the importance of investigating research topics cross-culturally to check if findings vary (Nisbett et al., 2001). The current study offered insight into an individual difference in cognitive style that can affect responses to food (Beekman & Seo, 2023; Beekman & Seo, 2024; Cheon et al., 2022; Zhang & Seo, 2015) and one that is important to sensory and consumer research, which has continuing interest in exploring cross-cultural variations (Meiselman et al., 2022).

This study aimed to further test the notion that outcomes of consumer and sensory studies may change based on participant analytic-holistic cognitive style, particularly when different contexts are adopted.

Specifically, the key objectives were to investigate:

i) the impact of cognitive style on a range of typically collected consumer responses including hedonic liking, emotional and sensory associations, and perceived sensory attribute intensity.
ii) the impact of context on consumer response to chocolate.
iii) whether grouping consumers by cognitive style affords deeper insights than whole sample population data.

Based on findings in the recent literature, it was hypothesised that:

1) Context would influence sensory perception (attribute intensity ratings) when whole-sample analysis was performed.
2) Holistic individuals would have higher liking ratings for chocolate samples than analytic participants.
3) Holistic individuals would be more affected by context than analytic participants, observed via more significant differences in sensory intensity ratings when comparing data from VE and CLT contexts.
4) More significant mean drops in liking in penalty analyses would be observed for the analytic group than for the holistic group.

The study also compared speeded responses to emotional/sensory words between analytic and holistic participants; however, as this has not featured in existing literature, no specific hypothesis was stated.

2. Material and methods

2.1. Participants

Participants (n = 118) were recruited through the Feast (Food experience and sensory testing) laboratory, (Massey University Palmerston North, New Zealand) consumer database. They were aged between 18 and 65 yr old (77% female and 23% male), with no dairy allergies or intolerances and were also required to be proficient in English and be chocolate consumers. Chocolate consumers were defined as individuals consuming chocolate at least once a month.

The study was assessed as low risk following the Massey University Human Ethics Committee process (Ethics Notification Number: 4000029300). All participants were informed about the study procedure and signed a consent form before commencing the study. After the session was finished, participants received a supermarket voucher in compensation for their time.

2.2. Screening

As part of the study recruitment, using a previous study for guidance (Castura et al., 2023), participants were requested to complete a

screening questionnaire asking chocolate consumption frequency, whether they preferred milk, dark or white chocolate and an open question describing their most recent experience of consuming chocolate. This was carried out to ensure engaged and attentive consumers were recruited for the study to help improve data quality. As a further check, participants were given a list of chocolate brands and asked to state which brands they had consumed in the previous six months. The brands included eight well-known brands available in New Zealand and two brands that were fictive. Participants reporting to have consumed the fictive brands were not invited to participate in the study nor were those who gave no or very limited information for the open question.

2.3. Samples

Chocolate has previously been studied when investigating analytic-holistic tendencies and indulgent food cravings and consumption imagery (Hildebrand et al., 2019). It is also a highly accepted, familiar product, which has been studied extensively in sensory and consumer research (eg. Kong et al., 2020; Schouteten et al., 2018; Thomson et al., 2010).

Chocolate samples were commercially made (Kapiti Chocolate Factory, Paraparaumu, New Zealand) specifically for the study and included a 32% milk chocolate and a 47% dark chocolate sample. Samples were square, weighed 5 g and served in their individual foil packaging, with assigned three-digit codes printed on top (Fig. 1). Two codes were assigned to milk chocolate and two to the dark chocolate. Participants received a different code for each sample in each condition). A 45% cocoa content sample (Bennetts of Mangawhai, New Zealand) was used as a dummy sample to prevent any first sample order effects (Lawless & Heymann, 2010). The practice sample (5 g) was served unwrapped on a napkin and had no branding information.

2.4. Contexts

The study ran for four days (4 sessions per day) with participants attending one session where they evaluated chocolates across two different contexts. The contexts were a traditional CLT, and a digital immersive home environment. This simulation was achieved by projecting a 360° image of a kitchen and dining space in Feast's digital immersive space (Igloo Vision©, Craven Arms, UK). A television was placed in the room and displayed a looped sequence of five videos from 1News (TVNZ, retrieved from https://www.1news.co.nz/). Other props such as tablecloths, small bookshelves and plants were used. The tables in both contexts were arranged in the same way (see Fig. 2). Participants were assigned the same table number in both contexts, meaning they sat beside the same person to prevent any variations in the social aspects of the eating environment. Participants did not talk with each other during the session. The temperature of both the VE room and the CLT were set at 21 °C. Half the sessions were started with the VE context, half with the CLT context. Due to no-shows and issues with data capture, 60 participants participated in the CLT first and 55 participated in the VE first.

Fig. 1. Chocolate samples served in silver packaging with unique 3-digit codes.

2.5. Speeded response task

A speeded response task, similar to that utilised in previous consumer research was adopted (Haase & Wiedmann, 2020; Till et al., 2011). By utilising a task assessing emotional associations to the samples, which may be closer to automatic than self-reported responses (Ranganath et al., 2008), any differences based on cognitive thinking styles could be identified at different levels of processing. Participants practiced the speeded response task at the beginning of the session after the instructions were given to allow them to get used to responding quickly. For the practice, participants were asked to press 'yes' as quickly as they could if the term could be associated with the weather, such as 'hot', and to press 'no' as quickly as they could if the term would not normally be associated with the weather, such as 'face'. Participants were informed this was for practice only and were given the opportunity to receive further instruction on the speeded response task before proceeding to the experimental task if they required.

Sixteen words were selected as stimuli for the research task including eight individual words from 12 word-pairs from an emotion questionnaire adapted for products from the circumplex of emotions (Jaeger et al., 2020). As word-pairs can be confusing to participants in a speeded response task, in-house testing supported the idea of including the word from each word pair that was the easiest to respond to for participants. The chosen words included 'passive', 'nervous', 'relaxed', 'energetic', 'active', 'unhappy', 'bored', 'happy'. The sensory terms 'bitter', 'hard', 'creamy', 'sweet', and 'soft' were also included in this task to determine whether variations in sensory perception brought about by different contexts, could be found in these responses. The conceptual terms 'healthy', 'indulgent' and 'tasty' were also included for exploratory purposes. Participants were asked to respond based on whether they associated the words with the sample they had just tasted. Each word was randomly shown twice for a maximum viewing time of 3000 ms, with a 1000 ms fixation cross between words.

Words appeared in black on a white background, with text size coded at 5% of the screen size in Inquisit 6 (Inquisit 6.6.3, Millisecond, USA, 2022). The 'no', 'yes' response buttons were visible on the iPad screen during the display of all word terms but not visible during the fixations. This task took approximately two and a half minutes including the time to read instructions.

2.6. Liking task

Participants were asked how much they liked the chocolate. Responses were given on an 11-point scale with the label anchors 'dislike extremely' and 'like extremely' at the scale ends and 'neither like nor dislike' in the middle.

2.7. JAR scales

Participants were asked to rate their opinion of the chocolates for the attributes bitterness, sweetness, creaminess, and hardness. The attributes were presented randomly with a 5-point scale including the label anchors 'too little', 'just-about-right', and 'too much' at points 1,3 and 5 respectively.

2.8. Sensory attribute intensity scales

Participants were also asked to rate their perceived intensity of the attributes bitterness, sweetness, creaminess, and hardness. The attributes were presented randomly with an 11-point horizontal scale, which included the label anchors 'not at all' and 'extremely' at either end.

Fig. 2. a) Central Location Test (CLT) set-up, b) Home-dining digital immersive virtual environment (VE) set-up (headphones not used in this study).

2.9. Individual differences questionnaires

Following all chocolate evaluation, participants were directed to a survey, which included questions from a series of pre-validated, published questionnaires related to food and technology traits and behaviours including the 1) Food Neophobia Scale (Pliner & Hobden, 1992), 2) Health, Familiarity, Sensory Appeal, Mood subscales from the Food Choice Questionnaire (Steptoe et al., 1995), and 3) F-AHS (Beekman & Seo, 2023). Data from the F-AHS only was of interest to the aims of this paper; therefore, the remaining questionnaires are not discussed further. The F-AHS scale is a 15-item, 7-point scale measuring analytic-holistic tendencies specific to food, developed for use in sensory and consumer research (Beekman & Seo, 2023). The scale contains five reverse-scored questions. It was given to participants preceded by instructions in line with those advised by the developers (Table 1 taken from Beekman & Seo, 2023).

2.10. Demographic questions

Following all tasks, participants were asked to provide information on their age, gender and ethnicity to characterise the participant sample.

2.11. Procedure

The full experiment was coded in Inquisit 6 (Inquisit 6.6.3, Millisecond, USA, 2022), Inquisit Web was used to run the script on iPads (6th Generation, Apple, California, 2018). All tasks were completed using the touchscreen.

Sample presentation order was counterbalanced across participants. Following participant consent, the session started with the researcher presenting a video designed to give participants an overview of what would be expected of them in the session. This was presented on a projector by the researcher and enabled consistent instructions to be given to all participants across all sessions (for a visual overview of the session see Fig. 3).

The first task was the practice speeded response task, which was carried out before the sensory testing began. After instructions and completion of the practice task, participants started the sensory testing, which followed the same format in both contexts. Participants tasted the practice milk chocolate sample first, which allowed them to have a run-through of the consumption instructions and acted as a dummy sample before experimental data were collected. Participants were instructed to have a sip of water then place the sample in their mouth for five seconds before eating as they normally would. No questions were asked for the practice sample consumption, instead participants were directly instructed to palate cleanse. They were then instructed to consume the next sample in the same way as the first sample and complete questions in the speeded response task, followed by ratings of liking and sensory attributes using both the JAR and sensory intensity scales. Following another palate cleanse, participants carried out the same procedure for the second chocolate sample. A short break (5 min) was given to participants before moving through to the second context where they carried out the same sensory testing with the same products but with different 3-digit codes assigned. Following evaluation of all samples, participants completed the series of individual differences questionnaires including the F-AHS.

2.12. Data analysis

Data wrangling and cleaning was carried out in R using the tidyverse (Wickham et al., 2019) and dplyr (Wickham et al., 2023) packages. Plots were generated using ggstatsplot (Patil, 2021). All analysis was carried out in JASP version 0.18.1 (JASP Team, Netherlands, 2023), excepting penalty analysis and CATA analysis, which was carried out in XLSTAT

Table 1
Food-related analysis-holism scale (F-AHS) Items. Note: from Beekman and Seo (2023).

The surrounding store environment determines what I will buy when shopping for food.
I let my feelings decide what I will buy when shopping for food.
Promotions and coupons influence what food I buy.
I only purchase items that are on my grocery list.
I will only buy a food if I know I already like it.
Advertisements and displays never impact what foods I buy.
Preparing one part of a meal is dependent on all other aspects of the meal.
A small change when cooking can have significant impacts on all other aspects of the food.
All aspects of a meal I make must be connected to one another.
When I prepare a meal, I also focus on table setting that will go with the meal.
When I prepare a meal, I focus on featuring a single attribute or ingredient of the meal.
My feelings and experiences determine my perception of food I am eating.
Food liking is dependent on my overall perception of the food.
If I currently like a food product, I will always like that food in the future.
My opinions of food products are continuously changing.

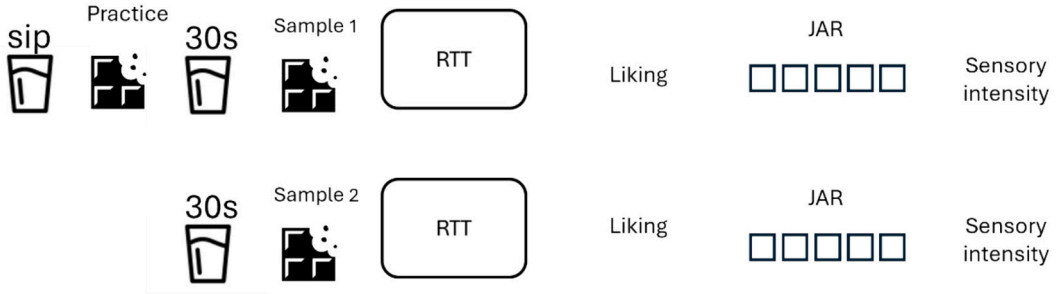

Fig. 3. Visual representation of the tasks and their order during the testing session. These were the same in both contexts with context one having instructions proceeding the experiment. At the end of the chocolate tasting, participants completed the food-related analysis-holism scale before leaving the session. RTT – Response Time Task (Speeded Response Task).

version 2023.2.1414 (Lumivero, USA, 2024). The significance level (α) was set at 0.05.

2.12.1. Liking and sensory attribute intensity analysis

Paired *t*-tests were run with data from the whole sample to determine differences in liking and sensory intensity ratings for each chocolate separately based on context. Bonferroni corrections were applied to control for family-wise error. Where data were found to violate assumptions of normality, the non-parametric Wilcoxon signed-rank test was run instead. To give further insight into the effect of cognitive styles on consumer response, a series of mixed ANOVAs were run, with context as a within-subjects factor and cognitive style group as a between-subjects factor with the dependent variables being liking or sensory intensity ratings. These were run with data from each chocolate separately. Post hoc tests were run on significant findings with Bonferroni corrections applied.

2.12.2. Speeded response task

To determine citation frequency based on consumer response to two repetitions of the same term, where a participant responded inconsistently, that is by saying 'yes' to one repetition and 'no' to another, citations were coded as zero (equal to a 'no' response). This task was a forced-choice task, rather than a traditional check-all-that-apply (CATA); however, previous research has found that, although citation frequency tended to be higher for forced-choice than CATA, forced-choice questions elicited similar results for insight into consumer product evaluations (Jaeger et al., 2014). Citation frequencies were analysed using typical CATA data analysis methods: data were used to construct contingency tables detailing the number of consumers who selected 'yes' to each term for each of the chocolate samples (Ares & Varela, 2018). For each chocolate type, Cochran's Q tests were applied to determine whether the frequency of term selection differed significantly between contexts (CLT vs VE). These analyses were also run separately for cognitive style groups. Where post hoc pairwise comparisons were run, the McNemar procedure was adopted. Finally, in line with previous literature (Beekman & Seo, 2022), total citation frequency was calculated for all terms selected in each context and a difference score was calculated by subtracting the total citation frequency of the VE from that in the CLT. An independent *t*-test was run on this difference score to check if the impact of context was significantly different for the holistic and analytic groups.

2.12.3. Food-related analysis-holism scale (F-AHS)

Each item of the 15-item scale was scored using the developers' instructions, including reverse scoring of items 4, 5, 6, 11 and 14 (Beekman & Seo, 2023). All item scores were totalled to give an overall score for each participant. As the study was a typically sized sensory study, it would be impractical to use only participants with a mean score greater or less than one standard deviation above or below the mean F-AHS, as was adopted in the study used to validate the questionnaire (Beekman & Seo, 2023). Instead, a median split was adopted, in line with previous research looking at cognitive styles and their impact on consumer perception (Beekman & Seo, 2022). Reliability analysis was also run on the F-AHS item data to establish internal consistency (Cronbach's alpha at 95% CI).

2.12.4. Penalty analysis

Penalty analysis was conducted on JAR data for milk and dark chocolate separately for the analytic and holistic groups in each context. JAR categories 1 and 2 were collapsed as were categories 4 and 5. The mean liking scores of the newly formed categories were compared to calculate mean drops in liking, carried out as per the penalty analysis procedure in XLSTAT (Lumivero, USA, 2024). Only attributes outside the JAR category for at least 20% of consumers were of interest. This allowed for an overview of sensory terms that impacted liking for the two cognitive style groups for the different chocolate types in the CLT and VE separately. Analysing these factors separately was important as 1) the chocolates had a different sensory profile so analysing pooled data would not be insightful, 2) comparing findings from a CLT and VE was required, and 3) there was a need to better understand the differences between cognitive groups and how they penalise liking scores when attributes are not ideal in different contexts.

3. Results

Three participants were removed due to a data capture issue during the session leaving 115 in the analysis. Of the participants, 53% identified as NZ European, 27% as Asian, 5% as Non-NZ European, 3.4% as Latin American,1.7% as Māori, 1.7% as African, 0.9% as Middle Eastern and the remainder as an 'other' ethnicity. Following a median split on participant F-AHS scores, two groups were formed with 59 in the analytic group (observed range of scores 50–67, mean item = 4.12) and 56 in the holistic group (observed range of scores 68–92, mean item = 4.99). Of the 115 participants in the study, 41 participants stated they usually preferred dark chocolate, 70 usually preferred milk chocolate and 4 preferred white chocolate. The proportion of participants in the preferred chocolate categories was similar for both groups ($p = .998$). This was also the case for gender categories ($p = .297$). There were also no significant differences in reported ethnicities of the participants making up the groups.

3.1. Liking

Paired samples *t*-tests revealed that liking ratings for both milk and dark chocolate did not change based on context (all $ps > 0.779$). There were also no differences between milk and dark chocolate liking ratings in either context (all $ps > 0.281$), see Fig. 4 for ratings.

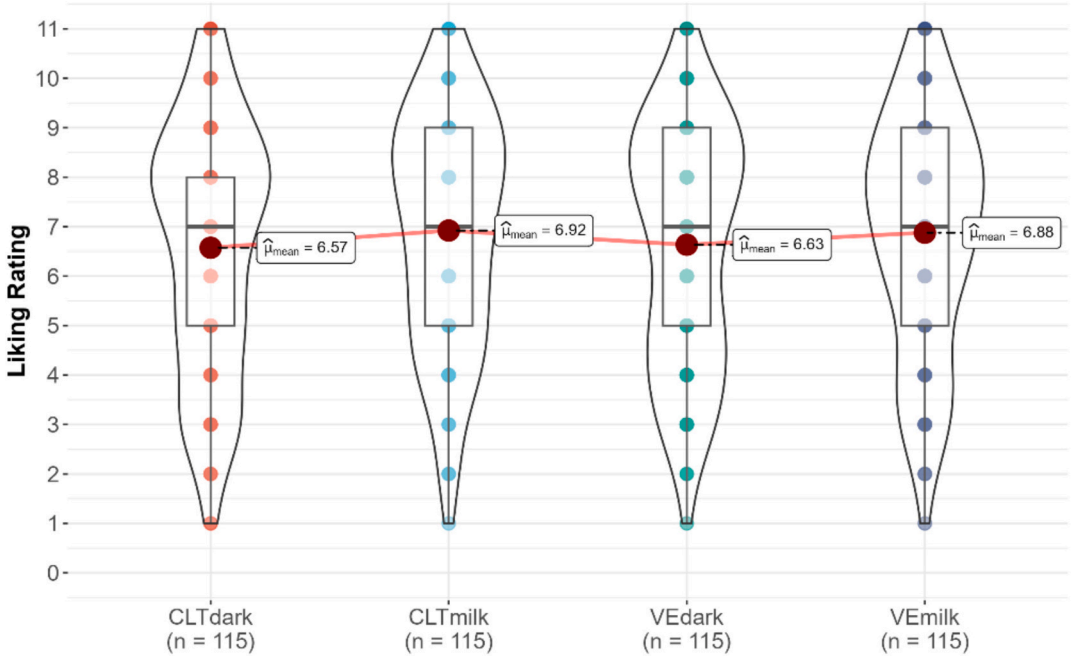

Fig. 4. Liking ratings of chocolate by context and sample. Red circle indicates the mean; box and whisker plots show lower quartile, median and upper quartile; smaller circles denote data points with shading representing frequency (lighter = fewer). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.2. Sensory intensity

With an α = 0.006 (controlling for family-wise error), Wilcoxon signed-rank tests revealed a significant difference in hardness ratings for the milk chocolate based on context, with the CLT eliciting a lower rating than the VE ($p < .001$). This was not the case for hardness of dark chocolate and in fact, there were no significant differences in sensory intensity ratings of any attribute for the dark chocolate (all $ps > 0.454$). Creaminess ($p = .038$) and bitterness ratings ($p = .027$) for milk chocolate were initially significant before correction, (see Table 2 for intensity ratings).

3.3. Citation frequency – Speeded response task terms

Results of CATA analysis on citation frequency for terms selected as associated with the chocolate, revealed a significant difference for the terms "tasty", "hard" and "sweet" for milk chocolate based on context (see Table 3), with the CLT eliciting higher citation frequencies for "sweet" and "tasty", and the VE eliciting higher citation frequencies for "hard". The term "bitter" was significantly different based on context for the dark chocolate, eliciting more citations in the CLT than in the VE (see Table 3).

3.4. Penalty analysis

The milk chocolate sample results revealed participants gave more significant mean drops in liking when an attribute was considered outside of the JAR category when in the VE than when the same

Table 2
Mean attribute intensity rating (SD) for each chocolate by context. Significant differences within each chocolate type (milk or dark) are shown in bold.

Attribute	Milk CLT	Milk VE	Dark CLT	Dark VE
Bitterness	3.21 (2.07)	3.50 (2.06)	6.43 (2.27)	6.38 (2.14)
Creaminess	6.68 (1.78)	6.26 (1.98)	4.88 (1.87)	4.93 (1.84)
Hardness	**5.84 (1.67)**	**6.39 (1.74)**	7.23 (1.72)	7.23 (1.60)
Sweetness	7.85 (1.98)	7.64 (1.98)	5.99 (2.13)	5.87 (2.17)

Table 3
Comparison of citation frequencies by context for milk chocolate. Different letters on the same row denote a significant difference between contexts at α = 0.05; significant differences also shown in bold.

Milk Chocolate		
Attributes	**CLT milk choc**	**VE milk choc**
Active	0.304 (a)	0.330 (a)
Bitter	0.052 (a)	0.087 (a)
Bored	0.017 (a)	0.061 (a)
Creamy	0.817 (a)	0.722 (a)
Energetic	0.400 (a)	0.365 (a)
Happy	0.739 (a)	0.713 (a)
Hard	**0.313 (a)**	**0.461 (b)**
Healthy	0.157 (a)	0.165 (a)
Indulgent	0.617 (a)	0.609 (a)
Nervous	0.052 (a)	0.035 (a)
Passive	0.191 (a)	0.226 (a)
Relaxed	0.600 (a)	0.661 (a)
Soft	0.435 (a)	0.435 (a)
Sweet	**0.948 (b)**	**0.878 (a)**
Tasty	**0.817 (b)**	**0.704 (a)**
Unhappy	0.043 (a)	0.035 (a)
	Dark Chocolate	
Attributes	**CLT dark choc**	**VE dark choc**
Active	0.383 (a)	0.383 (a)
Bitter	**0.617 (b)**	**0.504 (a)**
Bored	0.078 (a)	0.096 (a)
Creamy	0.409 (a)	0.426 (a)
Energetic	0.435 (a)	0.417 (a)
Happy	0.626 (a)	0.687 (a)
Hard	0.757 (a)	0.765 (a)
Healthy	0.339 (a)	0.374 (a)
Indulgent	0.530 (a)	0.530 (a)
Nervous	0.061 (a)	0.026 (a)
Passive	0.191 (a)	0.200 (a)
Relaxed	0.487 (a)	0.548 (a)
Soft	0.139 (a)	0.104 (a)
Sweet	0.591 (a)	0.574 (a)
Tasty	0.652 (a)	0.687 (a)
Unhappy	0.070 (a)	0.061 (a)

chocolate was evaluated in the CLT. This was also true for the dark chocolate sample but only for the hardness attribute (see Table 4).

3.5. F-AHS analysis

Reliability analysis revealed the F-AHS to have a Cronbach's alpha of 0.55, which may be considered lower than acceptable (Tavakol & Dennick, 2011). This value is in line with the findings of Beekman and Seo (2023) during their studies developing the questionnaire. Cronbach's alpha measures the extent to which the items in the questionnaire are measuring the same construct (Tavakol & Dennick, 2011). Therefore, a low value may be indicative of the food-related analytic/holistic cognitive thinking style not being a single coherent construct. Other measures of reliability such as test-retest estimates give an insight into the consistency of scoring on tests at two points in time. A subsequent unpublished study with 110 consumers at the Feast Lab was carried out involving completion of the questionnaire at two timepoints (approximately 2.5 weeks apart) and found moderate reliability, *ICC(2,1) = 0.59, 95% CI [0.46, 0.7]* (Wagner & Poggesi, 2025) . Moreover, previous literature cites correlations between F-AHS scores taken on the same day before sensory evaluation and after sensory evaluation as having an $r >$ 0.78 (carried out at the level of the cognitive style group) (Beekman & Seo, 2023). This suggests that responses are relatively consistent across timepoints; however, some change may take place based on situational factors. Indeed, literature utilising the Analysis-Holism Scale (AHS) has found changes in scores following sensory evaluations, mainly for holistic participants (Beekman & Seo, 2024).

3.5.1. Liking by cognitive style

Results of mixed ANOVAs run separately on liking of milk and dark, showed no significant main effects or interactions (all *ps* > 0.156), see Table 5 for ratings.

3.5.2. Sensory intensity by cognitive style

Results of mixed ANOVAs run on each sensory attribute intensity, showed a main effect of context for hardness ($p < .001$) and creaminess ($p = .021$) for the milk chocolate sample, with hardness rated higher in the VE than the CLT and creaminess rated higher in the CLT than the VE (see Fig. 5). However, only the hardness attribute survived Bonferroni corrections ($\alpha = 0.006$ if considering the family of sensory attributes). No significant effects of cognitive style or any interactions for ratings of attribute intensities existed.

3.5.3. Citation frequency – Speeded response task terms

Results of CATA analysis on citation frequencies for terms selected as associated with chocolate, revealed significant differences in citation frequency of the term "tasty" across contexts for the milk chocolate and the term "relaxed" for the dark chocolate for the holistic group (see Tables 6 and 7 for results for each group in both contexts run for each chocolate separately), whilst results from the analytic group data revealed differences across contexts in sensory terms "hard" for the milk chocolate and "bitter" for the dark chocolate. When comparing milk and dark chocolate for each F-AHS group, both groups showed significant differences in the citations of sensory terms, "creamy", "soft" and "sweet" (cited more frequently for milk versus dark chocolate), bitter and hard (cited more frequently for dark versus milk chocolate) in both contexts (all *ps* < 0.05). The analytic group cited "healthy" for dark chocolate significantly more frequently than they did for milk chocolate in both contexts, whilst this was only significant in the VE for the holistic group. The holistic group also differentiated the milk (citation proportion = 0.768) from dark chocolate (citation proportion = 0.554) on the term "happy" in the CLT, but this was not significant in the VE ($p > .05$).

An independent t-test testing for a between group difference on the difference of total citations in each context for chocolate samples combined, was not significant ($p = .401$).

Table 4
Results of penalty analysis showing the impact on liking ratings (mean drop) for attributes cited as non-JAR. Mean drops in bold indicate significantly different liking ratings compared to participants citing the attribute as JAR.

Milk Chocolate

	Bitterness		**Creaminess**		**Hardness**		**Sweetness**	
	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much
CLT	**1.67**	2.23	0.97	2.92	0.13	0.57	1.92	**1.53**
VE	**1.30**	2.23	**1.81**	1.93	0.63	**1.06**	1.62	**1.97**

Dark chocolate

	Bitterness		**Creaminess**		**Hardness**		**Sweetness**	
	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much
CLT	0.58	**2.88**	**1.08**	0.16	0.52	0.84	**2.02**	**1.65**
VE	0.68	**2.50**	**1.02**	0.91	2.20	**1.04**	**2.55**	**1.25**

Table 5
Liking and standard deviation (SD) of the chocolate samples by cognitive style.

Chocolate	Cognitive Style Group	CLT[a]	VE[a]
Milk	Analytic	6.95 (2.41)	7.19 (2.32)
	Holistic	6.89 (2.33)	6.55 (2.46)
Dark	Analytic	6.80 (2.48)	6.81 (2.30)
	Holistic	6.34 (2.55)	6.45 (2.58)

[a] CLT = Central Location Test; VE = Virtual Environment

3.5.4. Penalty analysis

Table 8 indicates that for the holistic group and milk chocolate, not enough creaminess and bitterness significantly impacted liking but only in the CLT. The holistic group showed no significant mean drops in liking for any attribute for milk chocolate considered not to be JAR in the VE and the magnitude of penalties were generally numerically lower in the VE compared to the CLT for this group. When the dark chocolate was too bitter and too sweet this significantly impacted liking in the CLT for the holistic group, whilst in the VE the chocolate being too bitter and not sweet enough significantly impacted the holistic group's liking scores.

However, as seen in Table 8, the analytic group had more significant mean drops in liking for attributes not being JAR, including too much bitterness and too much hardness for dark chocolate in both contexts, as well as too little creaminess and too much sweetness in the VE. For milk chocolate, the analytic group also had more attributes with statistically significant liking penalties in the VE than the CLT. Only too little bitterness, and too much sweetness had significant impacts on liking ratings in the CLT; whilst in the VE too little creaminess and too much hardness also had significant impacts on liking ratings.

4. Discussion

This study first set out to investigate the effect of context on consumer responses, including liking, sensory intensity, sensory perception captured using JAR, and emotion, conceptual and sensory associations captured during a speeded response task, when evaluating chocolate samples. Results partially supported the first hypothesis, and the sensory attribute 'hardness' was rated higher in intensity for milk chocolate in the VE than the CLT when whole-group analysis was considered. Furthermore, there were differences found for the terms "hard", "tasty" and "sweet" for milk chocolate in the speeded response task, with the VE evoking higher citations of "hard" and the CLT evoking higher citations of "tasty" and "sweet". For dark chocolate, the speeded response task showed a significantly higher citation of the term "bitter" in the CLT when compared with the VE. However, these sensory differences did not impact average liking, as this was not significantly different for the same sample evaluated in different contexts for milk or dark chocolate.

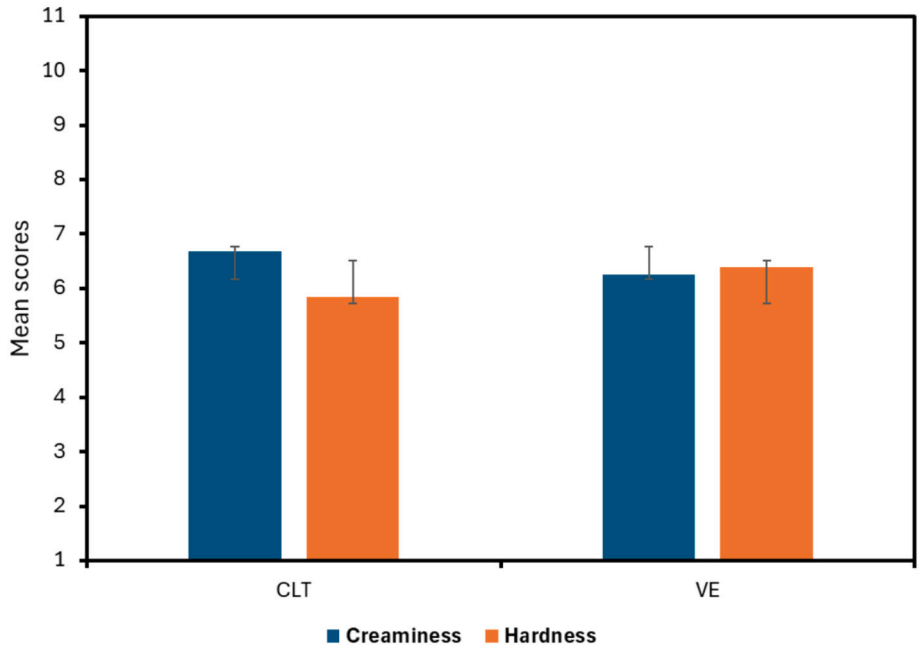

Fig. 5. Hardness and creaminess intensity for the milk chocolate sample by context across the whole group with 95% CI. Bars represent mean scores; CI = confidence interval.

Table 6
Holistic group data showing proportion of citations per term for each chocolate in each context. Significant differences based on context within each chocolate type (milk or dark) are denoted by different letters on the same row and in bold.

Attributes	CLT milk	VE milk	*p* value	Attributes	CLT dark	VE dark	p value
Active	0.393 (a)	0.411 (a)	1.00	Active	0.393 (a)	0.411 (a)	1.00
Bitter	0.071 (a)	0.125 (a)	0.371	Bitter	0.536 (a)	0.500 (a)	0.814
Bored	0 (a)	0.018 (a)	1.00	Bored	0.089 (a)	0.071 (a)	1.00
Creamy	0.804 (a)	0.696 (a)	0.181	Creamy	0.375 (a)	0.429 (a)	0.546
Energetic	0.482 (a)	0.446 (a)	0.752	Energetic	0.393 (a)	0.446 (a)	0.606
Happy	0.768 (a)	0.661 (a)	0.181	Happy	0.554 (a)	0.625 (a)	0.386
Hard	0.321 (a)	0.429 (a)	0.211	Hard	0.732 (a)	0.804 (a)	0.423
Healthy	0.179 (a)	0.179 (a)	0.683	Healthy	0.357 (a)	0.411 (a)	0.546
Indulgent	0.607 (a)	0.571 (a)	0.789	Indulgent	0.500 (a)	0.500 (a)	0.683
Nervous	0.054 (a)	0.036 (a)	1.00	Nervous	0.089 (a)	0.036 (a)	0.450
Passive	0.143 (a)	0.250 (a)	0.114	Passive	0.161 (a)	0.161 (a)	0.752
Relaxed	0.554 (a)	0.643 (a)	0.267	**Relaxed**	**0.446 (a)**	**0.589 (b)**	**0.043**
Soft	0.482 (a)	0.429 (a)	0.606	Soft	0.107 (a)	0.089 (a)	1.00
Sweet	0.929 (a)	0.875 (a)	0.371	Sweet	0.589 (a)	0.589 (a)	0.803
Tasty	**0.821 (b)**	**0.643 (a)**	**0.024**	Tasty	0.607 (a)	0.696 (a)	0.182
Unhappy	0.036 (a)	0.036 (a)	0.617	Unhappy	0.089 (a)	0.071 (a)	1.00

Table 7
Analytic group data showing proportion of citations per term for each chocolate in each context. Significant differences based on context within each chocolate type (milk or dark) are denoted by different letters on the same row and in bold.

Attributes	CLT milk	VE milk	p value	Attributes	CLT dark	VE dark	p value
Active	0.220 (a)	0.254 (a)	0.683	Active	0.373 (a)	0.356 (a)	1.00
Bitter	0.034 (a)	0.051 (a)	1.00	**Bitter**	**0.695 (b)**	**0.508 (a)**	**0.015**
Bored	0.034 (a)	0.102 (a)	0.221	Bored	0.068 (a)	0.119 (a)	0.371
Creamy	0.831 (a)	0.746 (a)	0.332	Creamy	0.441 (a)	0.424 (a)	1.00
Energetic	0.322 (a)	0.288 (a)	0.752	Energetic	0.475 (a)	0.390 (a)	0.131
Happy	0.712 (a)	0.763 (a)	0.450	Happy	0.695 (a)	0.746 (a)	0.505
Hard	**0.305 (a)**	**0.492 (b)**	**0.022**	Hard	0.780 (a)	0.729 (a)	0.606
Healthy	0.136 (a)	0.153 (a)	1.00	Healthy	0.322 (a)	0.339 (a)	1.00
Indulgent	0.627 (a)	0.644 (a)	1.00	Indulgent	0.559 (a)	0.559 (a)	0.773
Nervous	0.051 (a)	0.034 (a)	1.00	Nervous	0.034 (a)	0.017 (a)	1.00
Passive	0.237 (a)	0.203 (a)	0.752	Passive	0.220 (a)	0.237 (a)	1.00
Relaxed	0.644 (a)	0.678 (a)	0.773	Relaxed	0.525 (a)	0.508 (a)	1.00
Soft	0.390 (a)	0.441 (a)	0.606	Soft	0.169 (a)	0.119 (a)	0.505
Sweet	0.966 (a)	0.881 (a)	0.131	Sweet	0.593 (a)	0.559 (a)	0.823
Tasty	0.814 (a)	0.763 (a)	0.505	Tasty	0.695 (a)	0.678 (a)	1.00
Unhappy	0.051 (a)	0.034 (a)	1.00	Unhappy	0.051 (a)	0.051 (a)	0.617

Table 8
Group results of penalty analysis showing the impact on liking ratings (mean drop) for attributes cited as non-JAR. Mean drops in bold indicate significantly different liking ratings compared to participants citing the attribute as JAR.

Holistic group								
	Bitterness		**Creaminess**		**Hardness**		**Sweetness**	
	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much
CLT milk holistic	**1.36**	5.29	**1.63**	2.90	0.39	0.84	2.42	0.14
VE milk holistic	0.78	2.33	1.43	1.57	0.15	0.59	1.90	1.24
CLT dark holistic	0.94	**2.97**	0.90	–	–	0.24	2.59	**1.51**
VE dark holistic	0.96	**2.80**	0.67	0.28	1.83	0.61	**3.17**	1.05
Analytic group								
	Bitterness		**Creaminess**		**Hardness**		**Sweetness**	
	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much
CLT milk analytic	**2.06**	0.20	0.30	3.50	−0.27	0.28	0.63	**2.63**
VE milk analytic	**1.84**	2.14	**2.10**	2.20	1.06	**1.49**	0.52	**2.49**
CLT dark analytic	0.28	**2.76**	1.20	0.41	0.93	**1.32**	1.68	1.77
VE dark analytic	0.63	**2.28**	**1.36**	1.54	2.46	**1.37**	1.85	**1.46**

Nevertheless, penalty analysis carried out with the whole-group data and focusing on significant mean drops in liking, showed that liking was dependent on more attributes being JAR in the VE than the CLT, suggesting participants penalise liking more severely for non-ideal attributes in an environment that is more like real-life. This is in line with findings from a study showing more penalties for non-JAR attributes in more personally relevant than non-relevant settings (Man et al., 2023). This is important for product developers, as testing in a traditional CLT only may not be directly reflecting consumer expectations in normal consumption contexts, with expectation changing in different environments (Lee et al., 2021; Man et al., 2023).

The current study also revealed effects of cognitive style on consumer responses to chocolate samples captured in both contexts. However, the tool used to measure cognitive style demonstrated low internal consistency, suggesting it may not capture a single coherent construct. The second and third hypotheses – (2) holistic individuals would have higher liking ratings for chocolate samples than analytic participants, and (3) holistic individuals would be more affected by context than analytic participants, as observed through more significant differences in sensory intensity ratings between VE and CLT contexts - did not hold. No significant differences in liking ratings of chocolate for cognitive style groups were found, and there were also no significant differences in sensory intensity ratings across contexts based on cognitive styles. A previous study found holistic participants gave higher hedonic scores for pineapple when compared with analytic participants, when evaluating fruit-flavoured beverages and fruit samples (Beekman & Seo, 2024). Notably, the study by Beekman and Seo (2024) was carried out with extreme groups, not a median split, which may make differences more apparent between groups (Morriss et al., 2024). Furthermore, more food samples (fruit flavoured beverages and fruit samples) were used in their study and foods with no differences in liking (mixed-fruit salad sample) based on cognitive group were also noted (Beekman & Seo, 2024). Thus, it may be that the effect is product-specific and does not manifest for all food product categories.

No significant difference was found between the groups in the current study for the number of emotional/sensory terms selected in the speeded response task between contexts. This is not in line with the findings of a previous study, which used the Analysis Holism Scale (Choi et al., 2007) and found that the holistic group selected more terms in comparison to the analytic group when using CATA (Beekman & Seo, 2022). The Beekman and Seo study (2022) utilised a calculation that subtracted the absolute value of the control condition from the experimental condition, thus their result relates to impact of dining setting, which was found to be greater for the holistic group. In the current study, when considering the emotional, conceptual and sensory association results captured by the speeded response task, the same number of significant differences for individual terms were seen between contexts for the holistic group and the analytic group, when looking at the groups separately. However, the nature of the terms differed, with the holistic participants showing differences in the conceptual and emotional terms "tasty", which was cited more frequently in the CLT over the VE and the term "relaxed", which was cited more frequently in the VE over the CLT. The analytic group showed differences only in sensory terms across contexts for the chocolate; for instance, "hard" was cited more frequently for milk chocolate in the VE over the CLT and, for dark chocolate, "bitter" was cited more frequently in the CLT than VE, which is in line with whole-group analysis of the sensory association results where these attributes were also highlighted for their variation across contexts. Existing research suggests holistic participants are more concerned with the relationship between an object, in this case a chocolate, and its surroundings, rather than focusing on the object itself (Nisbett et al., 2001). The findings of the current study suggest the change in contextual cues had more impact on the non-stimuli specific sensory attributes for the holistic group than the analytic group.

Finally, hypothesis 4, which stated that more significant mean drops in liking would be observed overall for the JAR questions for the analytic group than the holistic group, was supported. In fact, the analytic group showed more mean drops in liking when attributes were outside of the JAR category than the holistic group when evaluating the milk chocolate sample in the VE and the dark chocolate sample in both the CLT and VE. This supports previous findings showing that a holistic group give fewer penalties for attributes not being JAR than participants in the analytic group (Beekman & Seo, 2024), suggesting participants in a holistic group may give more favourable responses even when the product attributes do not meet their ideal levels. This may reflect individuals with holistic tendencies paying attention to all aspects of the experience and therefore, even when one of the sample attributes is not ideal an acceptable consumption experience or the awareness of other ideal sensory attributes may mitigate the suboptimal attribute's impact on liking (Beekman & Seo, 2024).

Notably, the CLT elicited significantly lower hardness intensity ratings for milk chocolate, and this was also seen in the speeded-response task. Other findings from the Feast laboratory suggest speeded responses can be heavily influenced by contextual cues during sensory studies (Wagner et al., 2025). The rooms were kept at the same temperature, and the same milk chocolate was stored and served in the same conditions. However, one notable difference of the rooms was the lighting. The CLT used standard white lighting, which may be considered more intense than the digital immersive space, which has lower lighting emanating from eight projectors in the room. It may be that the milk chocolate itself appeared darker in the VE than the CLT, which may have modified participant perceptions of the milk chocolate's textural attributes. Previous research indicates that chocolate colour is influenced by cocoa content, with higher cocoa mass generally associated with a darker appearance (Schouteten et al., 2018). In the current study, the dark chocolate was rated as harder than the milk chocolate and it

may be that the lower lighting changed consumers expectations of the chocolate sample to being more in-line with dark chocolate, in turn affecting perceptions. However, this was not the case for the dark chocolate where there was no difference in the term 'hard' in the speeded response task or for sensory intensity. Furthermore, the term "bitter" was cited more frequently in the CLT than the VE for dark chocolate, which may conflict with this notion. As the VE contained props and soft furnishings and softer lighting, it may be argued that the sensory aspects of the environment itself transferring to the chocolate is unlikely to be the driver of these results. Alternatively, it may be that being in an environment closer to where participants would normally consume chocolate brought about different consumer expectations of the chocolate.

In the current study, for the analytic group, speeded response task results were similar to the whole group analysis. This was also the case for the penalty analysis, where the analytic group had more significant penalties to liking in the VE over the CLT, which was the case for whole sample analysis. Furthermore, the analytic group had significant mean drops in liking for the same attribute categories as the whole group analysis for the milk chocolate in both contexts.

On the other hand, the holistic group showed fewer significant drops in liking for non-JAR attributes in the VE, with only two categories – too little sweetness and too much bitterness for dark chocolate - penalising liking across both samples, compared to nine categories in the whole group analysis. The holistic group also had the same number of significant mean drops to liking as the analytic group in the CLT, having a total of four attribute categories that penalised liking across both chocolate samples. However, the holistic group tended to have lower magnitudes (reflecting raw numeric changes rather than statistical differences) for the significant mean drops in liking.

Taken together, these findings suggest that holistic participants are less harsh in their evaluations of product attributes and how these impact liking in consumer sensory studies (Beekman & Seo, 2022, 2023, 2024), which may reflect the characteristic of holistic individuals focusing on the whole, rather than individual objects, or in this case attributes (Koo et al., 2018). Furthermore, the analytic group exhibited more penalties to liking when attributes were not considered JAR whilst in the VE, whereas the holistic group had fewer penalties on liking in the VE. This may reflect the impact of the whole experience and background contextual cues in the pleasant digital immersive environment having an impact rather than only the food stimuli for individuals with a holistic thinking style (Beekman & Seo, 2022; Hildebrand et al., 2019; Zhang & Seo, 2015). However, for liking and sensory intensity attribute data, no differences existed based on cognitive style. Therefore, in the current study, the biggest difference regarding cognitive style was in the effect non-JAR attributes had on liking in the different contexts and not in the individual values of these measures. This suggests that for sensory and consumer studies that are interested in product optimisation, taking cognitive styles into consideration may be helpful for obtaining better insight into results. Otherwise, aggregating data may fail to consider the differences in these groups whose results do not unite across all question types (Beekman & Seo, 2022, 2023).

Although not in scope for this research, sensory and consumer researchers should consider analysing differences when carrying out cross-cultural research, as testing environments may have a different impact on individuals from cultures with analytic versus holistic thinking styles during food studies (Beekman & Seo, 2022; Hildebrand et al., 2019; Zhang & Seo, 2015).

Furthermore, more research is required to determine whether variations in product evaluation by cognitive style can be seen at a behavioural level including buying behaviour or consumption amount. Overall, the results of this study add to the growing literature suggesting context can have an impact on results of consumer studies (Bangcuyo et al., 2015; Lee et al., 2021; Lichters et al., 2021; Man et al., 2023) and gives evidence to suggest that adopting an individual difference measure that categorises analytic-holistic thinking can provide insight into results of such studies, as consumers may diverge on how they are affected by context. However, the main divergence was in penalty analysis; therefore, for consumer and sensory studies investigating hedonic liking and sensory perception there may be less requirement to include this individual measure. However, for those looking specifically at product development and adopting penalty analysis, including a measure to assess analytic-holistic tendencies may help with interpreting results and better understanding the consumer experience.

4.1. Limitations

This study utilised a median split to allow for a practical use of the F-AHS in a standard consumer sensory setting. Although in line with previous research on cognitive styles and food (Beekman & Seo, 2022), it is understood that a median split comes with drawbacks (McClelland et al., 2015). However, we did also carry out exploratory analysis after the initial write-up of this paper on reviewer request using a three-group approach and found it did not afford any further insights. The results revealed the clearest differences for the low (analytic) group and the high (holistic group) were in penalty analysis with the analytic group penalising attributes more when they were not found to be JAR.

Future research would also benefit from including a repeatability measure in the same context to check whether the results hold for the same product. Finally, utilising a home immersive environment with tables set up in a similar fashion to the CLT allowed for greater control of the variables potentially affecting outcomes. Nonetheless, there is the possibility that having such a set-up may make people in the home VE feel less immersed in the space, as it may be seen as too formal for a home dining experience.

5. Conclusion

The aim of this study was to investigate whether cognitive styles could offer an important insight into consumer responses to food in a typical sensory evaluation study by utilising the tool in a practical way. Overall, the results suggest considering analytic-holistic tendencies during sensory and consumer studies may offer greater insight into the consumer experience but mainly when penalty analysis is considered. However, even when whole-group analysis was carried out there was evidence to suggest more penalties on liking arise when attributes are not considered JAR in the VE than when in the CLT, which may be down to consumers being reminded of the expectations they have of the product in real-life. Thus, testing in real-life environments also appears to be important if the industry is to understand the consumer experience in greater depth.

Declaration of generative AI in scientific writing

AI-assisted technologies were used to aid readability with select sentences in the manuscript.

CRediT authorship contribution statement

Jennifer Wagner: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Annu Mehta:** Writing – review & editing, Formal analysis. **Simone Poggesi:** Writing – review & editing, Software. **Joanne Hort:** Writing – review & editing, Supervision, Resources, Funding acquisition.

Ethical statement

The study was assessed as low risk following the Massey University Human Ethics Committee process (Ethics Notification Number: 4000029300).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

References

Ares, G., Mawad, F., Giménez, A., & Maiche, A. (2014). Influence of rational and intuitive thinking styles on food choice: Preliminary evidence from an eye-tracking study with yogurt labels. *Food Quality and Preference, 31*, 28–37.

Ares, G., & Varela, P. (2018). Methods in consumer research. In *, 1. New Approaches to Classic Methods*. Chantilly, UNITED KINGDOM: Elsevier Science & Technology.

Bangcuyo, R. G., Smith, K. J., Zumach, J. L., Pierce, A. M., Guttman, G. A., & Simons, C. T. (2015). The use of immersive technologies to improve consumer testing: The role of ecological validity, context and engagement in evaluating coffee. *Food Quality and Preference, 41*, 84–95.

Beekman, T. L., Crandall, P. G., & Seo, H.-S. (2022). You eat how you think: A review on the impact of cognitive styles on food perception and behavior. *Foods, 11*(13), 1886.

Beekman, T. L., & Seo, H.-S. (2022). Cognitive styles influence eating environment-induced variations in consumer perception of food: A case study with pad Thai noodle. *Food Quality and Preference, 98*, Article 104525.

Beekman, T. L., & Seo, H. S. (2023). Development and validation of a food-related analysis–holism scale (F-AHS). *Journal of Food Science, 88*(S1), A205–A226.

Beekman, T. L., & Seo, H.-S. (2024). Analytic-holistic cognitive styles affect consumer responses to food and beverage samples during sensory evaluation. *Current Research in Food Science, 8*, Article 100635.

Castura, J., Pohjanheimo, T., Laaksonen, O., McEwan, J., Varela, P., & Næs, T. (2023). Screening respondents to increase data quality in consumer tests. *Food Quality and Preference, 112*, Article 105030.

Cheon, B. K., Lee, L. L., Lee, A., & Sim, A. Y. (2022). Context-sensitive thinking influences judgments of expected satiation from combinations of foods: The role of individual and cultural variations. *Journal of Sensory Studies, 37*(6), Article e12787.

Choi, I., Koo, M., & Choi, J. A. (2007). Individual differences in analytic versus holistic thinking. *Personality and Social Psychology Bulletin, 33*(5), 691–705.

Feeney, E. L., Nolden, A. A., & Hayes, J. E. (2024). *Assessment of individual differences in sensory evaluation*.

Giacalone, D. (2018). Product performance optimization. In *, 1. Methods in consumer research* (pp. 159–185). Elsevier.

Giezenaar, C., & Hort, J. (2021). A narrative review of the impact of digital immersive technology on affective and sensory responses during product testing in digital eating contexts. *Food Research International, 150*, Article 110804.

Haase, J., & Wiedmann, K.-P. (2020). The implicit sensory association test (ISAT): A measurement approach for sensory perception. *Journal of Business Research, 109*, 236–245.

Hildebrand, D., Harding, R. D., & Hadi, R. (2019). Culturally contingent cravings: How holistic thinking influences consumer responses to food appeals. *Journal of Consumer Psychology, 29*(1), 39–59.

Jaeger, S. R., Cadena, R. S., Torres-Moreno, M., Antúnez, L., Vidal, L., Giménez, A., & Yin, D. (2014). Comparison of check-all-that-apply and forced-choice yes/no question formats for sensory characterisation. *Food Quality and Preference, 35*, 32–40.

Jaeger, S., Hort, J., Porcherot, C., Ares, G., Pecore, S., & MacFie, H. (2017). Future directions in sensory and consumer science: Four perspectives and audience voting. *Food Quality and Preference, 56*, 301–309.

Jaeger, S. R., Roigard, C. M., Jin, D., Xia, Y., Zhong, F., & Hedderley, D. I. (2020). A single-response emotion word questionnaire for measuring product-related emotional associations inspired by a circumplex model of core affect: Method characterisation with an applied focus. *Food Quality and Preference, 83*, Article 103805.

Kong, Y., Sharma, C., Kanala, M., Thakur, M., Li, L., Xu, D., & Torrico, D. D. (2020). Virtual reality and immersive environments on sensory perception of chocolate products: A preliminary study. *Foods, 9*(4), 515.

Koo, M., Choi, J. A., & Choi, I. (2018). Analytic versus holistic cognition. In *The Psychological and Cultural Foundations of East Asian cognition: Contradiction, Change, And Holism* (p. 105).

Lagast, S., Gellynck, X., Schouteten, J. J., De Herdt, V., & De Steur, H. (2017). Consumers' emotions elicited by food: A systematic review of explicit and implicit methods. *Trends in Food Science & Technology, 69*, 172–189.

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: Principles and practices*. Springer Science & Business Media.

Lee, Y.-J., Kim, I.-A., van Hout, D., & Lee, H.-S. (2021). Investigating effects of cognitively evoked situational context on consumer expectations and subsequent consumer satisfaction and sensory evaluation. *Food Quality and Preference, 94*, Article 104330.

Lichters, M., Möslein, R., Sarstedt, M., & Scharf, A. (2021). Segmenting consumers based on sensory acceptance tests in sensory labs, immersive environments, and natural consumption settings. *Food Quality and Preference, 89*, Article 104138.

Low, J. Y., Janin, N., Traill, R. M., & Hort, J. (2022). The who, what, where, when, why and how of measuring emotional response to food. A systematic review. *Food Quality and Preference, 100*, Article 104607.

Low, J. Y., Lin, V. H., Yeon, L. J., & Hort, J. (2021). Considering the application of a mixed reality context and consumer segmentation when evaluating emotional response to tea break snacks. *Food Quality and Preference, 88*, Article 104113.

Man, K., Patterson, J. A., & Simons, C. (2023). The impact of personally relevant consumption contexts during product evaluations in virtual reality. *Food Quality and Preference, 109*, Article 104912.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology, 81*(5), 922.

Masuda, T., Ellsworth, P. C., Mesquita, B., Leu, J., Tanida, S., & Van de Veerdonk, E. (2008). Placing the face in context: Cultural differences in the perception of facial emotion. *Journal of Personality and Social Psychology, 94*(3), 365.

McClelland, G. H., Lynch, J. G., Jr., Irwin, J. R., Spiller, S. A., & Fitzsimons, G. J. (2015). Median splits, type II errors, and false–positive consumer psychology: Don't fight the power. *Journal of Consumer Psychology, 25*(4), 679–689.

Meiselman, H. L. (1996). The contextual basis for food acceptance, food choice and food intake: The food, the situation and the individual. *Food choice, acceptance and consumption*, 239–263.

Meiselman, H., Jaeger, S., Carr, B., & Churchill, A. (2022). Approaching 100 years of sensory and consumer science: Developments and ongoing issues. *Food Quality and Preference, 100*, Article 104614.

Morriss, J., Biagi, N., & Wake, S. (2024). Quantification choices for individual differences: An example of mapping self-report to psychophysiological responses. *International Journal of Psychophysiology, 205*, Article 112427.

Næs, T., Varela, P., & Berget, I. (2018). *Individual differences in sensory and consumer science: Experimentation, analysis and interpretation*. Woodhead Publishing.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review, 108*(2), 291.

Patil, I. (2021). Visualizations with statistical details: The'ggstatsplot' approach. *Journal of Open Source Software, 6*(61), 3167. https://doi.org/10.21105/joss.03167

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*(2), 105–120.

Ranganath, K. A., Smith, C. T., & Nosek, B. A. (2008). Distinguishing automatic and controlled components of attitudes from direct and indirect measurement methods. *Journal of Experimental Social Psychology, 44*(2), 386–396.

Schouteten, J. J., De Pelsmaeker, S., Juvinal, J., Lagast, S., Dewettinck, K., & Gellynck, X. (2018). Influence of sensory attributes on consumers' emotions and hedonic liking of chocolate. *British Food Journal, 120*(7), 1489–1503.

Stelick, A., & Dando, R. (2018). Thinking outside the booth—The eating environment, context and ecological validity in sensory and consumer research. *Current Opinion in Food Science, 21*, 26–31.

Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: The food choice questionnaire. *Appetite, 25*(3), 267–284.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53.

Thomson, D. M., Crocker, C., & Marketo, C. G. (2010). Linking sensory characteristics to emotions: An example using dark chocolate. *Food Quality and Preference, 21*(8), 1117–1125.

Till, B. D., Baack, D., & Waterman, B. (2011). Strategic brand association maps: Developing brand insight. *The Journal of Product and Brand Management, 20*(2), 92–100.

Vanutelli, M. E., Adorni, R., Leone, P. A., Luperini, A., D'Addario, M., & Steca, P. (2024). Who would taste it? Exploring decision-making styles and intention to eat insect-based food among Italian university students. *Nutrients, 16*(20), 3458.

Wagner, J., & Poggesi, S. (2025). *Investigating individual differences and the multisensory experience [unpublished raw data]*. Feast Lab: Massey University, NZ.

Wagner, J., Poggesi, S., Maggs, R., & Hort, J. (2025). The effect of emotional music on just-about-right and speeded-responses to chocolate. *Food Quality and Preference, 136*, Article 105746.

Wickham, H., François, R., Henry, L., Müller, K., & Vaughan, D. (2023). *dplyr: A Grammar of Data Manipulation*.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., & Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software, 4*, 1686. https://doi.org/10.21105/joss.01686

Zhang, B., & Seo, H.-S. (2015). Visual attention toward food-item images can vary as a function of background saliency and culture: An eye-tracking study. *Food Quality and Preference, 41*, 172–179.