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Analytic-holistic cognitive styles affect consumer responses to food and beverage samples during sensory evaluation

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ABSTRACT

Recent studies have shown that the analytic-holistic theory is applicable in sensory science-related areas. Analytic and holistic cognitive style groups have been found to have significantly different perceptions and behaviors within food-related scenarios. These differences were further investigated and identified within the current study, focusing on specific areas of common sensory tests and analyses where analytic and holistic cognitive style groups may differ from one another. Before the main study, 419 volunteers were classified into three groups based on their scores to the Analysis-Holism Scale (AHS). The extreme groups (65 adults for each) were identified as the "analytic" and "holistic" cognitive style groups, respectively. Participants evaluated fruit-flavored beverages and fruit samples for their impression of the intensity or hedonic aspects in the study conducted over two sessions. Each session either employed solely category or line scale for the questions. Analyses focused on the analytic and holistic group comparisons in mean, variance, penalty analysis, and pre- and post-AHS score differences. Results showed that the holistic group exhibited significantly higher mean scores and standard deviations in the hedonic ratings of fruit samples than the analytic group did. Compared to the analytic group, the holistic group showed significantly smaller mean drops in overall liking across the five Just-About-Right (JAR) questions related to flavors or tastes of the mixed-fruit flavored water. A significant difference between the AHS scores measured before and after the sensory evaluation was observed in the holistic group, but not in the analytic group. In conclusion, our findings provide empirical evidence that cognitive styles affect consumer responses to food or beverage samples during sensory evaluation tasks. This implies that sensory professionals may consider these analytic-holistic contrasts while exploring consumer responses to their target samples.

1. Introduction

The analytic-holistic (AH) cognitive styles, rooted in cultural psychology, are often linked to Western (e.g., USA) and Eastern (e.g., Korea) cultural contexts, respectively (Ji et al., 2001; Beekman et al., 2022). While initial research on the AH cognitive theory primarily compared these cognitive styles across cultures, subsequent studies showed that analytic and holistic distinctions could also be identified within a singular culture, yielding results like cross-cultural research findings (Cheng and Zhang, 2017; Ren et al., 2014). Earlier studies in psychology detailed characteristics of analytic individuals by highlighting their tendency to pay an attention to a singular focus, perceive stimuli as independent entities, and conceptualize changes in a linear fashion. In contrast, holistic individuals have been found to exhibit a different approach by considering contextual information, focusing on the interconnectedness of stimuli, and perceiving changes in a circular fashion (Masuda and Nisbett, 2001; Morris et al., 1999; Nisbett et al., 2001; Peng and Nisbett, 1999). Previous research has also highlighted that individuals categorized as either analytic or holistic may use disparate pieces of information when making decisions in various daily activities, such as mental accounting (Hossain, 2018) or social interactions (Apanovich et al., 2018).

Given the increasing interest in cross-cultural research within both industry and academia (Ares, 2018; Choi et al., 2020; Lonner, 2018; Wendelin et al., 2023), it is worth investigating how the AH differences, associated with cultural backgrounds, manifest in consumer sensory responses to test samples. In a recent review paper, Jeong and Lee (2021) provided a comprehensive insight into the significance of cross-cultural research, emphasizing findings that support previously mentioned "Western" (analytic) and "Eastern" (holistic) culturally associated differences. Recent works using eye-tracking methodologies, have also offered validation to the pillar of AH theory (Peng-Li et al.,

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2020; Zhang and Seo, 2015). For example, "Western" (analytic) individuals (e.g., Danes or U.S. Americans), compared to "Eastern" (holistic) individuals (e.g., Chinese people), focused more on the central aspect of the stimuli. Moreover, analytic and holistic cultures have been found to differ in perception of food-related stimuli (Choi, 2016; Choi et al., 2020; Chrea et al., 2004; Togawa et al., 2019), scale usage (Feng and O'Mahony, 2017; Yeh et al., 1998), variance consistency (Beekman and Seo, 2023), and environmental effect (Beekman and Seo, 2022; Cheon et al., 2022). These imply that the AH theory might offer insight into why consumer responses to identical test samples varied among groups of different cultures, especially "Western" versus "Eastern."

When applying the AH theory to consumer-based sensory research, independent of consumers' cultural background, there are multiple areas where the AH cognitive style is predicted to produce differences in consumer responses to test samples. An interesting application of the AH theory is to identify the elements of sensory evaluation tasks affected by the AH cognitive difference. Meaux and Vuilleumier (2016) indicated that more complex tasks may show increased levels of differences between the analytic and holistic groups. This suggests that the AH differences may be more pronounced with an increment of task complexity. Task complexity in sensory evaluation is affected by scale types (Gupta et al., 2021; Lim, 2011) and sample attributes (Kim et al., 2015; Pérez-Cacho et al., 2005; Yang and Lee, 2019). Therefore, scale and sample complexity may be altered to test their effects on the AH differences in sensory evaluation of food samples. It would also be interesting to test whether cognitive tendencies may be influenced by sensory evaluation tasks. In a related way, Beekman and Seo (2022) showed that holistic participants, when contrasted with their analytic counterparts, exhibited more substantial differences in AHS scores when assessing AH cognitive styles both before and after engaging sensory evaluation tasks of food samples. This result suggests that cognitive tendencies might shift during sensory evaluation, and these variations could differ between analytic and holistic individuals.

The primary goal of this study was to delineate how analytic and holistic groups differ in their responses to sensory evaluation tasks of food samples. To achieve this goal, we sub-divided our focus into three objectives. Firstly, we aimed to identify differences in consumer responses to test samples within the AH group by comparing cognitive styles groups in terms of means and variances of scale ratings, frequencies of Just-About-Right (JAR) responses, and mean drops in overall liking for the JAR questions. Secondly, we sought to explore whether the effect of cognitive styles on consumer responses to food or beverage samples could vary based on the complexity levels of the sensory evaluation, particularly concerning scale type and test sample attributes. Finally, we aimed to determine whether engaging in sensory evaluation tasks could influence the AH cognitive tendency.

2. Materials and methods

The protocol (No. 2108348528) used in this study was approved by the Institutional Review Board of the University of Arkansas (Fayetteville, AR, USA). Prior to participation, the experimental procedure was explained to all participants, and written consent indicating voluntary participation was obtained from each participant.

2.1. Participants

A total of 419 participants volunteered to partake in the study and were recruited from the Northwest Arkansas community through a consumer profile database of the University of Arkansas Sensory Science Center (Fayetteville, AR, USA). To qualify for the study, participants must have passed through a set of screening criteria, which included no diagnoses of COVID-19, no health conditions, no food allergies, and being acceptors of all samples within the study (Meilgaard et al., 2015). In addition, participants also provided responses to the Analysis-Holism Scale (AHS; Choi et al., 2007) to assess their analytic-holistic tendencies. The AHS scores, gathered from 419 volunteers, ranged from 87 to 156, with a mean score of 118.64, as shown in Supplementary Fig. 1. Individuals whose AHS scores were greater or less than one standard deviation above or below the mean were selected for the holistic and analytic cognitive style (CS) groups, respectively (Beekman and Seo, 2021, 2023; Hildebrand et al., 2019). Through these recruitment and screening steps, a total of 65 analytic [43 females; mean age ± standard deviation (SD) = 40 ± 12 years] and 65 holistic (42 females; mean age ± SD = 39 ± 12 years) participants were included in this study. While the two selected groups significantly differed in the mean AHS-score: analytic (mean ± SD = 106.31 ± 6.89) and holistic (131.60 ± 7.76), they showed no significant differences in terms of mean age ($P = 0.24$) or gender ratio ($P = 0.85$).

2.2. Samples and preparation

Following the theory and initial evidence from Beekman and Seo (2021) that the complexity of food-related tasks may induce some differences, corresponding to complex versus simple tasks, between cognitive style groups, sets of simple and complex samples were employed within this study. Two sets of samples were included to ensure findings were not reliant on the samples used within this study, with a simple and complex beverage sample and a simple and complex food sample being selected. Earlier research has supported how these different types of food and beverage samples can be perceived as more "simple" or "complex" by consumers due to the complex samples having a relatively greater variety of sensory attributes compared to the simple samples (Yang and Lee, 2019). The "simple" beverage sample was orange flavored, still, spring water (Item#347168, Orange Flavor Natural, Gold Coast Ingredients, Commerce, CA, USA) with 0.4% orange flavor. The "complex" beverage sample was a flavored, still, spring water with 0.4% of the same orange flavor, along with 0.2% blueberry flavor (Item#248150, Blueberry Natural and Artificial, Gold Coast Ingredients, Commerce, CA, USA), 0.1 % strawberry flavor (Item#444050, Strawberry Flavor N & A, Gold Coast Ingredients, Commerce, CA, USA), and 0.1 % cherry flavor (Item#355058, Cherry Red Flavor, Natural WONF, Gold Coast Ingredients, Commerce, CA, USA). All flavored water samples were prepared the day prior to serving to participants in larger quantities and poured into 118-mL clear plastic cups with clear plastic lids (Clear Portion Containers with Clear Plastic Lids, Dart Container Corporation, Mason, MI, USA) prior to serving to participants. The volume of each beverage sample was 50 mL. Beverage samples were stored and served at room temperature.

The "simple" food sample was frozen pineapple (Great Value Frozen Pineapple Chunks, Walmart, Bentonville, AR, USA). The "complex" food sample was a mixed-fruit salad sample and included the same frozen pineapple with frozen blueberries (Great Value Frozen Whole Blueberries, Walmart, Bentonville, AR, USA), frozen strawberries (Great Value Frozen Whole Strawberries, Walmart, Bentonville, AR, USA), and frozen blackberries (Great Value Frozen Blackberries, Walmart, Bentonville, AR, USA). All frozen fruit samples were thawed in a refrigerator at refrigerator temperatures (approximately 4 °C) prior to serving. Frozen fruit samples were served in 295-mL white foam bowls (Dart Container Corporation, Mason, MI, USA). Each fruit sample contained 50 g of fruit, which equated to approximately 3 pieces of pineapple in the simple food sample. The mixed-fruit salad sample included 1 piece of pineapple, 8 blueberries, 2 strawberries, and 3 blackberries (approximately equal weight of each fruit). All fruit samples were prepared directly prior to serving to participants and were served at refrigeration temperature (approximately 4 °C). Within this paper, future mentions of the samples refer to them as orange flavored water, mixed-fruit flavored water, pineapple, and mixed-fruit salad for the four different samples. Disposable materials were used to best maintain safety for researchers and participants regarding COVID-19 procedures and guidelines (Seo et al., 2021).

2.3. Procedure

Participants took part in this study on two separate days – one for each treatment involving either category scaling or line scaling, with a one-week interval between them. The treatment order was arranged in a randomized, balanced design. The test samples were presented in a balanced, randomized block design, with beverage and food samples constituting the two blocks, respectively. To prevent a potential carry-over effect, the beverage sample block was consistently presented before the food sample block.

As illustrated in Fig. 1, across both treatments, participants responded to questions in the following order for all samples: flavor liking (Q1), flavor intensity (Q2), orange (or pineapple) flavor liking (Q3), orange (or pineapple) flavor intensity (Q4), sweetness intensity (Q5), sourness intensity (Q6), bitterness intensity (Q7), and overall liking (Q8). Specific flavors, such as orange or pineapple, were targeted as they represented the focal or central flavors of each sample. Prior research has indicated analytic, compared to holistic, participants focused more on the central aspect of stimuli (Masuda and Nisbett, 2001). After all sample evaluations were finished within a session, a final question was about the relatedness of all four samples to one another (Q9). The sample-relatedness question was given to determine whether holistic participants exhibit a higher tendency to experience test samples as interconnected compared to analytic participants (Li et al., 2018). The test questions were identical across all samples and treatment sessions, differing only in the type of scale used – either a category scale or a line scale. Category and line scales were employed as treatments to assess the effect of task complexity on AH differences in consumer responses to food and beverage samples (Lim, 2011). In the category scale session, a 9-point hedonic scale for acceptance, a 9-point category scale for JAR question, and a 9-point category scale for the sample-relatedness question were utilized (Fig. 2). In the line scale session, a 15-cm line scale was employed for questions related to acceptance, JAR, and sample-relatedness questions, respectively (Fig. 2).

Upon arriving at the University of Arkansas Sensory Science Center, participants were given basic instructions about what would be expected of them during the test. Following the informational session, participants were seated in individual sensory booths and provided with their questionnaire packet, as all questions were presented and answered via paper ballots. Each participant received their test samples in a monadic fashion, with a 2-min (120 s) break provided between sample presentations. Participants were provided a cup of spring water (Clear Mountain Spring Water, Herber Springs, AR, USA) and unsalted saltine crackers for palate cleansing between sample presentations. Following the completion of the second session, participants were asked to answer the AHS for a second time to further assess the relationship between pre- and post-AHS scores.

2.4. Statistical analyses

Prior to analyzing the data between the scale types and cognitive style groups, all data was standardized following the Proportion of Maximum Scaling (POMS) method for the category and line scale data to be on the same scale (Little, 2013; Moeller, 2015). This standardization allows the data to remain in its same relative distribution, moved to a 0–1 scale, which allows the data to be compared and combined across both cognitive style groups and scale types. Following the standardization, a three-way analysis of variance (ANOVA) was performed, treating "scale type" and "cognitive style group" as fixed effects and "participant" as a random effect, to identify any significant interactions between scale type and cognitive style group. The questions for all samples were included as the response variables, which included both hedonic and JAR intensity questions, along with the sample-relatedness question. However, all response variables across all samples showed a non-significant interaction of scale type and cognitive group (for all, $P > 0.05$). Consequently, cognitive group comparisons were conducted solely across both scale types (i.e., collapsing both category and line scale data) (Choi et al., 2018).

2.4.1. Mean comparisons

To determine the effect of CS group on sensory responses, a two-way ANOVA was conducted across all scale-type data treating "cognitive style group" as a fixed effect and "participant" as a random effect. If a significant result was identified, a *post-hoc* Student's *t*-test was performed for mean comparisons. This model was designed to identify what consistent trends existed in participant responses between AH groups and where they could be found within sensory evaluations across different types of sample questions.

2.4.2. Standard deviation comparisons

Levene's test of equal variances (Levene, 1960) was conducted on all hedonic and JAR question variables for all samples between the AH groups to identify any variation differences between the cognitive style groups. Prior analytic-holistic research has indicated that both mean (Feng and O'Mahony, 2017) and variation (Bacha-Trams et al., 2018) can differ between the AH groups, and these analyses offer the opportunity to confirm these claims, specifically within an applied situation of sensory evaluation tasks.

2.4.3. Penalty analysis comparisons

To further identify over-arching differences between the CS groups in terms of consumer responses to food and beverage samples in sensory

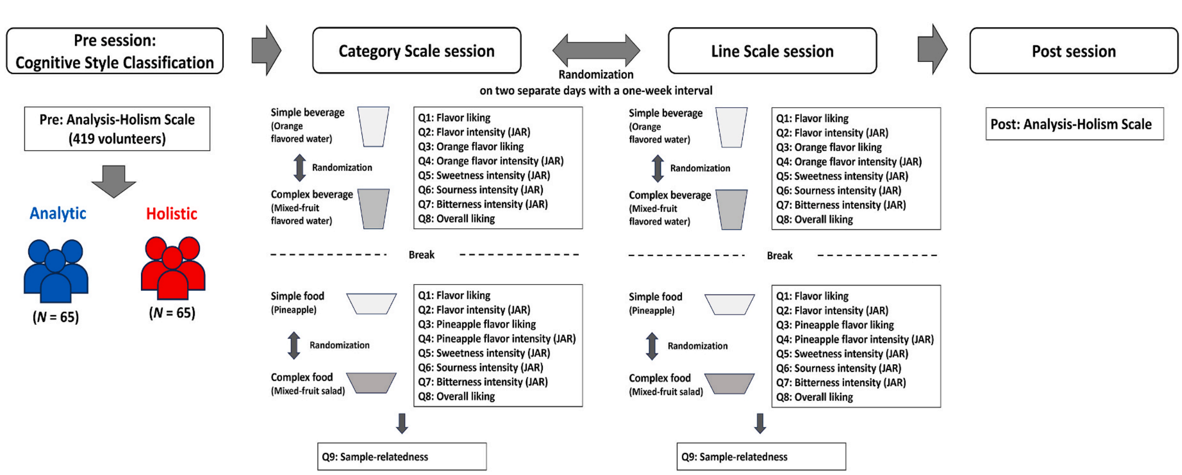

Fig. 1. Overall scheme of experimental procedure followed in this study.

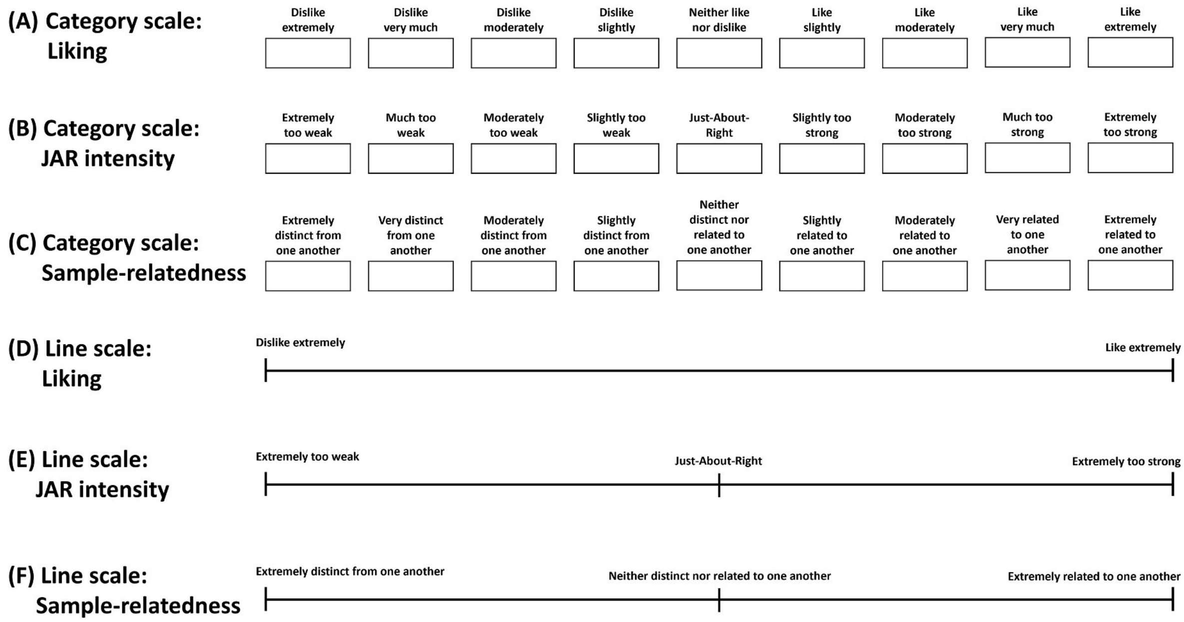

Fig. 2. Category and line scales used in this study.

evaluation tasks, the ratings for the JAR questions were additionally investigated. The penalty analysis employed only the non-transformed category scale response data. The line scale participant response data were excluded from these analyses following the methods outlined by XLSTAT (Pagès et al., 2014; XLSTAT, 2022). In each CS group, participants' responses rated using a 9-point JAR scale were collapsed into three levels: "too weak" (1 to 4-point), "JAR" (5-point), and "too strong" (6 to 9-point). The number of participant responses for each sample within either analytic or holistic group were compared using Fisher's exact tests. This analysis was repeated for each JAR intensity question within each sample. Next, the penalty analyses utilized the participant response data from the "overall liking" question for each sample, along with the response data from the JAR questions of "overall flavor", "orange (or pineapple) flavor", "sweetness", "sourness", and "bitterness". For each sample, the mean drops in overall likings of the analytic and holistic groups were directly compared to identify relative differences in how the JAR questions impacted the overall liking within each CS group.

2.4.4. Sample-relatedness rating comparisons

To determine the effect of CS group on the ratings of sample-relatedness question, a two-way ANOVA was conducted treating "cognitive style group" as a fixed effect and "participant" as a random effect.

2.4.5. Pre- and Post-AHS score comparisons

To address the potential impact of sensory evaluation tasks on AHS scores, the pre- and post-AHS score data were compared first across all participants, and within each CS group separately. The comparisons were conducted using a two-way ANOVA with "participant AHS score" as the dependent variable, the "pre-post session" as the fixed effect (i.e., pre-AHS score *vs.* post-AHS score), and "participant" as a random effect. Pearson correlation analysis was also conducted to test associations between the pre- and post-AHS scores in each CS group. Data were analyzed using JMP Pro software (version 17.0, SAS Institute, Inc., Cary, NC, USA) and XLSTAT software (Addinsoft, New York, NY, USA).

3. Results

3.1. Comparisons between cognitive style groups with respect to the mean of the ratings

Mean ratings were compared between the analytic and holistic groups for all questions across all samples (Supplementary Table 1). Fig. 3 shows five instances of significant differences between the analytic and holistic groups in terms of mean ratings for sensory-related questions. Compared to the holistic group, the analytic group exhibited a significantly higher mean rating for the bitterness JAR question in both orange flavored water ($F = 3.97$, $P = 0.049$) and mixed-fruit flavored water ($F = 4.25$, $P = 0.04$), respectively. However, the mean distances from the JAR score (0.50) did not significantly differ between the analytic and holistic groups in either orange flavored water ($P = 0.13$) or mixed-fruit flavored water ($P = 0.61$). With respect to the

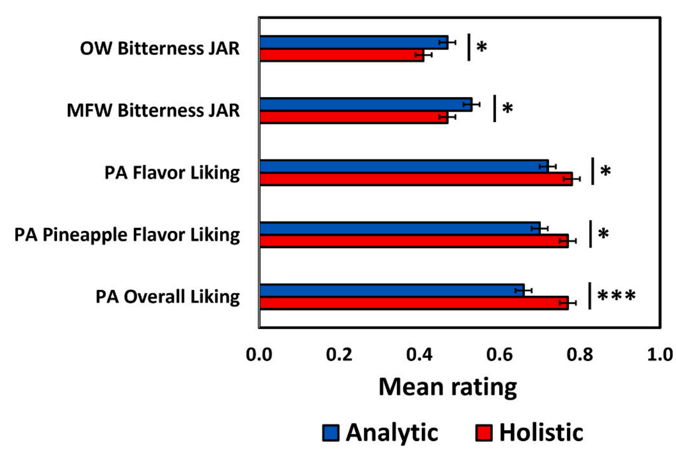

Fig. 3. Comparisons between analytic and holistic groups in terms of mean ratings for each Just-About-Right (JAR) or hedonic question across category and line scale data. Error bars represent standard errors of the mean. * and *** indicate a significant difference at $P < 0.05$ and $P < 0.001$, respectively. OW, MFW, and PA represent orange-flavored water, mixed-fruit flavored water, and pineapple, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

liking-related questions, the holistic group, in comparison to the analytic group, exhibited significantly higher mean ratings for flavor liking ($F = 4.15$, $P = 0.04$), pineapple flavor liking ($F = 4.25$, $P = 0.04$), and overall liking ($F = 11.53$, $P < 0.001$), respectively, in the pineapple sample. However, such a group difference was not observed in the mixed-fruit salad sample ($P > 0.05$).

3.2. Comparisons between cognitive style groups with respect to the standard deviation of the ratings

The standard deviations of response data for each question within each CS group were compared between the analytic and holistic groups (Supplementary Table 2). As illustrated in Fig. 4, the holistic group, in comparison to the analytic group, showed significantly higher mean standard-deviations for sourness intensity ($F = 4.03$, $P = 0.046$) and bitterness intensity ($F = 10.70$, $P = 0.001$) in the orange flavored water, as well as for overall liking ($F = 4.05$, $P = 0.045$) in the mixed-fruit salad.

3.3. Comparisons between cognitive style groups with respect to the penalty analysis

Using only the category scale data for participants, the proportions of responses for "too weak," "JAR," and "too strong," respectively, were compared between the analytic and holistic groups for each sample (Supplementary Table 3). As depicted in Fig. 5, in the pineapple sample, the holistic group exhibited more JAR responses than the analytic group with respect to flavor intensity ($P = 0.01$) or pineapple flavor intensity ($P = 0.02$). In contrast, the analytic group had more "too weak" responses than the holistic group in terms of flavor intensity ($P = 0.03$) or pineapple flavor intensity ($P = 0.04$). No other significant differences between the analytic and holistic groups were observed.

Penalty analyses were conducted by treating the overall liking question (Q8) as the liking score and the flavor intensity (Q2), orange/pineapple flavor intensity (Q4), sweetness intensity (Q5), sourness intensity (Q6), and bitterness intensity (Q7) as the JAR scores for each of the four samples individually. Table 1 displays the mean drops for either "too weak" or "too strong" response categories in each sample within either analytic or holistic group. Values with * indicate significant mean drops, whereas those labeled *N.S.* indicate non-significant mean drops. Values in italics represent cases where significant testing could not be performed due to a lack of data for the cell categories. Overall, the analytic group, in comparison to the holistic group, tended to exhibit more instances of significant mean drops with higher magnitudes, especially in the mixed-fruit water sample. As shown in Fig. 6, the analytic group exhibited a significantly higher average of the mean-drop scores across the five JAR questions than the holistic group ($P = 0.02$) in the mixed-fruit flavored water. For the mixed-fruit salad sample, compared to the analytic group, the holistic group tended to exhibit more instances of significant mean drops with higher magnitudes, especially in the flavor intensity, pineapple flavor intensity, and sourness intensity. However, the two CS groups did not differ significantly in the average of the mean-drop scores across the five JAR questions in the mixed-fruit salad ($P = 0.09$) (Fig. 6).

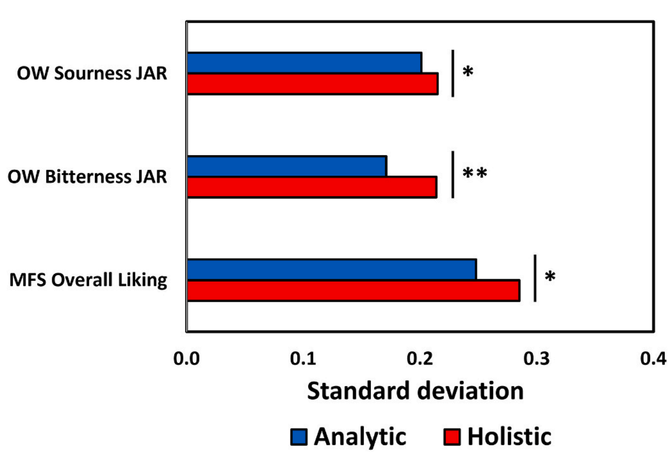

Fig. 4. Comparisons between analytic and holistic groups in terms of standard deviations for each Just-About-Right (JAR) or hedonic requestion across category and line scale data. * and ** indicates a significant difference at $P < 0.05$ and $P < 0.01$, respectively. OW and MFS represent orange-flavored water and mixed-fruit salad, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

3.4. Comparisons between cognitive style groups with respect to the sample-relatedness rating

The mean ratings for the sample-relatedness question (Q9), across category and line scale data, did not significantly differ between the analytic (mean = 0.42) and holistic (0.46) groups ($P = 0.26$). However, the holistic group (SD = 0.29), in comparison to the analytic group (0.25), exhibited significantly higher mean standard-deviations for the sample-relatedness question ($F = 10.39$, $P = 0.001$).

3.5. Comparisons between cognitive style groups with respect to the relationship of pre- and post-AHS scores

When comparing participants' pre- and post-AHS scores, the holistic group's post-AHS scores were significantly lower than their pre-AHS scores ($t = 3.14$, $P = 0.002$), while the analytic group did not exhibit a significant difference between the pre- and post-AHS scores ($t = -0.35$, $P = 0.73$) (Fig. 7). In addition, correlation analyses revealed a significant association between pre- and post-AHS scores in both analytic ($r_{65} = 0.46$, $P < 0.001$) and holistic groups ($r_{65} = 0.59$, $P < 0.001$).

4. Discussion

By piecing together the results from individual analyses, a relatively weak but consistent trend emerges, revealing the impact of cognitive styles, especially analytic *vs.* holistic, on consumer responses to food and beverage samples. The main findings and discussions of this study are as follows:

Firstly, cognitive styles affected consumer responses to food and beverage samples tested in this study. Although this trend was not observed in all samples, the holistic group exhibited higher mean ratings and standard deviations than the analytic group (Figs. 3 and 4), aligning with our expected outcomes and collaborating with previous findings (Beekman and Seo, 2022, 2023). Earlier research indicated that holistic individuals tend to reconcile contradictions and aspire toward harmonious outcomes, possibly involving being less critical (Spencer-Rodgers et al., 2010). Moreover, cultures associated with holistic processing, compared to those with analytic processing, place greater importance on cultural respect (Triandis et al., 1988). By being more respectful, holistic participants may select higher hedonic ratings relative to analytic participants. Holistic participants pay more attention to multiple contextual details of food stimuli, while analytic individuals tend to focus more on the focal aspect of stimuli (Beekman and Seo, 2021; Zhang and Seo, 2015). Therefore, if there is a sensory aspect that holistic individuals do not like, they may still pay attention to other attributes they do like and not rate hedonic scores as low as analytic participants, who may only focus on the singular attribute they do not like. Holistic individuals, accepting contradictions such as liking some food attributes and disliking others, may allow them to select higher hedonic scores, while analytic individuals, who are less comfortable with contradictions, may feel compelled to base their hedonic ratings on the attribute they dislike. Like the mean comparisons, the variance comparisons indicated that the holistic group has a weak trend of significantly greater standard deviations compared to the analytic group (Fig. 4). This result is in contrast

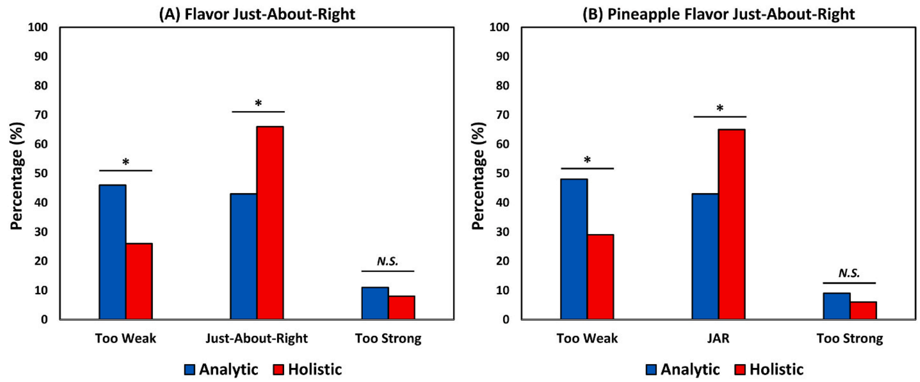

Fig. 5. Comparisons between analytic and holistic groups in terms of response percentages for “too weak,” “Just-About-Right” (JAR), and “too strong” levels, respectively, in the flavor JAR (A) or pineapple flavor JAR (B) question assessed on a 9-point category scale. * indicates a significant difference at $P < 0.05$. *N.S.* represents no significant difference at $P < 0.05$.

Table 1
Mean drops in overall liking for the “too weak” (TW) or “too strong” (TS) response category with respect to each of the four test samples evaluated using the Just-About-Right (JAR) scale for each cognitive style (CS) group.

Sample	CS Group	Flavor JAR		Orange (or pineapple) flavor JAR		Sweetness JAR		Sourness JAR		Bitterness JAR	
		TW	TS	TW	TS	TW	TS	TW	TS	TW	TS
Orange flavored water	Analytic	2.23*	*4.57*	2.47*	*2.67*	1.51*	*2.94*	1.60*	*3.38*	1.40*	*2.50*
	Holistic	2.04*	*4.27*	1.87*	*4.17*	1.59*	*0.00*	1.55*	*3.30*	1.00$^{N.S.}$	*2.00*
Mixed-fruit flavored water	Analytic	3.34*	3.68*	3.66*	3.41*	3.08*	*2.06*	1.58*	*3.00*	1.70*	2.97*
	Holistic	1.78*	2.47*	1.75*	*1.55*	2.17*	*1.62*	1.22*	*3.89*	0.29$^{N.S.}$	1.48$^{N.S.}$
Pineapple	Analytic	1.98*	*1.96*	2.36*	*1.56*	2.56*	*1.20*	0.49$^{N.S.}$	*1.58*	*0.28*	*1.74*
	Holistic	1.67*	*0.79*	2.08*	*1.23*	1.95*	*0.95*	0.82$^{N.S.}$	*1.37*	*0.15*	*1.95*
Mixed-fruit salad	Analytic	2.00*	1.29$^{N.S.}$	1.30*	*0.87*	2.19*	*3.07*	*0.29*	0.82$^{N.S}$.	*−0.10*	1.71*
	Holistic	2.53*	3.18*	2.00*	*2.78*	1.38*	*1.59*	*2.21*	1.29*	*1.18*	1.88*

The 9-point JAR scale responses for each question were collapsed to three levels: “too weak,” “JAR,” and “too strong.”
While values with * indicate significant mean drops at $P < 0.05$, those labeled *N.S.* indicate non-significant mean drops. Values in italics represent cases where significant testing could not be performed due to a lack of data for the cell categories.

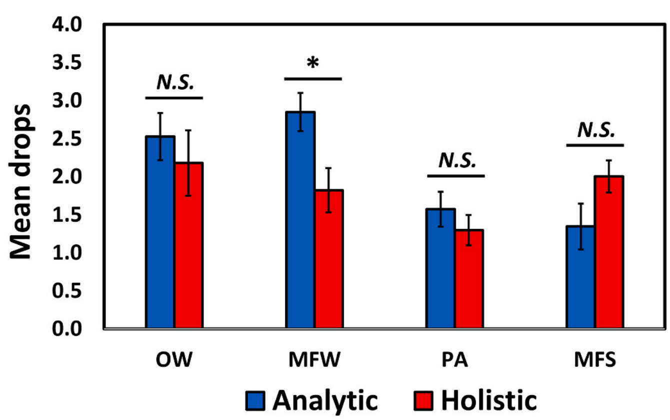

Fig. 6. Comparisons between analytic and holistic groups in terms of mean drops in overall liking for “too weak” and “too strong” levels across the five Just-About-Right (JAR) questions assessed on a 9-point category scale in each sample. * indicates a significant difference at $P < 0.05$. *N.S.* represents no significant difference at $P < 0.05$. OW, MFW, PA, and MFS represent orange-flavored water, mixed-fruit flavored water, pineapple, and mixed-fruit salad, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

to prior research indicating the holistic group having a smaller response variability relative to the analytic group (Bacha-trams et al., 2018; Beekman and Seo, 2023). Future research expanding on the stimuli and situations in which response variability is compared between CS groups could help address why contrasting results are seen between previous and present studies.

The results of penalty analyses for the JAR questions across the test samples provide additional corroboration to the existences of AH differences in standard sensory evaluation tasks. Specifically, the holistic group exhibited significantly higher percentages of JAR responses for the flavor JAR and pineapple flavor JAR questions in the pineapple sample than the analytic group (Fig. 5). Additionally, the holistic group, in comparison to the analytic group, showed significantly smaller mean-drops in overall liking for the mixed-fruit flavor water (Fig. 6). These results align well with the earlier theoretical details about holistic individuals and cultures placing a greater emphasis on respect while also minimizing conflict to ensure harmonious relationships (Spencer--Rodgers et al., 2010; Triandis et al., 1988). Given these inclinations, smaller penalties (mean drops) were expected. Beekman and Seo (2021) have also recently elucidated that holistic individuals show more concern with the overall experience of food stimuli. Interpreted in the context of the current study, the holistic participants, compared to their analytic counterparts, may not penalize individual attributes as harshly since they are more focused on their overall opinion of the samples.

Secondly, the complexity level of sensory evaluation, particularly concerning scale type and test sample attributes, showed minimal impacts on the effect of cognitive styles on consumer responses to food and beverage samples. Specifically, there were no significant interactions between scale type and cognitive style in consumer responses to food and beverage samples. The lack of a significant interaction between scale type and cognitive style is probably due to the fact that the two scales may require different types of cognitive processing to comprehend and respond to, even though the line scale task may still be more complex than the category scale task. To compare, the category scale consists of verbally labeled categories, while the line scale consists of a continuum with bookends labeled for the questions, and the center also

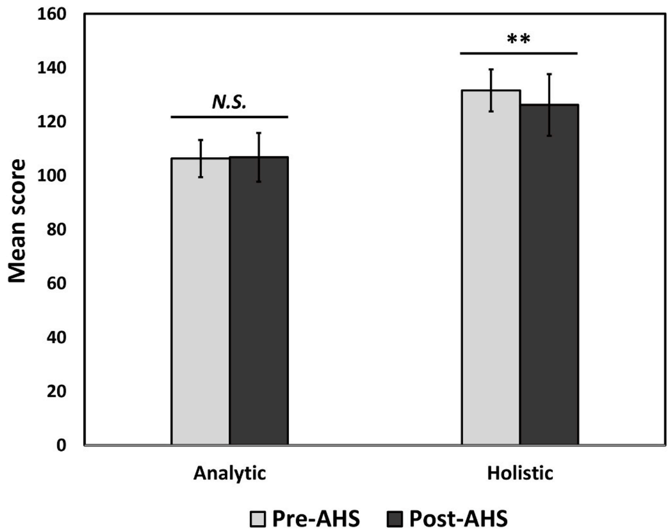

Fig. 7. Comparisons between pre- and post-analysis-holism scale (AHS) scores within each cognitive style group. The AHS measurement was conducted before (pre) and after (post) sensory evaluation tasks. ** represents a significant difference at $P < 0.01$. *N.S.* represents no significant difference at $P < 0.05$.

labeled for JAR questions (Fig. 2). Due to the contrasts between these scales, the category scale could induce more linguistic processing, while the line scale could trigger more numerical processing. On the other hand, participants, regardless of their cognitive styles, might have experienced similar levels of complexity when they evaluated test samples, leading no significant interaction with cognitive styles in consumer responses to food and beverage samples. In a related way, previous studies have also shown minimal differences in subjective ratings and discrimination sensitivity between category and line scales (Greene et al., 2006; Jeon et al., 2004; Schifferstein and Frijters, 1992).

We did not observe a strong trend that the effect of cognitive styles on consumer responses to test samples differs between "simple" and "complex" foods and beverages. Significant differences between the analytic and holistic groups in terms of JAR frequencies and mean drops were observed in either simple or complex food/beverage samples (Figs. 5 and 6). Therefore, to draw a strong conclusion on the effect of task complexity on the cognitive style-induced difference in consumer responses to food and beverage samples, further study is needed under test conditions showing a clear difference in task complexity.

Thirdly, there was no significant effect of cognitive style on the mean ratings of sample-relatedness, suggesting that the perspectives from both analytic (mean = 0.42) and holistic (0.46) groups regarding how the four test samples are related to one another were similar. This result contracts our expectation, as previous findings have shown that holistic individuals tend to perceive stimuli as more interconnected and related to one another (Choi, 2016; Li et al., 2018; Varnum et al., 2010). Notably, in the current study, the mean standard-deviations of the ratings for sample-relatedness were greater in the holistic group (SD = 0.29) than in the analytic group (SD = 0.25), which might be linked to the lack of a significant difference between the two groups. On the other hands, this result, i.e., the analytic group's greater standard deviations, is in line with the holistic groups having greater standard deviations of hedonic ratings or JAR intensity ratings (Fig. 4).

Fourthly, engaging with sensory evaluation tasks affected holistic individuals' cognitive tendency. There was a significant difference in AHS scores for the holistic group when measured before and after a sensory evaluation task (Fig. 7). After the sensory evaluation task, the holistic group's AHS scores were lower, whereas the analytic group's AHS scores showed no significant difference. In other words, the holistic group appears to become more analytical, which might be associated with a function of learning from being asked to repeat a test. These suggests that (1) the sensory evaluation task itself may induce more analytic thinking in holistic individuals, and (2) within such a task, the AHS may not yield consistent scores for holistic individuals. These findings, along with results from Beekman and Seo (2022), emphasize the need for a modified AHS specific to food-related experiences to ensure accurate AH consumer segmentation. Lux et al. (2021) and Lux (2017) further support this idea, suggesting that in specific applications, such as sensory evaluation, food shopping, and food consumption, the AHS may measure overly general cognitive tendencies. Responding to this, Beekman and Seo (2023) developed the food-related AHS (F-AHS), comprising 15 questions across three food-related experience categories: food shopping, food preparation, and food consumption. In their study, Beekman and Seo (2023) demonstrated that the F-AHS performs better than the AHS in classifying individuals into analytic or holistic groups in the contexts of food experience or sensory evaluation of foods and beverages. When the same study was conducted with analytic and holistic participants classified by the F-AHS, CS group differences more closely matched previous findings related to the characteristics of analytic or holistic individuals.

Finally, these findings together offer valuable insights into understanding consumer responses to foods and beverages and how to optimize the utilization of sensory evaluation data. As observed in this study, professionals in the food industry and academia researchers can acknowledge the potential impact of cognitive styles on consumer responses to their target samples. In a related manner, they may consider consumer segmentations based on cognitive styles and then apply strategies tailored to the characteristics and behaviors of each segmentation group in the processes of product development, marketing, and sales. This approach allows food industry professionals to better comprehend variations in consumer responses and behaviors toward their target samples, ultimately leading to increased customer satisfaction. Moreover, it would be beneficial to explore whether AH contrasts in "food-related experiences," such as sensory evaluation, can exist across multiple populations and cultures, despite prior research validating cognitive style tendencies both across and within a variety of cultures. Expanding these results across populations and cultures is especially pertinent due to the wide diversity and strong connections individuals have, not only with their over-arching cultures, but also with more localized food cultures (Choi, 2016; Reddy and van Dam, 2020; Zhang et al., 2022).

5. Conclusion

Recent research has detailed the divergent perceptions and behaviors that analytic and holistic cognitive style groups exhibit in food-related situations or with food stimuli (Choi, 2016; Beekman et al., 2022; Beekman and Seo, 2022). The current study digs deeper into this area by investigating the presence and location of analytic-holistic differences within common sensory evaluation tasks. More specifically, this study provides empirical evidence that analytic and holistic individuals differ in their sensory and hedonic responses to food and beverage samples during sensory evaluations. Holistic individuals show trends of greater hedonic ratings, more frequent JAR responses, and smaller penalties (i.e., smaller mean drops in overall liking for "too weak" or "too strong" attributes), but this pattern was not consistent across all test samples, as compared to their analytic counterparts. In addition, holistic individuals can exhibit more analytic tendencies after engaging with sensory evaluation tasks. Our findings provide both industry and academic researchers with a better understanding of how cognitive styles influence consumer responses to food and beverage samples during sensory evaluation, emphasizing the need for consideration of data interpretation and consumer segmentation based on individuals' cognitive styles.

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CRediT authorship contribution statement

Thadeus L. Beekman: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Visualization. **Han-Seok Seo:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Visualization, Supervision, Funding acquisition.

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.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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