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Effects of Cognitive Style on Food Perception and Eating Behavior

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in Food Science

by

Thadeus Lyndon Beekman
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This dissertation is approved for recommendation to the Graduate Council.

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ABSTRACT

Within the fields of psychology, notably cultural psychology, the analytic-holistic cognitive style theory has been introduced, developed, fine-tuned, and validated across a wide range of situations, stimuli, and populations. This research, combined with recent applications of the analytic-holistic theory, suggests that the differences in analytic or holistic tendencies of individuals in food, sensory, and consumer tests can impact food perception and associated behaviors. This dissertation aimed to investigate the impact of analytic-holistic cognitive styles of consumers in food situations. The first objective to accomplish this goal was to conduct exploratory research to identify if and where the analytic-holistic theory may be applicable across areas of the consumer food experience. The second objective was then to replicate one of the paramount differences of analytic and holistic groups by investigating the effect of the eating environment and how analytic-holistic cognitive styles may mediate this effect. The third objective was to identify where and how analytic and holistic groups differ in their responses to standard sensory evaluation tasks. Finally, the fourth objective was to develop and validate an analytic-holistic measurement tool that could accurately separate participants based on their analytic-holistic tendencies in food-related situations. Through completing these objectives, it was first found and continuously supported that analytic and holistic groups have significantly different perceptions of and reactions to food stimuli and food experiences. In addition, the completed studies also provide evidence that the two cognitive style groups subsequently have significantly different response data in sensory evaluation tasks, while also showing indications the current methodology to separate consumers based on analytic-holistic tendencies is not the most accurate within food-related applications. Finally, the completed studies were able to show that a food-related analytic-holistic measurement tool could be adequately developed and had

superior performance to the existing assessment tool in validation testing. Combining the studies within this dissertation offers valuable insights to food science, sensory, and consumer researchers across academia and industry by showing the necessity of accounting for analytic-holistic consumer differences in their respective fields. Moreover, this dissertation provides these researchers a new, more accurate measurement tool to allow them to easily and accurately separate analytic and holistic groups within their own research. To conclude, this dissertation offers ample evidence for the importance of accounting for analytic-holistic differences in food-related consumer testing through a variety of studies showing significant differences between analytic and holistic consumer groups in terms of food perception and food-related behavior.
Keywords: Analytic, Holistic, Cognitive style, Consumer testing, Sensory evaluation, Scale development, Food perception

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 2 –

LIST OF FIGURES

CHAPTER 2 –

CHAPTER 3 –

LIST OF PUBLISHED ARTICLES

Beekman, T. L., & Seo, H.-S. (2021). Analytic versus holistic: Cognitive styles can influence consumer response and behavior toward foods. *Journal of Sensory Studies*. (In press) https://doi.org/10.1111/joss.12723 (CHAPTER 2)

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*, 104525. https://doi.org/10.1016/j.foodqual.2021.104525 (CHAPTER 3)

GENERAL INTRODUCTION

Sensory perception can be defined as how consumers use their five senses and trigeminal sensations to form opinions about situations or events, with sensory and consumer sciences often applying this concept to food (Meilgaard et al., 2016; Ragnar, 1955). Findings from consumer perception studies are the base of sensory science and are used to not only push the field forward through novel discoveries, but also provide industry partners with insight about product success. After decades of work, consumer behaviors and decision-making processes are seemingly more complex than ever before (Costell et al., 2010; Stolzenbach et al., 2016). Many factors are involved with how consumers form these decisions ranging from physiological aspects of skin conductance and autonomic nervous system responses (Benedek & Kaernbach, 2010; Gatti et al., 2018), to macro and micro environmental surroundings (Altundag et al., 2014; Piqueras-Fiszman & Spence, 2015), to psychological aspects of emotions, engagement, or stress (Krishna, 2012; Samant & Seo, 2019; Torres & Nowson, 2007). Due to the plethora, and constantly increasing complexity, of these factors being shown capable of influencing consumer sensory perception, it is understandable how there are often more questions than answers related to clarifying perception. Some researchers argue these complex interactions of factors can explain contrasting results regarding sensory perception. Comparatively, cognitive processing variation of individuals is an alternative reasoning behind unexpected (lack of) differences of sensory and food perception that can offer at least partial insight into answering some of the many unknown questions (Masuda et al., 2020).

Cultural and social psychologists have been detailing how cognitive processing is used by humans on a daily basis, with a focus on investigating how these cognitive processes may differ between radically different cultures (Berry, 1969; Segall et al., 1990). Original work concentrated on looking at individual aspects of cognition, such as field-dependence or collectivism, between historically contrasting cultures of East Asia and Western Europe to highlight how cognition and behavior may differ (Triandis, 1972; Witkin & Berry, 1975; Witkin et al., 1962). One drawback of these initial studies was the focus on singular aspects of cognition, which resulted in contradictory findings and difficulties in generalizability. Each person has developed a unique cognitive framework in how they process information, with these frameworks formed through the culture in which they reside. Eastern Asia and Western Europe historically had such different cultures that could produce contrasting cognitive frameworks among their constituents (Highet, 1949; Zhongyun, 1987). To address the issue of narrowly focused cognitive aspects hindering generalizations, researchers proposed a novel, more encompassing cognitive aspect of analytic and holistic processing (Nisbett et al., 2001). Analytic cultures were seen as being historically aligned with “Western” societies (European) and holistic cultures aligned with “Eastern” societies (Asian). Analytic thinking is associated with increased attention on focal points of a situation, linearized thought, and independent interpretation of events, with holistic thinking associated with opposite behaviors of contextual attention bias, cyclical interpretation and prediction, and interdependent relationships of events (Nisbett & Masuda, 2003). Interdisciplinary research has supported cultural psychology findings by elucidating how the differences in neural development and genetic expression between cultures are congruent with the prior psychology results (Chee et al., 2011; Cheon et al., 2018)

Connecting back to the influence of a multitude of factors on consumer sensory perception and behavior is the indication of some research findings that the analytic-holistic cognitive tendencies of individuals operate in a top-down fashion (Higgs, 2016; O’Callaghan et al., 2017). The analytic-holistic cognitive frameworks of individuals thus may act as a potential mediating factor of the myriad of physiological, environmental, and psychological factors associated with sensory perception and help better understand consumer behavior. A spark in being able to apply consumer cognitive tendencies as an additional factor in research studies was the development of the Analytic-Holistic Scale (AHS) (Choi et al., 2007). This quantifiable scale provided a concise and effective tool for researchers to identify where consumers fell on the spectrum of analytic to holistic. Initially, the scale provided confirmation of the separation of analytic and holistic cognitive styles between cultures that psychologists had theorized existed (Choi et al., 2007; Lechuga et al., 2011). Comparatively, a large majority of academic and industry projects focus on consumer perception within a single culture. To address this additional need of the AHS, supplementary research has shown how even within a single culture, there are still distinct analytic and holistic groups (Cheng & Zhang, 2017; Ren et al., 2014). Possessing the capability to quantify the difference in how cultures contrast with one another in cognitive processing is promising to use in growing numbers of cross-cultural sensory studies (Ares, 2018; Lonner, 2018). Differentiating cognitive groups within a singular culture allows a wider application of treating consumer analytic-holistic style as a potential mediating factor in sensory and food tests.

As a double-edged sword, this growth in the reliability and applicability of the impact of consumer analytic-holistic on perception has produced some knowledge gaps related to food, sensory and consumer research. One such area is the potential of inaccurate results when analytic-holistic style is not accounted for in sensory testing. As analytic and holistic consumer groups have drastically different perceptions of stimuli and processing strategies, a single population may contain two distinct sets of results with respect to food and sensory stimuli perception. Through this pathway, the tendency of various cultures employing different parts of the scale could be explained from the cognitive groups offering divergent sensory results (Feng

& O'Mahony, 2017; Yeh et al., 1998). Clarifying how analytic and holistic consumer groups significantly differ in the processing and response to food and sensory stimuli offers the potential to revolutionize how sensory and consumer tests are conducted and interpreted.

Recent studies have validated some of the findings between analytic and holistic consumers within food-based situations. White and others (2020) detailed how aspects of analytic-holistic cognition could influence chemosensory perception, while Hildebrand et al. (2019) displayed how analytic and holistic consumer groups differed in how they perceived and processed food-related advertising. Jeong and Lee (2021) have offered a recent review of the effects of cultural backgrounds associated with either analytic or holistic thinking can have notable impacts on how consumers perceive food. Additional recent research has also provided interesting insights showing analytic-holistic differences in more than just perceptual effects, such as having different physiological responses to basic cognitive tasks (Bakhchina et al., 2021) and differing emotional processing and responses to identical information (Santos et al., 2021). Such findings incorporate the opposing inclinations of analytic and holistic consumers into food and sensory settings and suggest differences in how analytic and holistic groups may subsequently respond to food and sensory stimuli. However, prior literature has discussed how cognitive tendencies of individuals may fluctuate depending on certain contextual or situational bases (Miyamoto, 2013). Moreover, the general nature of the AHS has been discussed as a potential drawback when used in applied settings (Li et al., 2018; Lux, 2017; Lux et al., 2021). Such applied settings encompass food and sensory studies, indicating the AHS may not provide accurate separability of consumers' analytic-holistic tendencies. To improve on the downfalls of the generality of the AHS, a food-related analytic-holistic cognitive scale needs to be developed to accurately account for consumer cognitive groups within sensory and food testing. To ensure the novel scale's generalizability to all sensory and food testing, validation steps should be carefully conducted across a multitude of populations and situations to be comparable to the AHS and other sensory measurement tools (Choi et al., 2007; Hannum & Simons, 2020; Koo et al., 2018). Prior research has also indicated the complexity of a sample or task can modify the cognitive tendencies of consumers, which necessitates validating within a variety of sensory contexts (Calvo & Beltrán, 2014; Meaux & Vuilleumier, 2016). By developing and validating a food-related cognitive scale, sensory and food researchers will have access to a measurement tool to accurately account for the significant impact analytic-holistic cognitive style has on consumer food perception and behavior. Through investigating how analytic and holistic groups differ in their food and sensory perceptions and behaviors and how to best measure these cognitive styles in food situations, this research offers the first collection of evidence showing the significant effect of consumer analytic-holistic thinking tendencies in food and sensory research, while also providing a measurement tool to further grow this area of food-related analytic-holistic research in future studies.

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CHAPTER 1

REVIEW OF LITERATURE

1. Sensory perception of foods

1.1. Concept

Sensory perception involves the use of the five senses (i.e., sight, smell, hearing, tough, and taste) and trigeminal sensations (i.e., trigeminal nerves responding to spiciness and carbonation) to build an opinion about a specific consumer good (Meilgaard et al., 2016; Ragnar, 1955). One step further are common interactions among the senses that are referred to as a cross modal correspondence (CMC) (Meilgaard et al., 2016). Specific examples of CMCs that help sensory scientists to understand how foods are perceived by consumers exist between sight and smell (Biswas et al., 2021; Maric & Jacquot, 2013), touch and taste (Biggs et al., 2016), taste and smell (Spence, 2015), sight and taste (Shankar et al., 2010; Spence, 2019), and trigeminal spiciness and sound (Wang et al., 2017). These interactions highlight how the senses and their respective neural signals are not perceived individually from one another; rather, they activate multiple overlapping brain regions of the brain (Calvert, 2001; Hwang et al., 2019; Seo et al., 2013). In addition, autobiographical memory incorporates previous experiences, which can interact with the stimulus information from the senses to further impact sensory perception (Arshamian et al., 2013; Larsson et al., 2014).

Considering how such a wide array of stimuli and previous experiences can affect sensory perception, researchers need some way of quantifying this perception to gain insight into how foods, beverages, and consumer goods are perceived by the people using them. When measuring sensory perception, researchers have generally employed some type of scale within their methodology (Meilgaard et al., 2016). These scales can range from binary scales of “Same” or “Different”, to other common scales such as 9-point scales to measure hedonic impression. Some authors argue sensory perception data should be in interval and ratio from by using magnitude estimation (ME) or labeled magnitude scales (LMS) (Cardello, 2017; Wichchukit & O'Mahony, 2015). Employing qualitative methodologies, such as focus groups, interviews, or open-ended survey questions can allow researchers to obtain a more complete picture of how consumers interact with a product (Jervis & Drake, 2014). Industry researchers aim to better understand their target consumers to build their business while academic interests primarily aim to grow the knowledge base and push their respective fields forward, with some areas of overlap between the two areas (Johnson & Johnston, 2001; Manjarrés-Henríquez et al., 2009). Taking into account the variety of ways one may interpret a specific food, it is important to have a detailed understanding of how physiological, environmental, and psychological factors are potentially impacting one's perception and consequent liking of food.

1.2 Factors of consumer perception and liking of foods

1.2.1. Physiological factors

Among the many factors found to impact consumer perception and food liking, three main categories can be recognized and discussed: physiological, environmental, and psychological. Physiological factors represent the body's inherent responses and can be pivotal in shaping one's perception of a food product and their subsequent liking. Regular body functions of sensory, motor, visceral, and neuro-endocrine functions are controlled through the sympathetic branch (immediate and adaptive responses) and the parasympathetic branch (homeostasis and self-regulatory responses) (Nance & Hoy, 1996; Schaaf et al., 2010). These bodily activities are controlled without conscious input and developed evolutionarily to assist humans in making immediate "fight" or "flight" decisions. (Schmidt & Thews, 1989). Aspects of autonomic nervous system (ANS) responses impacting sensory perception are skin conductance, cardiovascular activity (CA), and respiratory activity.

When considering skin conductance, galvanic skin response (GSR) is often considered which measures the electrical changes of the skin (Montagu & Coles, 1966). More specific to sensory perception is the phasic portion that is indicative of specific bodily responses to events and is associated with emotions and sensory responses (Benedek & Kaernbach, 2010; Christopoulos et al., 2019; Lang, 2014). Contrary to some of these findings was the result of a study which found ANS responses, such as skin conductance, were not necessary to build a predictive model of consumer liking (Samant et al., 2017). However, this model focused on predictive liking, meaning the ANS responses may still be important for sensory perception and less important for liking. Along with skin conductance, CA has also been shown to interact with sensory perception through heart rate (HR), heart rate variability (HRV), and skin temperature. HR and HRV offer physiological insight into the bodies responses to sensory situations and can interact with neural signals to help consumers develop their sensory perception (Critchley & Garfinkel, 2015; Croy et al., 2013).

Skin temperature can often be indicative of these CAs and have further implications related to consumer perception. As vessels dilate (constrict) from increased (decreased) blood flow, skin temperature can rise (fall) (Kistler et al., 1998). As with HR and HRV, skin temperature can also be associated with responses to sensory and taste stimuli, indicating physiological changes in response to food that help contribute to a consumer’s overall perception of a product (He et al., 2017; Rousmans et al., 2000). Combining ANS measures and pairing them with emotional aspects has been successful, as the physiological ANS parameters can be indicative of consumer neural and arousal changes in response to sensory stimuli (Schulte-Holierhoek et al., 2017).

Other pieces of physiological factors extend past ANS responses into how salivary activity and metabolic rate may further impart their own effects on consumer sensory perception. Saliva is excreted to help with food processing; unfortunately, the salivary response is not consistent across consumers, with some research indicating a 10-fold difference in salivary flow rates among people exposed to the same stimulus (Edgar, 1992; Neyraud et al., 2003). Additional research suggests differences in salivary properties can impact taste (Christensen et al., 1987) and texture (Liu et al., 2017) perception immediately and throughout consumption. Commonly interacting with salivary properties is the physiological composition of taste papillae (taste buds). Taste papillae have been shown by some researchers to exhibit correlations to taste and oral processing perception, while other contest more of an interaction with salivary regulation (Essick et al., 2003).

Prior research has indicated metabolism, which incorporates many physiological parameters, is capable of modifying sensory perception through hormone concentrations (Riera & Dillin, 2016). Metabolic hormones, such as ghrelin and leptin, have been found to impact olfactory and gustatory perception respectively (Kawai et al., 2000; Tong et al., 2011). Often associated with metabolism is body mass index (BMI). BMI differences have been shown to alter sensory perception, most notably through satiety and hunger, yet some research suggests BMI does not directly influence sensory perception and is more dependent on interactive metabolic factors (Low et al., 2016; Vignini et al., 2019). The complexity of human physiology is far from being fully understood, and it is important to understand how various aspects may impact sensory performance, perception, and the consequential food behavior.

1.2.2. Environmental factors

Along with internal, physiological factors, consumer perception and liking are proven to be impacted through external, environmental factors. These factors range from macro-level factors of weather or geography to smaller factors of food packaging or cutlery. Within the macro type of environmental factors, geographical location, through altitude, impacts food experience by lowering olfactory functions at higher altitudes (Cingi et al., 2011). In addition, diminishing olfactory ability may be combined with taste perception differences across altitudes through lower atmospheric pressures lowering taste and odor threshold levels (Baharuddin & Sharifudin, 2015; Burdack-Freitag et al., 2011). Related research on mechanistic gustatory functions suggests a temperature effect on taste perception (Green & Nachtigal, 2015; Talavera et al., 2007). Combining temperature and humidity's individual environmental impacts on perception, as they are often correlated, can potentially amplify these effects on olfaction (Fang et al., 1998; Wang et al., 2011). An over-arching environmental aspect is season, and research indicates sensory perception and liking may be impacted via seasons due to evolutionary needs of humans (Herman, 1993) or psychological aspects of cravings or seasonal associations (Arbisi et al., 1996; Cahill et al., 2013).

A smaller scale of factors focused on the specific dining environment offer additional impacts on consumer experiences with food. Product-extrinsic cues such as lighting, sound, themes, brightness, aromas, and interactions among them have been shown to affect food liking and perception (Kuo & Lin, 2019; Piqueras-Fiszman & Spence, 2015). An additional body of work supporting the influence of the external environment on product perception is the Mehrabian–Russell (MR) model, stating how the environment surrounding a consumer may induce emotional changes capable of impacting how a food is perceived (Liu & Jang, 2009;

Mehrabian & Russell, 1974). A piece of the environment capable of altering food perception is the auditory component, as one rarely eats in complete silence, and the specific types of music may dictate the overall food impression (Fiegel et al., 2014; Pellegrino et al., 2015). Background noise is further comprised of individual factors, such as pitch, tempo, and volume; each capable of individually impacting food perception and liking (Fiegel et al., 2019).

A second main facet of the consumer environment are visuals cues, as they are often first perceived and able to strongly influence the food perception, consumption behavior, and food choice (Antheunisse, 2017). Brightness (Xu & Labroo, 2014) and hue (Cho et al., 2015; Yang et al., 2016) aspects are both important pieces of visual cues capable of separately impacting perception. A potential lack of generalizability of these environmental color findings was proposed by Schifferstein et al. (2017), detailing how food liking depended on the color of the environment, yet the optimal color was dependent on the food matrix. Many of these visual cue impacts on food perception rely on the consumer interacting with both a food product and the external environment. However, some research details how simply viewing something food-related can modify neural activity and consequent food behavior (Spence et al., 2016).

A third environmental factor capable of modifying sensory perception is smell. Studies conducted within food-specific settings show ambient scents have impacts on sensory perception and liking (Gaillet et al., 2013; Spence & Youssef, 2015). One aspect of an environmental cue's impact on consumer experiences is the scent congruency, as even though a scent may be well-liked among consumers, reversed findings may be found if it is not congruent with the food presented (Amsteus et al., 2015; Fitzgerald Bone & Scholder Ellen, 1999). Scent-congruency between the ambient scent and the food can interact with perception and behavior through increased feelings of fullness or satiety (Biswas et al., 2014; Yin et al., 2017). Most research has focused on the ambient scent, with a recent study showing wait staff can similarly decrease consumption by wearing a scent congruent with the restaurant's food (Singh et al., 2019). Focusing the environmental lens to an even smaller degree brings the impact of table setting cues into focus. For example, glasses (Mirabito et al., 2017; Mielby et al., 2018), cutlery (Laughlin et al., 2011; Harrar & Spence, 2013), and plates or bowls (Andreae, 2017; Harrar et al., 2011) are all capable of influencing sensory perception and/or eating behavior. Drinkware, cutlery, and eating receptacles can individually affect sensory perception. Garcia-Segovia et al. (2015) expanded these finding by examining differences among table settings, and results indicated consumer behavior was altered depending on the overall table setting conditions.

1.2.3. Psychological factors

Psychological factors can additionally alter sensory perception and liking, notably through emotions. Before delving further into emotions and their impacts on sensory perception, it is important to first acknowledge the presence of lower-order cognitive processes, such as valence and arousal. These processes involve the more basic brain structures of the brainstem, limbic structures, and basal ganglia and are often closely connected to subconscious or immediate psychological responses and encompass a multitude of emotions (Gutjar et al., 2015; Ng et al., 2013). Together valence and arousal have been proposed to mediate and process emotional perception through combining core cognitive dimensions and incorporate them into higher-level, top-down cognitive processes (Beck & Clark, 1997; Jaeger et al., 2018).

Higher level processes associated with emotions, through neuro-imaging studies, are shown to be interwoven with brain areas associated with perception and cognition (Barrett et al., 2013; Linhartová et al., 2019). Specific to human senses, emotions can affect the perception of smell (Chen & Dalton, 2005; Herz, 2005), taste (Noel & Dando, 2015), sight (Most et al., 2010), sound (Asutay & Västfjäll, 2012), and touch (Kelley & Schmeichel, 2014). Specific to food liking and acceptance, recent studies have begun to reveal how emotional states are prominent in food choice and hedonic responses (Crist et al., 2018; Gutjar et al., 2015; Samant & Seo, 2019). Moreover, emotions are often logically paired with eating behavior, which is not unwarranted. Discussed in literature is how emotions are known to be associated with eating behavior (Macht & Simons, 2000). Modern studies have detailed how both positive and negative emotions have important impacts on eating behaviors, while further developing the saliency of emotional states regarding food choice, consumption, and cognitive eating controls (Jiang et al., 2014; Patel & Schlundt, 2001).

These findings agree with the importance of emotions on how people perceive food and their consequent actions guided by their food-related emotions. Further psychological factors impacting consumer food perception are stress (Adam & Epel, 2007; Cardi et al., 2015), sleep deprivation (Costa & Pereira, 2019; Lv et al., 2018), and mental diagnoses (Hur et al., 2018). Complex interactions among psychological, environmental, and physiological aspects necessitate researchers to consider the range of potential factors in research. However, one way to reduce such a complexity is to consider a factor encompassing many pieces under a singular, cognitive umbrella that enables researchers to better explain differences among consumers.

2. Cognitive style effects on perception and liking of sensory stimuli

2.1 Concept of cognitive style

Aspects of cultural psychology began to gain popularity in the later portion of the twentieth century, with the prior mainstream beliefs leaning more toward the idea of adults having a common hardware that functions equally regardless of personal differences (Block, 1995; Nisbett et al., 2001). As the ideals of cultural psychology were disseminated, it did not take long for them to become recognized by professionals throughout the field to progress forward (Markus & Kitayama, 1992; Shweder, 1999). One of the more unique aspects of cultural psychology is its interdisciplinary nature (Markus & Kitayama, 1992). Backing theory behind modern cultural psychology delves into historical examples of how philosophical and cultural differences were present among ancient societies. Historians and anthropologists have detailed how the ancient Greek and Chinese empires differed in what was encouraged to constituents within those cultures (Highet, 1949; Zhongyun, 1987). These historical underpinnings highlight how understanding and accounting for widespread cultural differences is important in human studies. Encompassing much of the prior research is the concept of Ancient Chinese-influenced countries producing dissimilar or contrasting results to Ancient Greece-inspired countries.

As cultural psychology developed, other theories and differences among people followed suit, most notably field (in)dependence and dialectical thinking. Field independent individuals show more autonomy and articulate events as discrete, while field dependent individuals take a more global view and rely on an increased amount of external or social contexts for perception and decisions (Tinajero & Paramo, 1998; Witkin et al., 1962). In addition, dialectical thinking is focused on decreasing conflict and finding a reasoning-based “middle way” during decision making (Basseches, 1984; Spencer-Rodgers et al., 2010). By combining these perceptual and reasoning aspects, Nisbet et al. (2001) provided an updated way of differentiating psychological aspects of peoples’ culture that encompasses field (in)dependence, dialectic thinking, and other cognitive aspects. This modified definition discusses two ways of thinking between analytic and holistic, reflective of cultural differences in reasoning, perception, and cognition (Masuda & Nisbett, 2001).

2.2. Types and scales of cognitive style

2.2.1. Analytic versus Holistic style

Analytic and holistic categorization manifests into two general types of cultures, with analytic and holistic thinking being more prevalent in Western or European-influenced areas and Eastern or East Asian-influenced areas respectively (Koo et al., 2018). As mentioned, the two cognitive styles can be traced back to important aspects of ancient cultures (i.e., Greece and China) that consequently induced two divergent types of cultures to develop with differing modern-day cognitive styles (Nisbett et al., 2001; Triandis, 1995). This analytic-holistic separation incorporates reasoning, perception, and cognitive processing reflective of more general cognitive styles (Nisbett et al., 2001). One important caveat is analytic and holistic are two cognitive styles that are opposite, yet not mutually exclusive, as findings indicate people are capable of both styles yet have an inclination toward one or the other (Calvo & Beltrán, 2014; Li et al., 2018). Additional recent work also highlights how analytic and holistic groups are not equally impacted by the stimuli and situations, such as when exposed to the opposite cognitive thinking style, analytic individuals will choose more familiar stimuli, with this effect not seen for the holistic group (Koo et al., 2020). This asymmetrical finding supports that the groups can function independently of one another and be differentially impacted by stimuli or environmental situations.

Analytic thinking is associated with increased attention given to focal points of a situation, linearized thought, and independent interpretation of events; and holistic thinking is associated with opposite behaviors of contextual attention bias, cyclical interpretation and prediction, and interdependent relationships of events (Koo et al., 2018; Nisbett, 2003; Nisbett et al., 2001). These differences among analytic and holistic cultures accentuate how each may process events or information inversely. As briefly mentioned, analytic cultures tend to state events or objects are independent and current trends should continue linearly (Ji et al., 2001; Spencer-Rodgers et al., 2010). From the holistic perspective, events and change are handled oppositely and are seen as more interrelated, in the fact that there are no "independent" events, and change is more cyclical in nature (De Vaus et al., 2018). Such stark differences between how analytic and holistic people process information logically produce separate cognitive styles, which lead to divergent mental categorization and decision-making strategies. Cognitive neuroscience research details how neural and potential genetic differences between analytic and holistic cultures offer explanations of why the cognitive idiosyncrasies exist (Calvo & Beltrán, 2014; Chiao, 2018). A wide variety of applications into how analytic and holistic cultures differ can lead to the question of how people or cultures can be consistently categorized.

Choi et al. (2003) created a comprehensive analytic-holistic categorization method by recognizing the final decision is not the sole difference between cultures and a measurement tool needs to account for a wider variety of cognitive processes. Building upon this work was the culmination of the Analysis-Holism Scale (AHS) to measure analytic versus holistic tendencies (Choi et al., 2007). Original studies on AHS development highlighted its ability to separate traditionally holistic (Korea) and analytic (United States) cultures from one another, while also separating analytic and holistic cognitive groups within a single culture (Choi et al., 2007). This ability to separate cognitive groups within conventionally analytic or holistic cultures was a more novel finding and has been further validated (Martin et al., 2019; Ren et al., 2014). Supplementary validation supported these findings of within and between culture analytic-holistic separability of the AHS (Chen & Murphy, 2019; Lechuga et al., 2011). Another important attribute of the AHS was the authors ensured it was truly measuring the analytic-holistic spectrum of cultural psychology rather than other specific cognitive measures (Choi et al., 2007). Discriminant validity helps to ensure the scale is measuring the target cognitive styles of analytic and holistic instead of other unwanted measures that could provide excess categorization noise. While cognitive styles of analytic and holistic are the focus of this dissertation, it is important to understand other types of cognitive styles that have been used to classify consumers, and how they relate to analytic and holistic styles.

2.2.2. Collectivism versus Individualism style

Another way of categorizing individuals and their respective cognitive style is to consider their cultural belonging in a slightly different way: either collectivist or individualistic. Between these two categories are different tendencies people within those cultures tend to display. This cognitive concept was put forth originally to help explain differences among individuals having different backgrounds and experiences (Triandis, 1972; Triandis et al., 1986). As the theory was further developed, individuals could exhibit tendencies of either collectivism or individualism, yet one end of the spectrum tended to be more dominant within an individual. Individualist cultures can often be formed or shaped by a multitude of smaller groups within a culture, which then induce more individualistic inclinations and less feelings of belonging among individuals (Murdock & Provost, 1973; Triandis et al., 1988). An example of this type of culture would be the United States or Canada, in which both were formed by large influxes of various cultural groups. Contrastingly, a collectivist culture, such as China, had a more singular cultural group and did not rely on global immigration during its formation, which would result in interdependent beliefs among individuals. Furthermore, in collectivist cultures power imbalances are common, as there is a greater respect toward authority and acceptance of the imbalances, as the population focuses on the greater benefits provided (Bontempo et al., 1990; Triandis et al., 1988). Comparatively, individualistic cultures have more equal power balances, as individuals feel less obligated to conform with their culture (Witkin & Berry, 1975).

Much of the earlier research on collectivism and individualism hinged on how people's social roles or interactions differed, with modern research indicating emotions, motivation, and cognition can also differ between the two categories (Kitayama & Park, 2010). Initial evidence suggested individualism-collectivism differences alter higher-level processes of decision-making by showing individualists are more rational and collectivists are more interdependent when forming decisions (LeFebvre & Franke, 2013). While understanding the consequences of individuals being associated with an individualist or collectivist culture, many argue it is crucial to quantitatively measure those tendencies. One of the initial measurement tools was the Individualism-Collectivism (INDCOL) Scale. This scale was developed to effectively capture a general view of characteristics behind individualism or collectivism and focus on measuring the concept as an aspect of one's personality and individual relationship tendencies (Hui, 1988; Kim & Coleman, 2015). A drawback of individualism and collectivism classification is its inherent focus on how people perceive their personal and societal relationships or motivations, which can be seen as a portion of analysis-holism cognitive perception (Kitayama & Park, 2010).

2.2.3. Convergent versus Divergent style

An alternative way to differentiate cognitive styles is by considering convergent and divergent thinking (Guilford, 1959, 1967). The employment of these cognitive styles has provided researchers a dimension and pathway to understand how people process information. Convergent thinking style can be interpreted as individuals converging on the "correct" answer to a problem by focusing on a singular aspect of a situation (Razumnikova, 2013). Oppositely, divergent thinking is associated with generating multiple solutions, considering wide varieties of information, and focusing on many portions of a situation or problem (Brophy, 2001; Runco, 2010). Divergent thinking has been linked to creativity and this linkage has been further supported by neural imaging research indicating similar areas of brain activity between divergent and creative thinking (Mölle et al., 1996; Sun et al., 2016). Cognitive styles are rarely binary, and these findings reflect how consumers can be impacted by many factors in how they process information and fall onto a cognitive convergent-divergent spectrum.

Related to divergent thinking are traits paralleling creative tendencies, such as openness to experience, extraversion, imagination, and curiosity (Batey et al., 2009; McCrae & Ingraham, 1987). Convergent thinking individuals will tend to have negative emotions and divergent thinking individuals more positive emotions (Chermahini & Hommel, 2012). With divergent-convergent cognitive styles capable of altering personality and emotions, one would predict higher-order neural processes (i.e., decisions or learning) may also be affected. Evidence suggests decision-making, under convergent versus divergent thinking, utilizes contrasting information, while also activating opposing neural pathways (Eris, 2003; Hommel, 2012). Consequently, individuals on the opposite ends of the divergent-convergent continuum may reach differing decisions. Like analytic versus holistic categorization, convergent-divergent thinking has also been shown to differ between "Eastern" and "Western" countries, and additional insight has detailed how it can be seen as a sub-portion of analytic-holistic thinking (Koo et al., 2018).

2.2.4. Left Brain versus Right Brain style

One aspect of cognition that is sometimes underutilized is explaining how cognitive categories may relate to brain areas, or the Hemispherical Lateralization Concept (HLC). Initial research in the 1960's and early 1970's suggested humans have two "halves" of the brain by studying patients undergoing procedures to disconnect the corpus collosum (Ornstein, 1972; Sperry, 1967). However, even as early as the 1970's, these views that the halves of the brain work independently and the possibility of classifying people as "right" or "left" brained were being challenged (Robinson, 1976). Findings further discussed how areas within the left hemisphere (i.e., verbal, motor skill, and analytic logic processing) interacted more with areas in same hemisphere, and right hemisphere regions (i.e., spatial reasoning and creative processing) interacted across both hemispheres (Gotts et al., 2013). Transforming HLC is this modern take on brain lateralization research, which discusses how there are proven relative differences between the lateralized halves of the brain (Corballis, 2018; Nielsen et al., 2013). However, these relative differences are not dichotomous between left or right brain people; rather, they are bookends along a continuum where people are more likely to lean when processing information.

As research began to elucidate brain lateralization was not binarily right or left brain, a focus on brain asymmetry provided insight into how HLC can be used to categorize individuals. Studies specifically aimed to distinguish how falling onto different portions of the HLC spectrum may influence behavior via contrasting neural pathways (Rossion et al., 2000; Vallortigara & Versace, 2017). These hemispheric contrasts in brain activity go beyond subconscious bodily functions and indicate behavioral differences can be imparted by relative activity variations between the left and right brain (Karolis et al., 2019; Nielsen et al., 2013). Education research field has detailed how the cognitive differences may exist between individuals tending to employ more right (intuitive or creative) or left (logical and analytic) brain activity when learning and problem solving (Kitchens et al., 1991; Mehrdad & Ahghar, 2012).

One related way to conceptualize cognitive style is the relational-experiential, or cognitive-experiential self-theory (CEST). This cognitive theory categorizes individuals along a spectrum from analytic/rational to intuitive/experiential (Epstein et al., 1996). One major difference resides in HLC focusing on geometric cerebral guidelines that mediate the cognitive styles and CEST focusing on the behavioral output. Details of CEST indicate rational thought will be deliberate and logical and experiential thought will be intuitive and emotionally driven. Another differentiating factor of CEST is it classifies individuals on type of thought (automatic versus deliberate) rather than on actual cognitive styles (Epstein et al., 1996; Garrison & Handley, 2017). Within the analytic-holistic cognitive style, the behavioral tendencies of CEST and HLC are both seen, without the limiting factors of different thought types or the debate on the theoretical accuracy and validity (Corballis, 2014; Nielsen et al., 2013). A consistent theme across cognitive style classifications is the focus on a specific portion of an individual's tendencies regarding information processing or decision-making. These categorizations fit under the encompassing arch of analytic-holistic cognition, which does not rely on niche aspects of information processing or problem solving (Koo et al., 2018; Nisbett et al., 2001).

2.3. Influences of cognitive style on perception and liking of sensory stimuli

2.3.1. Single module stimuli

Much of the cognitive style research has pertained to psychological studies focusing on theory and problem solving. Unfortunately, there is a lack of research connecting cognitive style to how various stimuli are processed between individuals with contrasting thinking styles. To begin to understand how cognitive styles may induce changes in stimuli perception, it is first important to clarify single module and multi-module stimuli. A single mode stimulus is one that is directed toward one sense (i.e., a single basic taste, the color blue, or a single olfactory stimulus), while a multi-mode stimulus is one that involves many stimuli across the senses and within the same sense (i.e., a cheeseburger using sight, olfaction, and gustation, or a movie involving multiple visual and sound stimuli). Research suggests contrasting cognitive styles may be associated with changes in how individuals process simple versus multi-module stimuli (Kozhevnikov, 2007; Mei-Hua, 2008).

Single mode stimuli can be connected to each of the five senses: olfaction, visual, gustatory, auditory, and tactile (touch) cues. Research specific to olfaction indicates potential impacts of cognitive style on olfactory perception, with some researchers predicting cognitive style may be a mediating factor of perceptual differences or be important in olfactory perception in conjunction with non-cognitive factors (Sabiniewicz et al., 2021; Thomas-Danguin et al., 2014; Vinitzky & Mazursky, 2011). Visual stimuli perception displays similar trends, with researchers elucidating how neuroimaging results of individuals support the notion of thinking style altering the interpretation of visuals (Bendall et al., 2019; Kraemer et al., 2014). Relative to olfactory and visual cues, gustatory cues have received little specific attention in research, with most studies focused on special cases or incorporating taste into a more complex stimulus. Synesthesia (i.e., one stimuli triggers interpretation using another sense) involving gustation can be linked to cognitive style according to initial studies on the subject (Lunke & Meier, 2018). Auditory processing among individuals has garnered some academic and industry attention with respect to cognitive style, as music perception and liking were found to associated with cognitive style differences (Greenberg et al., 2015). Tactile cues have also received some attention in association with cognitive style differences, and findings indicate tactile responses and interpretation partially depended on the individual’s cognitive style (Minagawa & Kashu, 1989; Zoccolotti et al., 1979). With each of the senses capable of being modified by consumer’s cognitive styles singularly, it is understandable in more realistic contexts how cognitive styles may have increasingly clear and noticeable impacts.

2.3.2. Multi-module stimuli

Cross-modal correspondences and synergistic effects can be seen across the senses, and they involve multi-module stimuli, such as food or drinks, and are more representative of consumer's daily interactions (for a review, see Heatherly et al., 2019; Spence, 2017). Cross-modal correspondences are an example of multi-module stimuli, meaning they are dependent on a stimulus engaging multiple senses. Multi-module stimuli are increasingly representative of realistic situations, as the brain rarely receives unimodal stimuli (Sigrist et al., 2013). These multi-module stimuli are used to support the concept of multisensory integration, which has garnered attention in explaining how humans process and interpret their surroundings by employing a flexible, combinative neural network (Follmann et al., 2018; Freeman, 1998). Recent models measuring the multisensory integration have suggested methodologies are more accurate in capturing human responses to multi-module stimuli when considering an average of all the senses (Turner et al., 2017).

A multitude of researchers agree the human-food interaction is a multi-module experience in which consumers rarely separate senses singularly (Bruijnes et al., 2016; Frank et al., 2013; Verhagen, 2007). Interactions among the senses have been known to exist, with newer research beginning to detail additional cognitive interactions among the senses capable of influencing neural processing of food stimuli (Hoffmann-Hensel et al., 2017). An important part of consumer perception of food is neurological and psychological processing of the food-related stimuli to reach decisions. Consumer cognitive style has proven to be an effective variable in explaining how food-related opinions and decisions are formulated. For example, Hidalgo-Baz et al. (2017) discussed how an individual's cognitive style could impact how they perceived the quality of organic and conventional foods after interacting with products, with parallel results found in relation to processing depth of food stimuli (Mawad et al., 2015). Jeong and Lee (2022) further these arguments by discussing how over a variety of food and beverage samples and situations, that the cultures associated with differing cognitive styles consistently display different perceptions of the food or beverage. Differences in how consumers process food-specific information cause ensuing schisms in perception and liking, which have been shown to be dependent on individual's cognitive style.

3. Influences of analytic or holistic cognitive style on food perception and eating behavior

3.1. Single module stimuli

Analytic versus holistic thinking is the main cognitive style of interest to investigate its effects on how consumers process stimuli to develop the food-related decisions and behaviors. Within the research regarding the effects of cognitive style on information processing and stimuli perception, there is some debate on the significant differences being due to contrasting cognitive styles between groups (Bendall et al., 2016; Hudson et al., 2006). A lack of consistent findings could suggest differing methodologies, which has been common when cognitive styles are investigated. To prevent research on consumer thinking style becoming too narrow and missing relevant data, the analytic-holistic cognitive style classification can be utilized (Nisbett et al., 2001). When developing the framework and measurement tool (AHS) to classify individuals along the analytic-holistic spectrum, a main goal was to ensure the final result was a general classification style representative of the cognitive steps individuals undergo when processing information (Choi et al., 2007; Nisbett et al., 2001). Considering analytic-holistic classification when investigating the effect of cognitive styles on consumer perception is therefore predicted to produce more consistent and accurate results.

Unfortunately, this classification style is more recently developed and validated with fewer studies on how analytic-holistic cognitive style can impact single-module stimuli compared to other cognitive style theories. In addition to analytic-holistic cognition being a novel classification tool, researchers within the field have often suggested it for identifying behavioral, decision, and cultural differences (Ji et al., 2001; Miyamoto, 2013). Directing methodologies and studies toward higher-level processing to understand contextual and realistic decision making has left a gap in the research toward singular areas of stimuli perception. The most studied single-module stimuli type has been visual, with researchers consistently finding analytic (holistic) people consider less (more) contextual information related to visual stimuli (Koo et al., 2018; Masuda & Nisbett, 2001; Miyamoto et al., 2006). Related to olfactory differences between cognitive styles, Chrea et al. (2004) detailed how olfactory processing and identification can differ between analytic and holistic cultures. One recent study combined two singular stimuli (visual and gustatory) and found analytic-holistic cognition moderated the perceptual differences (Togawa et al., 2019). Cultural neuroscience has found analytic and holistic individuals differ in the neural development, functioning of higher-order informational processing regions, and emotional processing (Cheon et al., 2018; Chiao, 2018). From the neuroscience findings, it would be expected analytic and holistic individuals differ in their perception of stimuli in each of the five senses. Interesting research has applied the analytic-holistic cognitive theory to some basic cognitive tasks involving vision and responses, with findings indicating that physiological responses, such as heart rate, were found to differ between the groups (Bakhchina et al., 2021). If even basic stimuli can elicit such responses, multi-modal stimuli may result in further physiological response differences between cognitive groups.

3.2. Multi-module stimuli

Multimodal sensory experiences induce more complex, interactive stimuli that the brain must respond to and interpret into a cohesive experience, thus a multitude of shared brain areas associated with the senses are involved in food and beverage perception (Bonny et al., 2017; Castillo, 2014). In most foods one would consume, there are many interacting pieces depending on each food matrix. Humans are poor at separating each of these components to be interpreted monadically; rather, they are experienced together to allow for a comprehensive perception and hedonic impression of the food (Small & Prescott, 2005; Verhagen, 2007). To answer the type of question of how food may be perceived differently between consumers, some research has discussed how multi-module information and stimuli can be perceived inversely between analytic and holistic cultures (Cui et al., 2013).

Studies applying the factor of analytic-holistic cognitive styles to advertising have found that by accounting for cognitive tendencies of consumers, an explanation for the differences in perception of and responses to food advertising can be offered (Yang et al., 2019). Holistic thinkers were more sensitive to food advertising claims made by the researchers and their opinions of the food products were more variable dependent on the type of advertisement shown. These findings parallel Nisbett et al.'s (2001) description of holistic individuals being more likely to consider contextual information, as consumers considered the context of the advertisement more when forming their opinion. Such results could apply to environmental cues or packaging claims being more effective with holistic consumers. An interesting application of analytic and holistic differences adjacently related to food-related stimuli involves the findings from Santos et al. (2021) that detail how when presented with contradicting information, analytic and holistic groups differed in how they handled such contradictions through contrasting mixed emotional responses between the cognitive groups. As it is well known that emotions and emotional processing significantly impacts food perception, a logical application of such findings suggests that analytic and holistic individuals would also have contrasting food perceptions due to the inequivalent process in which those from the cognitive groups utilize and apply emotions.

3.3. Eating behavior

A perplexing issue to food and sensory science researchers is the complexity and lack of common understanding of consumer food behavior (Rana & Paul, 2017; Steenkamp, 1993). Some researchers tend to become hyper-specific when understanding aspects of food behavior by applying existing theories, while others tend to take a more general, exploratory approach (Kumar & Smith, 2018). Researchers have found consumer food behavior is not consistent across cultures when they took a step back to look at the exploratory and comparative picture of their results (Loose & Remaud, 2013). An aspect of food behavior often receiving attention is consumer eating behavior and understanding how or why eating decisions are made. Both industry and academia aim to understand eating behavior to effectively market foods to match eating behavior and address health issues (van der Laan & Smeets, 2015). To better explain some of the unknowns of eating behavior, researchers have begun to combine the extrinsic and personal factors by investigating the potential role of cognitive style in guiding eating behavior. Results investigating eating behaviors of specific cultures help support the notion of analytic-holistic cognition being an influencing variable on eating behavior (Kabir et al., 2018; Santana et al., 2017). Another point made about analytic-holistic cognitive style contrasts between cultures is that the differences can also exist within a culture (Ren et al., 2014). Adding analytic-holistic cognition as variable in analyses has the potential to explain unexpected findings or clarify results by separating two previously unseen groups within a single population.

Prior studies delineated how decision-making differs between analytic and holistic groups, most notably between the amount and type of information considered for the decisions (Apanovich et al., 2018; Koo et al., 2018; Masuda & Nisbett, 2001; Nisbett et al., 2001). Researchers built upon those findings and applied them to food-related conditions where it was found holistic individuals are more susceptible to food advertising claims and product information, with the associated cultures of the cognitive groups also having differential food buying behavior (Hildebrand et al., 2019; Vanbergen et al., 2020; Zhang et al., 2022). Holistic consumers were found to display less self-control when indulgent food was advertised with situational cues. These food specific findings match with previous research indicating holistic consumers should see more relationships between sensory cues. Further support has been provided by research indicating the use of prior information on decision making and how sensory information is formed into memories differs between analytic and holistic individuals (Swallow & Wang, 2019). Additional recent work has detailed how analytic and holistic groups and cultures can have divergent cross-modal correspondences and sensory-task discriminability between such cognitive groups and cultures (Gupta et al., 2021; Peng-Li et al., 2020). Through this research it is clear how important it is to understand the impact on immediate sensory perception, as well as the impact throughout the food experience.

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CHAPTER 2

ANALYTIC VERSUS HOLISTIC: COGNITIVE STYLES CAN INFLUENCE CONSUMER RESPONSE AND BEHAVIOR TOWARD FOODS

Abstract

While there is a growing body of attention to the diversity of cognitive styles among individuals, that has yet to be directly applied to sensory and consumer sciences. This study was aimed at identifying how divergent analytic and holistic cognitive styles can affect individuals' food-related experiences. Participants were classified into either analytic or holistic cognitive style groups based on their scores on the Analysis-Holism Scale. Focus group interviews were conducted to identify group differences with respect to three aspects of food-related experience: (1) shopping for, (2) preparing, and (3) consuming food. The results revealed that analytic consumers focused more on individual ingredients, separate meal portions, and singular important food attributes, while holistic consumers focused more on overall impressions, entire meal portions, and multiple food attributes as being important. In conclusion, this study sheds lights on how cognitive styles can modulate consumers' food-related experiences in everyday life. Prior analytic-holistic research has highlighted how these two consumer groups can exhibit different processing and interpretations of identical situations. By utilizing psychology theory in the applied setting of sensory evaluation, it has been detailed how analytic and holistic groups that co-exist in a single population can provide significantly different results in response to food samples in everyday life. Analytic-holistic cognitive styles should therefore be taken into consideration when conducting consumer-oriented sensory evaluation and product development to achieve better understanding of and predict consumer response and behavior toward food products.

Keywords: Cognitive style, Analytic, Holistic, Consumer behavior, Focus group interview, Culture

1. Introduction

Cultural psychology has been under development since the early and mid-portions of the twentieth century, with many of its original theories and findings revolving around specific portions of individuals' cognitive behaviors. For example, convergent-divergent, field (in)dependence, and hemispheric lateralization theories all produced findings during the mid-1900's that described the various ways in which cognitive and information processing differences among individuals could impact human behavior (Guilford, 1959; Ornstein, 1972; Tinajero & Paramo, 1998). A downfall of these initial cultural psychology theories was a lack of consistency across the findings of the various studies that some researchers have attributed to aspects of situational dependency of these findings when paired with differing locations, sample populations, and methods (Smith et al., 1992). However, despite such contrasting findings, the significant impact of cognitive style differences among individuals has been widely agreed upon. As cultural and social psychologists have conducted research investigating how individual thinking styles or cognitive behavioral tendencies alter outward behaviors and information processing, the necessity for a more encompassing cognitive-style categorization has become apparent (Pacini & Epstein, 1999).

At the turn of the twentieth century, the analytic-holistic cognitive style spectrum was put forth as an over-arching theory to separate individuals based on general cognitive style rather than specific cognitive features (Peng & Nisbett, 1999; Nisbett et al., 2001). This modern cognitive theory addressed some of the drawbacks of earlier theories by putting the focus on broad categorization themes rather than niche attributes. Analytic cultures were historically aligned with "Western" societies (e.g., European) and holistic cultures more associated with "Eastern" societies (e.g., Asian) (Markus & Kitayama, 1992; Peng & Nisbett, 1999). Analytic thinking is associated with increased attention on focal points of a situation, linearized thought, and independent interpretation of events, while holistic thinking is associated with opposite behaviors, i.e., contextual attention bias, cyclical interpretation and prediction, and interdependent relationships of events (Nisbett et al., 2001). Through a multitude of studies, such separation of findings about analytic and holistic consumers have been replicated, thus supporting the validity of the theory among individuals and cultures (Masuda & Nisbett, 2001; Nisbett & Masuda, 2003; Miyamoto et al., 2006; For a review see Koo et al., 2018). As originally delineated, and subsequently confirmed in following studies, analytic-holistic cognitive differences ranging from visual cue recognition to learning style preferences can induce and mediate differences in people (Calvo & Beltrán, 2014; Cheng & Zhang, 2017). Interdisciplinary work has also found neural processing differences between analytic and holistic individuals, inducing widespread perceptional and behavioral differences (Chee et al., 2011; Chiao, 2018). These findings reveal how accounting for analytic-holistic cognitive style as a factor in applied settings outside of psychology can provide impactful results.

A few recent studies have identified how analytic and holistic differences can induce divergent responses between individual consumers in applied settings of food perception (Yang et al., 2019; Vanbergen et al., 2020). Hildebrand et al. (2019) contributed to this developing body of interest by displaying how holistic consumers are significantly more impacted than analytic consumers by food advertisement contextual cues, which can be specifically impactful during the shopping piece of food behaviors from advertisements influencing shopping decisions (Haider & Shakib, 2017). In addition, recent literature has discussed how cultural differences can impact cooking behaviors due to the cognitive processes that rely on the contrasting observational and practical learnings individuals undergo within these differing cultures (Farmer et al., 2018;

Reddy & van Dam, 2020). There is also initial evidence that cognitive styles may influence consumer food consumption through altering how the perception of food aspects are connected and how individuals form their opinions and memories of these instances (Lee, 2017; Swallow & Wang, 2019). These primary findings suggest that cognitive styles (especially, analytic versus holistic) can induce individual variations in response and behavior toward foods or food-related contexts across the food experience from shopping to preparation and consumption instances. However, previous studies have notably detailed how analytic or holistic tendencies of individuals may fluctuate depending on the contextual situation when delving outside the area of general cognition (Miyamoto, 2013). Because sensory perception and behavior in response to foods have previously been shown in detail to vary with food-related contexts (Hasenbeck et al., 2014; Heatherly et al., 2019; Wang et al., 2019), it is worth investigating how analytic or holistic cognitive styles modulate individuals' food-related experience. Understanding of such cognitive styles-induced variations in consumer response and behavior may to some extent explain contradictory findings related to how certain pieces of sensory experiences are impacted by specific factors such as differences in cognitive procesing. Hence, sensory professionals could gain insight into a cognitive-processing variable capable of altering consumer perception and behavior in a top-down fashion (White et al., 2020). By gaining an enhanced understanding into how the consumers response and behavior toward foods are modulated depending on consumers' analytic-holistic tendencies, a variable portion of cognitive behaviors toward foods could be better clarified.

Since there has been only a limited number of sensory studies incoporating such a modern cognitive model, the degree to which analytic and holistic consumers may differ in food-related contexts is still unknown. To address this knowledge gap, an exploratory study was necessary to identify how analytic and holistic cognitive differences among consumers become apparent across the aspects of behavior toward foods. Qualitative textual analysis techniques of interviewing, encoding, and data analysis to collect in-depth data have previously been shown to match well with the requirements of an exploratory study in providing preliminary findings of novel theories and contexts (Maxwell, 2013; Creswell & Poth, 2018a). Therefore, by combining traditional quantitative sensory techniques with exploratory qualitative techniques, this study aimed at identifying how cognitive styles, i.e., analytic versus holistic, could affect consumer response and behavior toward foods over the range of food-related experiences. To break down the complexity of consumer response and behavior toward foods, three main sections that make up the consumers' food-related experiences were drawn from the body of related research: food shopping, food preparation, and food consumption (Seo, 2020).

2. Materials and methods

The protocol (No. 1902176265) 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 286 volunteers (199 females and 87 males) of ages between 21 and 82 years were recruited from the Northwest Arkansas community through a consumer profile database of the University of Arkansas Sensory Science Center (Fayetteville, AR, USA). Volunteers with known food allergies or clinical histories of major diseases were not included in this study.

Participants were also screened through an open-ended series of questions to ensure their ability and willingness to discuss food-related opinions and reactions in a focus group interview (FGI) study. To identify those representing either analytic or holistic cognitive style, the Analysis-Holism Scale (AHS) (Choi et al., 2007) was applied to the volunteers. The AHS scale, developed for the purpose of categorizing individuals over the analytic-holistic spectrum, has been validated through multiple studies, both between and within cultures (Lechuga et al., 2011; Ren et al., 2014; Koo et al., 2018). Within the scale, there are a series of 24 statements to be answered on a scale ranging from 1 (strongly disagree) to 7 (strongly agree), with higher and lower scores corresponding to stronger holistic and analytic tendencies, respectively. The AHS has also recently been employed successfully within applied food- and consumer-related research studies, offering initial support to its validity outside of general psychological research (Hildebrand et al., 2019; Vanbergen et al., 2020). Participants in the current study, based on falling into the top 25% (holistic cognitive style group) and bottom 25% (analytic cognitive style group) of scores, were separated into two cognitive consumer groups (DeMotta et al., 2016; Tu & Pullig, 2018; Hildebrand et al., 2019). Within this study, the analytic and holistic cognitive style groups were comprised of 33 participants [19 females; mean age ± standard deviation (SD) = 50 ± 14 years] and 30 participants (17 females; mean age ± SD = 48 ± 15 years), respectively; both groups did not differ with respect to mean age (P = 0.49), gender ratio (P = 0.85), ethnicity background ratio (P = 0.16), income level (P = 0.40), or education level (P = 0.27).

2.2 Questionnaire and samples

To conduct the focus group interviews (FGIs), a semi-structured questionnaire was developed to allow comparisons across all FGI sessions based on the common shared interview structure and questions in all the sessions, while also accounting for common areas of difference between analytic and holistic groups (Nisbett et al., 2001; Maxwell, 2013). The questionnaire script was developed to collect in-depth data regarding the effect of analytic-holistic cognitive style on three sections of the food-related experience: food shopping, food preparation, and food consumption. Each section consisted of three questions formulated to be consistent with previous analytic-holistic cognitive research that would optimally locate where differences in sensory perception may exist between the two cognitive style groups (Nisbett et al., 2001; Choi et al., 2007; Hildebrand et al., 2019). Portions of the interview script were also modified to ensure in-depth data collection by encouraging discussion among FGI participants after initial review with content experts and comparisons to other related FGI questions and scripts (Creswell & Poth, 2018b). Upon development of the script, a preliminary test session was conducted to ensure question clarity and relevancy to both sensory experience and analytic-holistic cognitive style. Based on the preliminary test, a total of ten questions within the script corresponding to the three sections were developed: food shopping (Q1 to Q3), food preparation (Q4 to Q6), and food consumption (Q7a, Q7b, Q8, and Q9). The full questions can be referenced in Table 1.

As part of the food consumption section, two food samples, i.e., watermelon and fruit salad, were prepared and provided to participants. Seedless watermelon (Robinson Fresh, Eden Prairie, MN, USA) and fruit salad samples were chosen to represent simple and complex food items, respectively. Prior research suggested that analytic and holistic individuals may show different responses to tasks ranging from simple to complex (Calvo & Beltrán, 2014; Meaux & Vuilleumier, 2016). The fruit salad consisted of five fruit items: the seedless watermelon, honeydew melon (Legend Produce LLC, Scottsdale, AZ, USA), clementine (AMC Direct Inc., Glassboro, NJ, USA), black seedless grapes (Sun World Innovations, Palm Desert, CA, USA), and pineapple (Marketside, Walmart, Bentonville, AR, USA), providing a wide variety of sensory attributes (i.e., color, shape, taste, flavor, and texture). While watermelon, honeydew melon, and pineapple samples were all cut to similar bite-sized pieces to maintain consistency, grape samples were kept whole and removed from the vine, and clementine samples were peeled and served as slices. Another reason for choosing both samples (watermelon and fruit salad) was to maintain food category consistency (i.e., fresh fruit), thereby avoiding potential influences of food type introducing an additional variable other than sample-complexity or analytic-holistic differences in cognitive style. Finally, both samples were also chosen to offer participants a familiar set of food samples that made sense for the time of year the project was conducted in, which was the summer in this case (Raudenbush & Frank, 1999; Jaeger et al., 2017). Participants were also screened to ensure they were all acceptors of these samples. All fruit samples placed in 590-mL white bowls (Soak Proof Foam Bowls, Great Value, Walmart, Bentonville, AR, USA) were served at approximately 5 °C, along with a glass of spring water (Clear Mountain Spring Water, Herber Springs, AR, USA).

2.3 Procedure

Four FGI sessions were conducted within each cognitive-style group. Prior to beginning each session, the use of audio and visual recording was explained to all participants and a brief introduction was provided to enhance the participant-moderator relationship and produce higher-quality data (Adams & Cox, 2008). All sessions were audio- and video-recorded to allow audiovisual data to be referenced during subsequent data analysis. In addition, to prevent cognitive biasing or priming, participants were provided with a pen and blank paper and instructed to write down their responses to each question prior to group discussion (Varnum et al., 2010). To maintain consistency across sessions, all FGI sessions were conducted by the same moderator, who introduced all the questions except for Questions 7a and 7b that involved the presentation of the watermelon and fruit salad samples prior to introducing the question. Depending on the make-up of the FGI, each session lasted from 45-60 min. Moderator notes were also maintained throughout each FGI session as a form of data triangulation used to collect group consensus notes (Creswell & Poth, 2018b).

2.4. Data analysis

All written and audio data were encoded for each participant across all questions, then cleaned to remove tautological data. Following phenomenological methods, to sort each participant's responses within each question, all encoded data were processed using open and categorical coding (Moustakas, 1994; Creswell & Poth, 2018c). Clusters of meaning were then formed across participants to identify shared "categories" within each question, and textural and structural analyses to deduce concise categories that considered context and meaning underlying the encoded data were subsequently performed. Through these qualitative data analysis steps, each FGI question produced a list of shared "keyword categories" across participants in both cognitive style groups, allowing comparisons to be made regarding the frequencies of keyword categories between them (Piqueras-Fiszman, 2015). Each "keyword category" (hereafter abbreviated "keyword") was separately counted across participants for the two groups across the data for each FGI question. Frequency tables were then generated for analytic and holistic cognitive style group data counts across each keyword for each question. Analytic-holistic groups were treated as the independent variable and keywords were treated as the dependent variable.

Prior research had followed similar qualitative steps of then applying quantitative analyses of global and cell chi-square tests among each of the contingency tables containing the data to identify significant keyword-frequency differences between consumer groups (Symoneaux et al., 2012; Piqueras-Fiszman, 2015). However, an initial set of analyses was conducted, prior to following these analyses, to check if there were any significant differences in keyword generation between cognitive style groups that could impact results or interpretations from later analyses. Student's *t*-tests were, thus, performed to determine whether the number of keywords cited per participant were different between the two groups (1) across all FGI questions in each food-related experience section, and (2) across all FGI questions.

Global chi-square analyses employing Fisher's exact tests were conducted on the above contingency tables within each question to provide insight into those FGI questions that reflected a significant dependency between cognitive style group and keyword variables. Subsequently, a cell chi-square analysis employing Fisher's exact tests was performed to identify keywords that represented a significant difference between the two cognitive style groups within each question. As previously described, the food-related experience was split up into three sections: food shopping (Q1-Q3), food preparation (Q4-Q6), and food consumption (Q7-Q9). To investigate the cognitive-style group differences within these three sections, keyword frequencies for each cognitive-style group were summated across the questions within each of the respective food-related experience sections, and separate Fisher's exact tests were then carried out to identify significant relationships between the cognitive style group and keyword variables within each section.

To visualize general differences between analytic and holistic cognitive style groups throughout their food-related experiences, all keyword categories, significant and non-significant, were summated within each food-related experience section and cognitive group. The summed keyword frequencies listed within each section were then analyzed to create word clouds for each food-related experience section. Relative frequencies of keywords were showcased by larger words to indicate a higher frequency for the corresponding keywords, and the association of keywords between the two cognitive style groups was represented by the color of the keyword. Upon visualization of keyword differences between cognitive style groups, additional data steps were taken to identify further association between food experience responses and cognitive style groups. First, a hierarchical cluster analysis (HCA) was conducted with Ward's method that utilized the response data summed across all FGI questions due to the relatively smaller size of the dataset and the replicability of the HCA methods (Steinbach et al., 2000; Abbas, 2008). The variables included were all participant demographic variables, all keywords treated as individual variables, and their respective counts summed across all FGI questions for participants. No analytic-holistic related variables (e.g., AHS score or analytic-holistic group label) were included to prevent skewing the formed clusters, as the participants had already been previously separated into cognitive style groups, with this method allowing participants and food response keywords being used to determine clusters. HCA cluster separation was based on a combination of maximizing the cubic clustering criterion (CCC), employing the elbow method when evaluating the cluster distance graph, and considering prior analytic-holistic research to separate the results into the most logical clusters (Guess & Wilson, 2002; Leskovec, 2021). Following cluster identification and separation, mean comparisons between the clusters with respect to the summed keyword citations across all FGI questions for each participant, were conducted using independent *t*-tests.

To compare with the cluster formation and relative separation of cognitive style groups within the clusters, a recursive partition decision tree analysis was conducted with the same variables that were used in the cluster analysis to predict participants belonging to either analytic or holistic cognitive groups (Morgan, 2014). This analysis allows visualization as to what are the most important variables into participants being categorized as either analytic or holistic based solely on their demographic and FGI responses. The partitioning procedure followed prior research on employing the decision tree algorithm to stop at the split point that maximizes the model fit by limiting the number of predictor variables separating the data points into groups, being the participants into analytic and holistic groups in this example (Morgan & Sunquist, 1963; Strobl et al., 2009). Following the decision tree analysis, the misclassification percentages of both the HCA and the decision tree analysis were calculated. After the cluster and partition analyses, predictor variables could be identified that had a greater impact on separating the two cognitive style groups, based largely on participant FGI responses.

Up to this point, much of the FGI responses highlighted individual trends of keywords between the two cognitive style groups. To aid in systematically connecting the results of the prior analyses together, a thematic proximity co-occurrence analysis was conducted to quantify and compare which terms appeared more often together. For this step, thematic (*t*)-coefficients were calculated that account for both the relative occurrence of each keyword and how often they appeared together for keywords that were found to significantly differ from one another between the cognitive style groups based on the prior Fisher's exact test results (Supplementary Tables 1-10; Armborst, 2017). The *t*-coefficients were compared between the responses of the cognitive style groups to identify meta-themes between the analytic and holistic groups, thus connecting much of the results from the qualitative data to earlier quantitative results (Alibage, 2020; Bayad et al., 2019). Through recommendations within this area of research, *t*-coefficients greater than 0.20 were considered to indicate keywords that had a moderate to high degree of co-occurrences with one another (Armborst, 2017; Pradarelli et al., 2021). Meta-themes were then developed based on these keywords exhibiting notable co-occurrence with each other between the two cognitive style groups (Armborst, 2017; Wutich et al., 2021).

Finally, a multiple corresponding analysis (MCA) was conducted to tie the above results together and seek more over-arching insights into the three variables: cognitive style groups, keywords, and food-related experience sections. To prevent skewing that could result from only considering the first two axes, the top three factors were utilized through two associations: (1) Factor 1 (F1) versus Factor 2 (F2) and (2) Factor (F1) versus Factor 3 (F3). Due to MCA procedures creating additional factors during the analysis that can cause severe underestimation of variance accounted for within the model, Greenacre adjusted inertia percentages are included on the axes (Greenacre, 1984; Abdi & Valentin, 2007). A statistical significance was defined when $P < 0.05$. Data were analyzed using JMP Pro software (version 15.1, SAS Institute Inc., Cary, NC, USA) and XLSTAT software (Addinsoft, New York, NY, USA).

3. Results

3.1. Comparisons between analytic and holistic cognitive style groups with respect to the number of keywords cited per participant during focus group interviews

Student's *t*-tests revealed significant differences between the two cognitive style (CS) groups in terms of the number of keywords cited per participant during a focus group interview (FGI). More specifically, participants in the holistic CS group used more keywords than participants in the analytic CS group when they described food-related experiences related to "food shopping" (t = -3.26, P = 0.002), "food preparation" (t = -3.10, P = 0.003), and "food consumption" (t = -3.43, P = 0.001) (Table 2). Overall, the number of keywords used across the three food-related experience sections during the FGI interview were also higher in the holistic CS group than in the analytic CS group (t = -5.10, P < 0.001) (Table 2).

3.2. Comparisons between analytic and holistic cognitive style groups with respect to the frequency of specific keywords cited during focus group interviews

Supplementary Tables 1 to 10 list keywords captured from participants' answers to each question during FGIs. For the contingency table between the CS group and keyword category for each question, a global chi-square analysis employing Fisher's exact test revealed that the two variables were not independent, and that there was a significant difference between the analytic and holistic CS groups with respect to the citation frequencies of keywords: Q1 (P < 0.001) Q2 (P < 0.001), Q4 (P < 0.001), Q5 (P < 0.001), Q6 (P < 0.001), Q7b (P < 0.001), Q8 (P = 0.002), and Q9 (P = 0.004). Non-significant differences between the analytic and holistic CS groups were also observed with respect to frequencies of keywords for Q3 (P = 0.48) and Q7a (P = 0.43).

A cell chi-square analysis employing Fisher's exact test was subsequently applied to each keyword for each question, with the results shown in Supplementary Tables 1 to 10. More specifically, for the Q1 and Q2 under the food shopping section, while participants in the analytic CS group cited "ingredient" or "single" more frequently, those in the holistic CS group cited "meal", "overall", "plan", "multiple", "brand", or "experience" more often (for all, P < 0.05) (Supplementary Tables 1 and 2). An analysis of aggregated data collected from answers to the three questions (Q1 to Q3) produced similar results: [for analytic > holistic: "single" (P =

0.004); for analytic < holistic: “meal” (P < 0.001), “overall” (P < 0.001), “multiple” (P = 0.002), “brand” (P = 0.045), or “experience” (P = 0.01)]; non-significant differences were also observed in the frequency of “ingredient” (P = 0.13) or “plan” (P = 0.06) (Table 3 and Fig. 1). For Q4 to Q6 under the food preparation section, while participants in the analytic CS group cited “individual”, “time”, or “single” more frequently, those in the holistic CS group cited “meal”, “overall”, or “multiple” more often (for all, P < 0.05) as shown in Supplementary Tables 1 to 3. When analyzing aggregated data collected from answers to the three questions (Q4 to Q6), similar patterns were observed: [for analytic > holistic: “individual” (P < 0.001) or “single” (P = 0.04); for analytic < holistic: “meal” (P < 0.001), “overall” (P < 0.001), “multiple” (P < 0.001)]; there was a non-significant difference in the citation frequency of “time” (P = 0.06) (Table 3 and Fig. 1). Finally, for Q7a to Q9 under the food consumption section, while participants in the analytic CS group used “single” more often, those in the holistic CS group cited “overall”, “multiple”, or “feeling” more frequently (for all, P < 0.05) (Supplementary Tables 7 to 10). When analyzing aggregated data collected from answers to the four questions (Q7a through Q10), similar results were found [for analytic > holistic: “individual” (P = 0.04) or “single” (P < 0.001); for analytic < holistic: “overall” (P < 0.001), “multiple” (P < 0.001), or “feeling” (P < 0.001)] (Table 3 and Fig. 1).

3.3. Over-arching thematic differences between cognitive style groups with respect to consumer response and behavior toward foods

To further visualize how cognitive styles could affect consumer response and behavior toward foods, a word cloud analysis was conducted using all keywords that showed either significant or non-significant group differences within each food-related experience section.

Larger keywords within each word-cloud figure represent relatively higher frequencies of the keywords compared to their smaller counterparts. Keywords were also colored to represent their associations with each respective CS group: i.e., blue, red, and green colors symbolizing an association with either the analytic, holistic, or neither group, respectively. Within the food shopping section, the analytic CS group prominently chose keywords “single”, “smell”, and “ingredient”, with “individual” having a moderate association [Fig. 2(A)], while the holistic CS group prominently displayed prominent keywords “multiple” and “meal”, with strong associations still with the terms of “overall” and “experience” [Fig. 2(A)]. Within the food preparation category, the analytic CS group exhibited one prominent keyword “individual”, followed by a less frequent but strongly associated keyword of “single” [Fig. 2(B)]. Comparatively, the holistic CS group more frequently used and had a stronger association with keywords “overall”, “meal”, and “multiple” [Fig. 2(B)]. For the food consumption category, the analytic CS group had a strong association with keywords “single” and “individual” [Fig. 2(C)], while the holistic CS group had strong associations with keywords “overall” and “feeling” with the keyword “multiple” exhibiting a moderately strong association with the holistic group [Fig. 2(C)].

The HCA revealed that a two-cluster model maximized the CCC, created the most visual elbow within the cluster distance graph, and matched the best when comparing results to prior literature (Supplementary Fig. 1). HCA Cluster 1 contained a high majority of the analytic CS group and was classified mostly by having stronger associations with the keyword variables of “individual” and “single”, with relatively weaker associations with the keyword variables of “multiple”, “overall”, “meal”, and “texture”. Contrastingly, HCA Cluster 2 had a high majority of holistic participants and was classified by the cluster members having opposite trends, meaning high associations with the variables of "multiple", "overall", "meal", and "texture", and relatively lower associations with the variables of "individual" and "single. Table 4 summarizes the participant response variables that significantly differed between the clusters based on mean comparisons of the summed keyword citations across all FGI questions for each participant. HCA Cluster 1 had greater mean scores in "budget" ($P = 0.008$), "individual" ($P < 0.001$), "single" ($P < 0.001$), and "vegetable" ($P = 0.048$), while HCA Cluster 2 had greater mean scores in "brand" ($P = 0.03$), "experience" ($P = 0.006$), "meal" ($P < 0.001$), "multiple" ($P < 0.001$), "overall" ($P < 0.001$), "feeling" ($P < 0.001$), "positive" ($P = 0.03$), and "sound" ($P = 0.03$). Table 5 shows the classifications between the HCA-based clusters and the actual analytic and holistic groups. Overall, the misclassification percentage was 9.52%, specifically with the 4 analytic participants being placed within the primarily holistic cluster (i.e., HCA Cluster 2) and 2 holistic participants being placed within the primarily analytic cluster (i.e., HCA Cluster 1).

Following the HCA results, a partition decision tree analysis identified the most prominent demographic (non-AHS related) or participant response variables that determined their placement into their respective CS groups. It was found that participants' relative frequencies of responses being coded into "overall" ($G^2 = 58.49$) and "single" ($G^2 = 16.34$) keyword variables produced the optimized partition model, which resulted in a misclassification percentage of 6.35% from 0 analytic and 4 holistic participants being misclassified, respectively (Table 5).

To identify meta-themes across participant responses, thematic (*t*)-coefficients were calculated, representing the relative co-occurrence of keywords that were found to significantly differ from one another between the two CS groups (Supplementary Tables 1 – 10), as shown in Table 6. The *t*-coefficients greater than 0.20 were considered to represent keywords that had a moderate to high degree of co-occurrence with one another (Armborst, 2017; Pradarelli et al., 2021). For the analytic CS group, there were notable co-occurrences between “single” and “brand”, “single” and “experience”, “single” and “individual”, “single” and “feeling”, “multiple” and “individual”, and “brand” and “experience” keywords. For the holistic CS group, there were notable co-occurrences between “meal” and “overall”, “meal” and “plan”, “overall” and “plan”, “overall” and “multiple”, “overall” and “feeling”, “ingredient” and “multiple”, “ingredient” and “brand”, “single” and “experience”, “multiple” and “brand”, “multiple” and “experience”, “multiple” and “individual”, and “brand” and “experience” keywords. Looking at these strong co-occurrences together, meta-themes can be developed both between and within the CS groups. The analytic CS group has strong co-occurrences: (1) “single” and “individual” and (2) “multiple” and “individual”, suggesting two meta-themes. First, as seen with other findings of this study, the analytic CS group is strongly depicted by its association with singular aspects of the food environment and experiences. Second, even when multiple pieces are important to the analytic group, they are still focused on individual aspects of the food experience. Comparatively, the holistic CS group has more strong keyword co-occurrences than the analytic group, which can in part be due to both their higher production of keywords per participant (Table 2) and the small frequencies of some of the keywords, such as “ingredient”, that may skew some of the thematic proximity results (Armborst, 2017). Nevertheless, there were some strong co-occurrences: “meal”, “overall”, “plan”, “feeling”, “multiple”, “experience”, “ingredient”, and “brand” all being associated with one another. These holistic co-occurrences also parallel the prior results of this study, suggesting a common meta-theme: holistic consumers are more impacted by the context and overall nature of their food experience, while still considering multiple pieces before forming their food perceptions and opinions. Some interesting takeaways from both the analytic and holistic co-occurrences are that “brand” and “experience” are consistently associated with one another, as are “multiple and “individual”. These pieces suggest that perceptions of food-related brands are often dependent on the associated experiences and, for both CS groups, when individual food aspects are noted, there is a relatively common aspect for multiple aspects noted together, especially in the holistic group.

Connecting much of the results thus far is the MCA biplots, with the first three factors accounting for 76.58% of the total Greenacre adjusted inertia, showing associations among three variables: cognitive style groups, significant keywords, and food-related experiences. Within the first two factors (F1 and F2), the analytic CS group exhibited closer associations with keywords “single” and “individual”, while the holistic CS group exhibited closer associations with keywords “multiple”, “overall”, and “meal” [Fig. 3(A)]. When considering the first and third factors (F1 and F3), the holistic CS group additionally appeared to have closer associations with “brand” and “experience” than did the analytic CS group [Fig. 3(B)]. Some additional associations can be visualized when considering food-related experience variables. While the holistic CS group exhibited closer associations with “food shopping” and “food preparation”, the analytic CS group exhibited a closer association with “food consumption”. This suggests that, while the holistic CS group’s characteristics are more pronounced in the activities related to food shopping and food preparation, the analytic CS group’s characteristics are more obvious in activities related to food consumption. Although the keyword “feeling” was more frequently cited by participants in the holistic CS group (Table 3), such a relationship was not obviously exhibited on the MCA biplots (Fig. 3). This result was because the analytic CS group’s characteristics were more pronounced in the “food consumption” section, in which participants in the holistic CS group cited “feeling” more often than did those in the analytic CS group. Some keywords were also displayed slightly more often when associated with certain food-related experience variables, such as “brand” and “experience” with “food shopping”, “meal” with “food preparation”, and “feeling” with “food consumption.”

4. Discussion

4.1 The impacts of cognitive styles on consumer response and behavior toward foods

Differences of results between analytic and holistic consumers in food settings were consistent across all analyses throughout the entirety of this study. Results from Fisher’s exact tests (Table 3 and Supplementary Tables 1 to 10) provided evidence of significant differences between the two cognitive style (CS) groups throughout all three main sections of the food-related experiences. More specifically, the results of this study showed how participants of holistic cognitive style tended to focus more on the overall aspects of foods comprising a meal and to comprehend food in terms of multiple aspects. On the other hand, participants of analytic cognitive style were found to perceive foods through a singular lens that focuses on individual ingredients or fragments of a food-related experience. Further support to these trends was also shown in the results from the HCA and decision tree analyses (Tables 4 and 5), highlighting how the prominent variables on determining if participants were categorized as either holistic or analytic, regardless of their AHS scores, were their responses being associated with the “overall” and “single” keyword variables.

Aspects of these findings are reflected in prior literature focusing on how analytic versus holistic people generally process information or make decisions. In the paramount studies detailing analytic-holistic cognition, analytic individuals were more likely to consider only the focal point of situations, while holistic individuals took more contextual information into account and relied on a wider variety of information when forming opinions and decisions (Masuda &

Nisbett, 2001; Nisbett et al., 2001). In a related example, a study using eye tracking methodology revealed that individuals from a holistic culture (China) were more influenced by contextual stimuli when looking at food images, while individuals from an analytic culture (USA) were more influenced by focal food images compared to their counterparts (Zhang & Seo, 2015). A combination of these aspects can be seen in the current study; as the analytic CS group was characterized more by individual and singular aspects than was the holistic CS group throughout the food shopping, preparation, and consumption aspects of the food-related experience (Table 3 and Fig. 1). In a related way, holistic individuals tended to focus on how aspects of the food experience fit together contextually, and the emphasis by the holistic CS group on the overall, meal, and multiplicity aspects of the food-related experience notably mirrors prior psychological analytic-holistic research.

Another interesting finding observed within the food preparation section, and to some extent in the others, revealed that the analytic CS group preferred to process food stimuli (i.e., food items being prepared or cooked) one at a time (Table 3, and Fig. 1 and 2). For comparison, the holistic CS group exhibited more association with a greater multiplicity of food items within the food preparation section, suggesting a greater tendency to multi-task when cooking. Other researchers have suggested that analytic and holistic individuals often process information in linear and circular fashions respectively (Ji et al., 2001; Choi et al., 2007). Preparing foods one at a time aligns closer with a linear thought model, compared to multi-tasking that more closely aligns with the circular goal of ensuring that everything finishes simultaneously. Such findings show how analytic-holistic cognitive style differences can be manifested within food-specific situations.

Additional aspects matching with prior literature were found. Holistic individuals generally looked at the overall picture and multiple aspects when regarding food stimuli, while analytic individuals considered more singular focal points of given situations within questions related to food stimuli (Table 3, and Fig. 1 and 2). Miyamoto et al. (2006) detailed how, when making decisions, analytic individuals may come to a more direct answer based on what they perceive as the most important aspect, with recent eye tracking studies supporting this claim (Alotaibi, 2017). A similar tendency may be seen with food stimuli, and a combination of prior literature and the current results suggest that analytic consumers make food-based decisions based on the most important facet of the food, while holistic individuals come to decisions through consideration of a greater variety of more evenly weighted factors. Similarities between the findings of the current study and the main pillars of prior research help to reinforce the point that these cognitive theories are applicable in applied settings, while some researchers have detailed that in these types of applied settings, there may be fluctuations in analytic-holistic tendencies (Miyamoto, 2013). While slight deviations from literature may be explained by prior research discussing how individuals have altered analytic-holistic tendencies depending on the task, there is yet an underlying analytic-holistic cognitive preference that guides behaviors (Li et al., 2018). Furthermore, it is necessary to consider how any deviations may also be related to potential ecological validity constraints of the analytic-holistic theory in more applied settings, which may suggest the need for additional measurements of the theory in such scenarios.

4.2. Additional perspectives for the effect of cognitive styles on consumer response and behavior toward foods

Within the current study, some divergence of results from expected research outcomes did occur. For example, there were no keyword frequency differences between analytic and holistic CS groups for the question regarding consumer responses to notable aspects of the watermelon sample (i.e., Q7a). While it was predicted that significant differences would be noted between the CS groups within the food samples, the complexity of the food sample may have affected the results. Researchers have discussed how complexity or difficulty of a task can induce changes in the degree of difference between analytic and holistic cognitive processing (Calvo & Beltrán, 2014; Albarracin & Shavitt, 2018). Because the watermelon slice is a simpler sample than the fruit salad (i.e., Q7b), the degree of difference in consumer food experience may have been diminished. In other words, the watermelon slice, relative to the fruit salad, has the fewer number of available stimuli to induce differences in consumer responses, resulting in little differences between the analytic and holistic CS groups (Nisbett et al., 2001). Additional recent research supports the notion that complexity of task may cause differences in evaluation outcomes that are based on cultural differences that parallel analytic-holistic CS differences and supports further investigating this topic in future studies (Fan et al., 2021).

Interestingly, another finding to consider is the corroborating evidence from word cloud images that shows words that have a shared degree of overlap between the cognitive groups (i.e., larger keywords with green colors). For example, the keyword "visual" was colored green, and the more common analytic keyword "individual" was still colored more toward green rather than strictly blue, thus indicating a slight association with the holistic CS group as well (Fig. 2). This trend of some keywords having shared associations can also be seen in the MCA biplot (Fig. 3) and the thematic proximity *t*-coefficients (Table 6), such as “feeling” or “multiple” displaying degrees of association with both cognitive groups. Consequently, when taking a step back to look at all keywords, regardless of significance, the analytic and holistic keyword categories may more realistically display significant differences in some portions, while simultaneously having shared areas of overlap. These shared areas can be seen throughout the word cloud figures (Fig. 2) where some of the same keywords, such as “visual”, “blend”, or “taste”, are prominent and equally associated between both CS groups. This finding on the surface may seem contradictory or illogical, yet prior psychological research has emphasized that the dichotomous labels of “analytic” or “holistic” do not represent mutually exclusive groups, and individuals can exhibit tendencies of both cognitive styles (Nisbett et al., 2001; Calvo & Beltran, 2014; Meaux & Vuilleumier, 2016). Such research has repeatedly discussed how analytic-holistic tendencies exist over a broad spectrum, with people falling onto different places of the continuous line, helping to explain why there may be areas of overlap in the common keyword categories elicited by food stimuli between the consumer groups. For example, while participants in the analytic CS group cited some keywords (e.g., “ingredient” or “multiple”) more frequently than participants in the holistic CS group, they also used specific keywords cited more often by participants in the holistic CS group, visualized by these keywords not being strictly blue or red (Fig. 2). The thematic proximity *t*-coefficients and the subsequential meta-themes (Table 6) further bolster this point of the CS groups displaying how each CS group has not only distinct tendencies, but also associations between the groups, i.e., a degree of shared or overlapping tendencies. For example, the holistic group was consistently associated with “overall” and “meal” themes, while the analytic group was consistently associated with “single” and “individual” themes. However, across the various findings, both CS groups indicate that “multiple” or “individual” aspects of the food experience can still be relatively important or focused upon by both CS groups. Similarly, recent findings within an applied setting by Koo et al. (2020) highlighted how analytic-holistic group differences are not always symmetrical, supporting the findings of this study, i.e., how cognitive CS groups may have some areas of overlap with how they experience foods in everyday life. The findings here suggest that the overlap may be more due to the holistic CS group employing more analytic tendencies within the perceptions of their food experience, as highlighted by "individual" still having some holistic associations (Fig. 2 and Table 6). Alternatively, the overlap could be emphasized by the holistic CS group exhibiting overall more co-occurring keyword variables and themes, as also denoted by the thematic proximity findings. Another corroborating piece of evidence can be seen by the more accurate partition decision-tree analysis, relative to the HCA findings, that only had CS group misclassifications from placing a holistic individual into the analytic group (Table 5). Nonetheless, these differing degrees of overlap signify an important area in needing to clearly delineate the extent to which CS groups differ from one another with respect to their response to foods.

Taking this concept one step further involves separating cognitive style differences that may vary depending on the food-related experience sections. Thus, treating the food-related experience as a singularity may not be the most accurate approach; the keyword frequency and association differences between CS groups were similar but not identical across shopping, preparation, and consumption (Table 3 and Fig. 1 to 3). Additional studies aiming to reveal these underlying questions of cognitive style group overlap and consistency of differences across the food-related experience offer viable next steps in this research area. An additional step in answering some of the remaining questions may involve delineating in what other cognitive or neurological areas the analytic and holistic groups differ in food-related scenarios. One may consider personality traits, emotions evoked by food-related experience, or implicit associations, which have all been associated with consumer food perception, to try and identify other pieces of why analytic and holistic groups differ in their food-related experiences (DeJesus et al., 2020; Samant & Seo, 2019; Seo, 2020; Spinelli et al., 2018). In addition, even though the demographic variables tested here did not differ between CS groups, future tests focused on more cross-cultural sampling may find the demographic variables to offer increased explanatory power or differences between groups.

4.3. Applications to sensory and consumer sciences

The current results indicate a cohesive finding that analytic and holistic cognitive styles induce significantly different responses to food-related stimuli. A combination of multiple qualitative and quantitative methods prevents a single result from skewing or over-fitting of the combined outcomes of this study, as has been cautioned by some researchers (Onwuegbuzie & Leech, 2007). These findings, paired with prior research, subsequently highlight the dire need to account for consumer analytic-holistic cognitive style within consumer studies. For example, prior research studies have shown that individuals from analytic versus holistic cultures use different portions of sensory scales, possibly differing mean ratings across cultures (Yeh et al., 1998; Feng & O'Mahony, 2017). An important aspect of pairing with scale-usage differences is described in a recent study suggesting that analytic, in contrast to holistic, individuals display greater variance in their results (Bacha-Trams et al., 2018). Combining these aspects with the current results suggests the potential for using a singular consumer test sample to produce two distinct results through mean, variance, and perceptual differences between analytic and holistic consumers. If two distinct groups of opposing results exist within a test population, and they are subsequently combined, the following result may provide evidence to researchers of a middle ground finding representing neither of the consumer groups (i.e., analytic versus holistic). Another common area in sensory and consumer sciences is often the need to for both industry and academic researchers to segment consumers based on their responses, especially within large scale projects involving wide population samples (Dolnicar et al., 2016). The HCA and partition decision-tree analysis results suggest that demographic and food perception response variables are capable of separating consumers into analytic and holistic groups (Table 5). Both methods had relatively low degrees of misclassifications, with the partition decision-tree able to separate consumers into CS groups with a lower misclassification rate and relying on only two response variables. One caveat to keep in mind is, from a consumer segmentation standpoint, the misclassification rates relative to the AHS classifications may not necessarily be an issue, as these individuals could have general AHS tendencies, yet display opposing tendencies in food-related scenarios (Miyamoto, 2013). Having a more homogenous group specific to the test topic would then be of greater importance and usefulness for researchers when segmenting consumers. Still, these exploratory findings offer promising steps that allow researchers to accurately *posteriori* categorize individuals into analytic-holistic segments based solely on demographic and response variables.

Another argumentative point to be made is the need for additional food-based tests to validate that the current findings are realistically present within sensory test results, because this study relied solely on explicit, verbal communications that may not best represent how consumers always process food stimuli. This study was conducted in a focus group setting, which is contrasting to some of the more isolated and controlled conditions found within traditional sensory testing. Further investigation can help provide additional evidence of significant differences between cognitive style groups and the consequential necessity to incorporate analytic-holistic cognition as a supplemental factor in sensory testing. Further studies can also be conducted to identify how these differences in consumer response to foods are manifested in more ecologically valid shopping, preparation, and consumption situations, such as in the store while shopping or in the kitchen during cooking. Carrying out additional tests between analytic and holistic consumers in applied settings could delineate how marketing and advertising can better cater to individuals, especially with the growing trend of cross-cultural marketing and research (Ares, 2018). Investigating analytic-holistic effects in such applied settings could help explain how the explicit verbal descriptions from consumers can relate to downstream behavioral differences in these specific food-based scenarios. Further studies could also investigate the complexity portion of these findings to help clarify whether cognitive style differences are consistently more severe with increasingly complex samples or tasks. These steps may involve modifying the design to be less exploratory in nature to identify more specific interactions between variables such as the complexity of the food stimulus or sensory task and individuals' preference or liking of specific food item. These methods can also allow for more focused delineations of sensory variables that are deemed important by each respective CS group. Analytic and holistic CS group differences can then be better understood by investigating and quantifying the relative importance of sensory-related attributes (e.g., taste or smell) versus non-sensory-related attributes (e.g., pricing, information about nutritional content, or organic statements) between CS groups. These findings would not only contribute to enhancing the understanding of analytic-holistic theory in food environments, but also allow industry partners to have a clearer picture of how to market and advertise food and food-related products to these two customer segments. Future studies could also help academic and industry researchers better understand the consistency and severity of analytic-holistic CS differences throughout the subsections of the food-related experience. Collectively, the consistent trends, themes, and significant findings from this study offer initial support for and validation of the importance of the analytic-holistic cognitive theory within food-related experiences.

5. Conclusion

In summary, this study's findings reveal significant differences between analytic and holistic consumers regarding their response and behavior toward foods. Contrasting tendencies of analytic and holistic individuals focusing on singular and overall aspects of food perception, respectively, are consistent with prior analytic-holistic cognitive theory, while providing unique applications to food-specific settings. Utilization of qualitative and quantitative analysis techniques revealed that differences between cognitive style groups were consistent throughout the study, from specific instances to over-arching trends and themes, while analyses within each food-related experience section (i.e., food shopping, preparation, and consumption) provided findings that support further investigation in specific ecologically valid testing environments and scenarios. Future studies can highlight in what particular areas of the food-related experience these analytic-holistic differences are most severe and gain a greater understanding into detailed, downstream behavioral differences between these cognitive style groups that may result from such response contrasts. The presence of significant differences between analytic and holistic consumer groups highlights the importance of accounting for analytic-holistic cognitive differences in sensory testing. Ignoring consumer cognitive styles thus has the potential to provide inaccurate results in consumer studies, supporting the use of analytic-holistic cognition to obtain more representative findings from consumer segmentation projects and sensory studies.

Table 1. Questions provided during a focus group interview as a function of food-related experience section: food shopping, food preparation, and food consumption

Food-related experience section	No.	Question
Food shopping	Q1	When purchasing food, how do you decide what items you are going to buy on that trip?
	Q2	What types of food attributes do you consider when making purchases?
	Q3	How do sensory attributes of foods impact your decisions when shopping?
Food preparation	Q4	How do you decide what you are going to cook, specifically individual foods or overall meals planned?
	Q5	What is the style or pattern you use to prepare foods and how would you explain it to us?
	Q6	When preparing food, do you tend to focus on individual meal aspects or ensuring all parts of the meal fit together, and why?
Food consumption	Q7a	(Watermelon sample) What stands out to you about the food or what first comes to mind?
	Q7b	(Fruit salad sample) What stands out to you about the food or what first comes to mind?
	Q8	When eating, what aspects of the food contribute to how much you enjoy the food?
	Q9	How do dining or environmental cues affect your eating experience?

Table 2. Mean (± standard deviation) comparisons between the analytic and holistic cognitive style groups with respect to the number of keywords cited per participant during a focus group interview

Food-Related Experience Section	Cognitive Style		*P*-value
	Analytic	Holistic	
Food shopping	7.4 (± 1.2)	8.4 (± 1.2)	0.002
Food preparation	5.5 (± 1.2)	6.3 (± 1.0)	0.003
Food consumption	8.3 (± 1.8)	9.9 (± 1.8)	0.001
Total	24.2 (± 2.9)	27.7 (± 2.5)	< 0.001

Table 3. A list of keyword categories that showed significant differences between the analytic and holistic cognitive style groups with respect to a frequency of citation within each food-related experience section: food shopping, food preparation, and food consumption

Food-related experience section	**Keyword:** ***Contextual example (quotation)***	***P*-value**
Food shopping	**Brand**: "*I tend to go with the more familiar brand.*"	0.045
	Experience: "P*rior experience plays a big part in purchases*."	0.010
	Meal: "*I follow a meal schedule and get what I need for those meals.*"	< 0.001
	Multiple: "*Whether it be for dinner or breakfast, I get foods to use for multiple things.*"	0.002
	Overall: "*I have a big family, so I focus on overall food and meals for the week*"	< 0.001
	Single: "*Cost is the big factor for me.*"	0.004
Food preparation	**Individual**: "*I tend to focus on an individual aspect, like spiciness, when cooking.*"	< 0.001
	Meal: "*I look at the whole meal and what combinations make sense*"	< 0.001
	Multiple: "*I try and do multiple things to finish all at same time.*"	< 0.001
	Overall: "*I focus on the overall view of the meal; everything needs to blend together because you eat it together.*"	< 0.001
	Single: "*I make meals all focused around a single item.*"	0.04
Food consumption	**Feeling**: "*Those outside factors help set the mood and feeling and can determine the experience.*"	< 0.001
	Individual: "*I mostly focus on different individual attributes.*"	0.040
	Multiple: "*There are multiple aspects of a restaurant that can impact how I like my food.*"	< 0.001
	Overall: "*I focused on the overall presentation and variety of tastes.*"	< 0.001
	Single: "*Flavor is the single most important thing for me.*"	< 0.001

Table 4. Mean (± standard deviation) comparisons between the two clusters determined by a hierarchical cluster analysis (HCA) with respect to the summed keyword citations across all focus group interview questions for each participant

Keyword[1]	HCA-based Cluster		*P*-Value
	HCA Cluster 1	HCA Cluster 2	
Brand	0.16 (± 0.37)	0.41 (± 0.50)	0.03
Budget	0.42 (± 0.50)	0.13 (± 0.34)	0.008
Experience	0.13 (± 0.34)	0.44 (± 0.50)	0.006
Individual	4.16 (± 1.29)	2.44 (± 1.19)	< 0.001
Meal	0.35 (± 0.66)	1.97 (± 0.82)	< 0.001
Multiple	1.58 (± 1.31)	3.13 (± 1.56)	< 0.001
Overall	0.74 (± 1.09)	3.31 (± 1.45)	< 0.001
Single	2.97 (± 1.30)	1.13 (± 1.13)	< 0.001
Vegetable	0.29 (± 0.46)	0.09 (± 0.30)	0.048
Feeling	0.16 (± 0.37)	0.78 (± 0.71)	< 0.001
Positive	0.03 (± 0.18)	0.22 (± 0.42)	0.03
Sound	0.13 (± 0.34)	0.38 (± 0.49)	0.03

[1] Only significant keywords that showed a significant difference between the two clusters were shown ($P < 0.05$).

Table 5. Misclassification percentages of the Analysis Holism Scale (AHS)-based cognitive style group participants to the clusters determined by either the hierarchical cluster analysis (HCA) or the decision tree analysis (DTA)

	Cluster	AHS-based cognitive style group	
		Analytic (*N* = 33)	Holistic (*N* = 30)
HCA-based cluster	HCA Cluster 1 (Analytic)	29	2
	HCA Cluster 2 (Holistic)	4	28
	Misclassification percentage	12.12%	6.67%
DTA-based cluster	DTA Cluster 1 (Analytic)	33	4
	DTA Cluster 2 (Holistic)	0	26
	Misclassification percentage	0.00%	13.33%

Table 6. Co-occurrence of keyword categories for each cognitive style (CS) group with keywords summed across all focus group interview questions and utilizing keywords previously found to significantly differ between CS groups (Supplementary Tables 1-10)

CS group		Meal	Overall	Plan	Ingredient	Single	Multiple	Brand	Experience	Individual	Feeling
Analytic	Meal	×	0.060	0	0	0	0	0	0	0.169	0
	Overall		×	0.105	0	0	0.129	0	0	0	0.122
	Plan			×	0.113	0	0	0	0	0	0
	Ingredient				×	0.104	0	0	0	0	0
	Single					×	0.016	**0.316**	**0.261**	**0.315**	**0.316**
	Multiple						×	0	0	**0.241**	0.110
	Brand							×	**0.225**	0.104	0
	Experience								×	0.129	0
	Individual									×	0.104
	Feeling										×
CS group		**Meal**	**Overall**	**Plan**	**Ingredient**	**Single**	**Multiple**	**Brand**	**Experience**	**Individual**	**Feeling**
Holistic	Meal	×	**0.506**	**0.351**	0.071	0.023	0	0	0	0.030	0
	Overall		×	**0.241**	0.134	0	**0.207**	0	0	0.158	**0.245**
	Plan			×	0	0	0	0	0	0	0
	Ingredient				×	0.078	**0.337**	**0.303**	0.098	0	0
	Single					×	0.020	0.161	**0.203**	0.176	0.105
	Multiple						×	**0.304**	**0.285**	**0.212**	0.150
	Brand							×	**0.223**	0.045	0
	Experience								×	0.085	0
	Individual									×	0.134
	Feeling										×

Co-occurrences are represented by t-coefficients, with values in bold representing moderate to strong (t > 0.20) t-coefficients between keywords (Armborst, 2017; Pradarelli et al., 2021).

Supplementary Table 1. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 1 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword						
			Meal	Overall	Plan	List	Needs	Budget	Ingre-dient
Food shopping	1	Analytic	3	3	6	13	12	12	11
		Holistic	21	18	14	6	6	5	2
		P-value[1]	< 0.001	< 0.001	0.03	0.11	0.17	0.10	0.01

[1]A significance difference was defined when *P* < 0.05 based on Fisher's exact test

Supplementary Table 2. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 2 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword							
			Cost	Single	Multiple	Brand	Exper-ience	Indivi-dual	Nutri-tion	Ingre-dient
Food shopping	2	Analytic	18	18	3	5	4	11	11	6
		Holistic	22	5	17	13	14	5	3	6
		P-value[1]	0.20	0.004	< 0.001	0.02	0.004	0.22	0.06	1.00

[1]A significance difference was defined when *P* < 0.05 based on Fisher's exact test

Supplementary Table 3. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 3 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword							
			Visual	Taste	Smell	Single	Indivi-dual	Multiple	Texture	Fresh
Food shopping	3	Analytic	17	16	20	16	12	9	13	5
		Holistic	19	19	12	9	12	11	6	7
		P-value[1]	0.45	0.31	0.13	0.20	0.80	0.59	0.11	0.53

[1]A significance difference was defined when *P* < 0.05 based on Fisher's exact test

Supplementary Table 4. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 4 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword						
			Meal	Ease	Overall	Meat	Indivi-dual	Main	Vege-table
Food preparation	4	Analytic	7	12	3	13	13	9	9
		Holistic	20	10	18	7	4	5	3
		P-value[1]	< 0.001	1.00	< 0.001	0.19	0.03	0.37	0.11

[1] A significance difference was defined when P < 0.05 based on Fisher's exact test

Supplementary Table 5. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 5 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword			
			Multiple	Indivi-dual	Finish	Time
Food preparation	5	Analytic	8	16	11	9
		Holistic	24	5	8	2
		P-value[1]	< 0.001	0.009	0.60	0.046

[1] A significance difference was defined when P < 0.05 based on Fisher's exact test

Supplementary Table 6. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 6 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword						
			Blend	Overall	Taste	Meal	Indivi-dual	Single	Flexible
Food preparation	6	Analytic	15	9	14	3	15	10	5
		Holistic	19	25	11	20	2	2	5
		P-value[1]	0.21	< 0.001	0.80	< 0.001	< 0.001	0.02	1.00

[1]A significance difference was defined when P < 0.05 based on Fisher's exact test

Supplementary Table 7. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 7a during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword						
			Visual	Indivi-dual	Taste	Single	Texture	Smell	Multiple
Food consumption	7a	Analytic	26	23	20	11	6	8	6
		Holistic	26	14	17	6	11	8	10
		P-value[1]	0.52	0.08	0.80	0.27	0.16	1.00	0.25

[1] A significance difference was defined when P < 0.05 based on Fisher's exact test

Supplementary Table 8. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 7b during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword								
			Visual	Taste	Indivi-dual	Overall	Smell	Single	Texture	Multiple	Positive
Food consumption	7b	Analytic	25	19	20	3	13	14	10	4	3
		Holistic	24	16	11	20	7	4	7	11	5
		P-value[1]	0.77	0.80	0.08	< 0.001	0.19	0.01	0.58	0.04	0.46

[1] A significance difference was defined when P < 0.05 based on Fisher's exact test

Supplementary Table 9. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 8 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword								
			Taste	Texture	Indivi-dual	Multiple	Single	Visual	Overall	Smell	Feeling
Food consumption	8	Analytic	24	17	17	10	19	11	3	6	3
		Holistic	23	16	14	16	3	11	14	10	9
		P-value[1]	0.78	1.00	0.80	0.08	< 0.001	0.80	0.001	0.25	0.05

[1] A significance difference was defined when P < 0.05 based on Fisher's exact test

Supplementary Table 10. Comparisons between analytic (N = 33) and holistic (N = 30) cognitive style groups with respect to the frequency of each keyword category cited from participant answers to Question 9 during focus group interviews

Section	Question No.	Cognitive Style Group	Keyword								
			Multiple	Overall	Feeling	Sound	Light	Indivi-dual	Single	Visual	Smell
Food consumption	9	Analytic	8	2	2	8	7	7	7	7	6
		Holistic	12	17	16	9	7	6	4	4	3
		P-value[1]	0.28	< 0.001	< 0.001	0.78	1.00	1.00	0.52	0.52	0.48

[1] A significance difference was defined when P < 0.05 based on Fisher's exact test

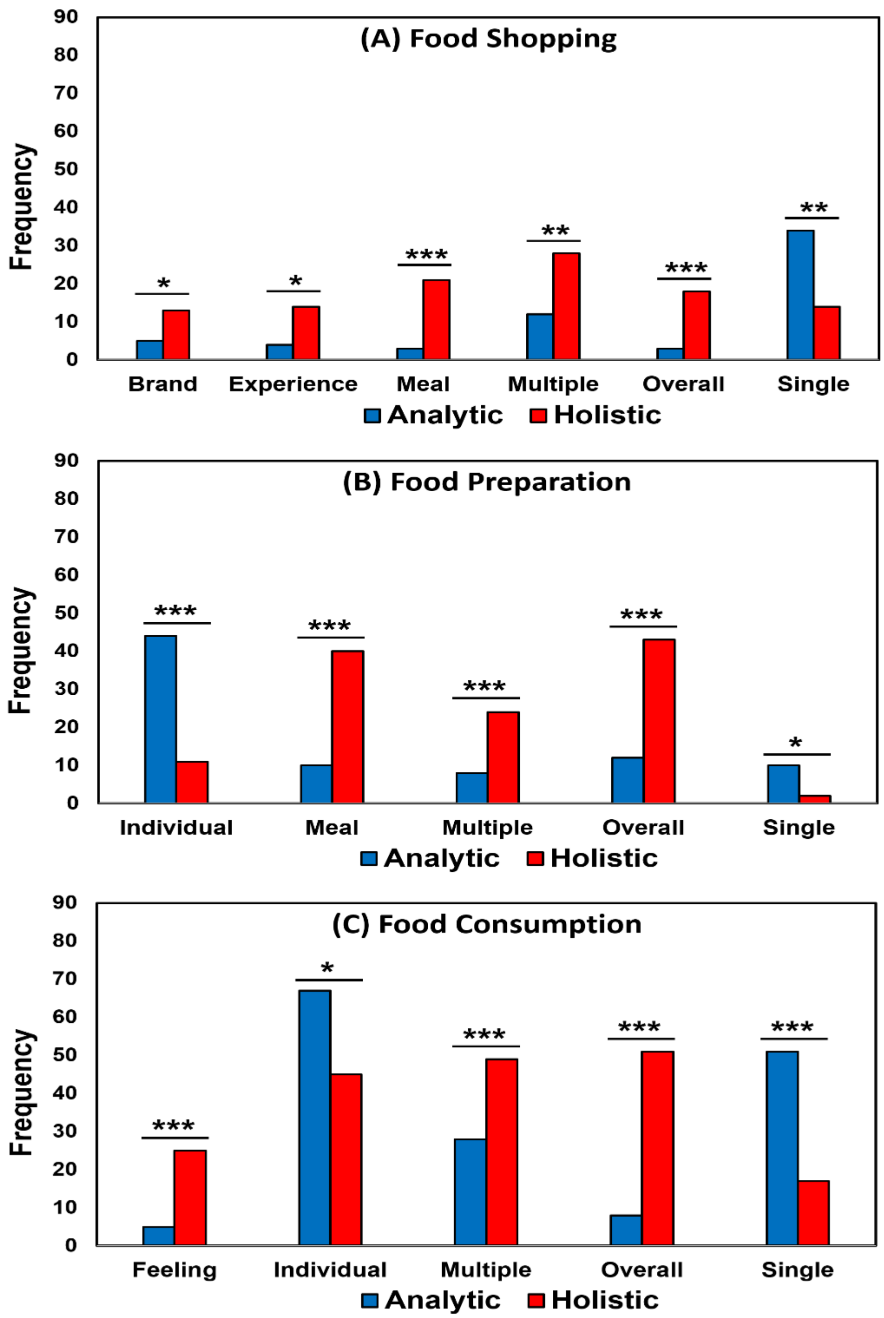


Figure 1. Keyword categories that showed significant differences between the analytic and holistic cognitive style groups with respect to a frequency of citation within each food-related experience section: food shopping (A), food preparation (B), and food consumption (C). *, **, and * represent a significant difference at *P* < 0.05, *P* < 0.01, and *P* < 0.001, respectively**

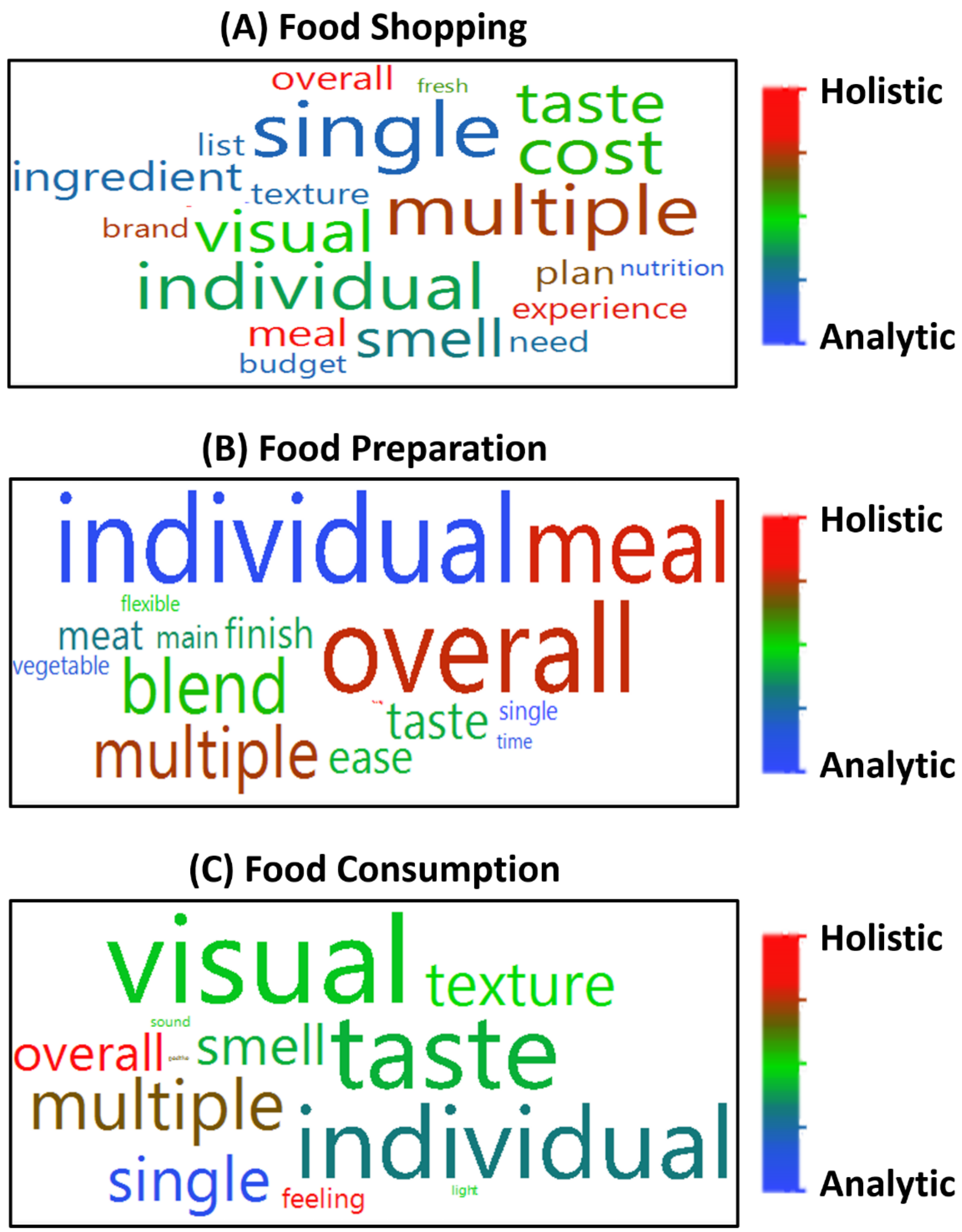


Figure 2. Cognitive style-induced differences in the association of keyword categories between cognitive style (CS) groups and their relative prominence within each food-related experience section. The size of a keyword in the visualization is proportional to the number of keywords captured from answers to the questions given during focus group interviews. The number of frequencies for each keyword category were summated within each food-related experience section: (A) food shopping, (B) food preparation, and (C) food consumption. The color of the keyword reflects its association with the respective CS groups, with blue and red indicating analytic and holistic associations, respectively

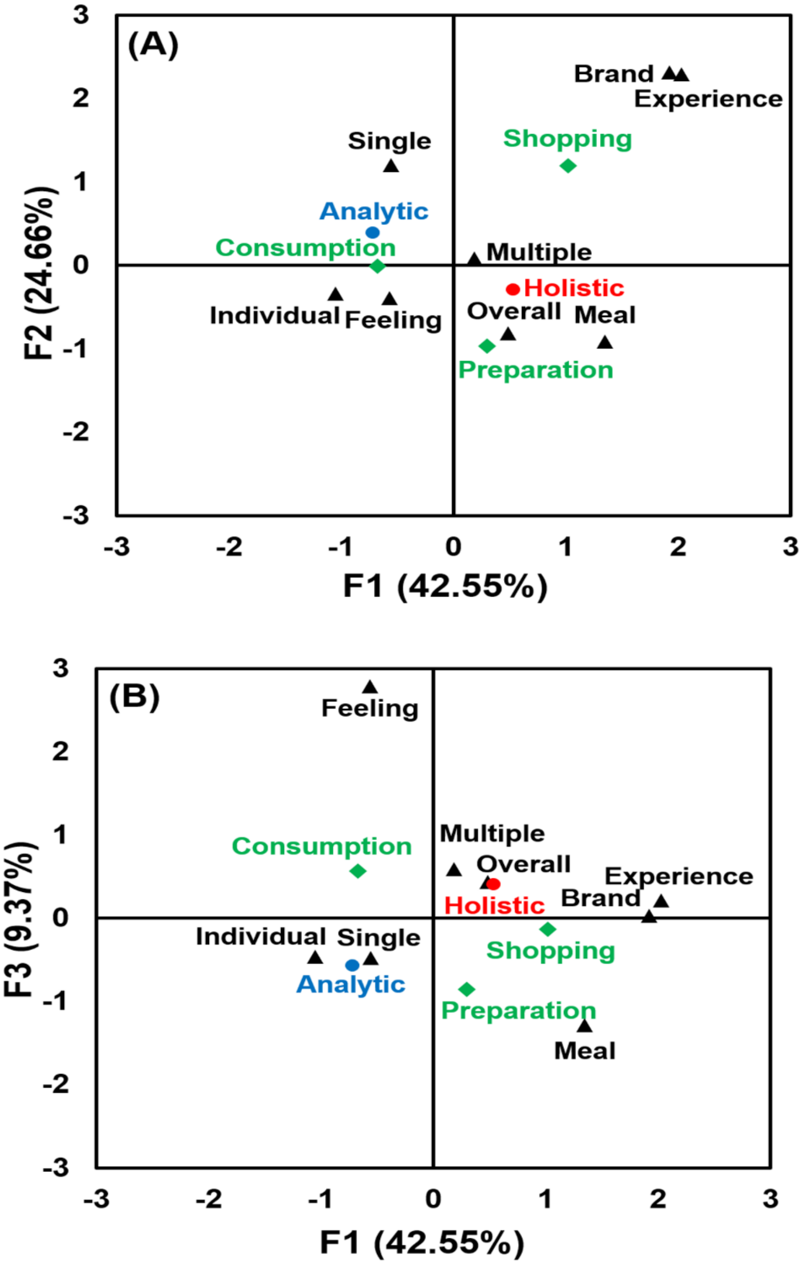
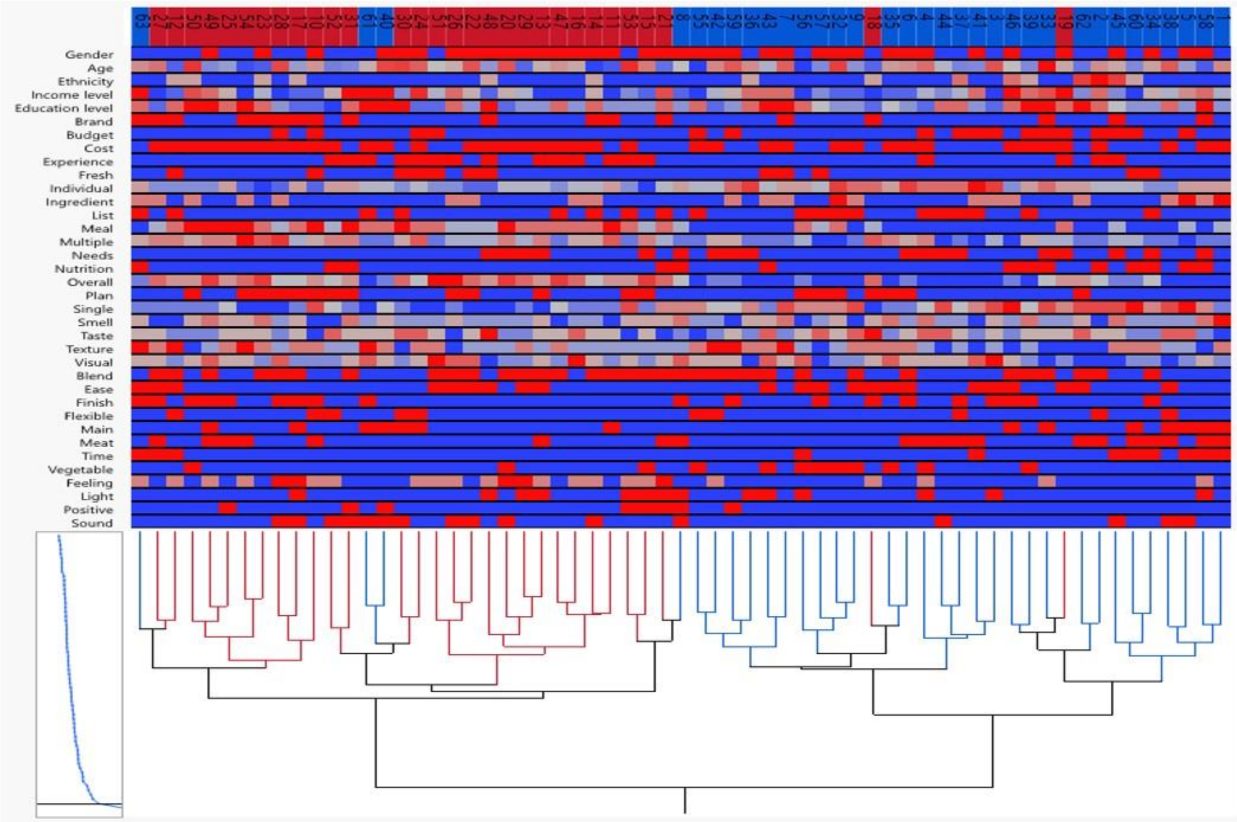


Figure 3. Biplots of multiple correspondence analysis (MCA) based on three variables: cognitive style groups (circles), keyword categories (triangles), and food-related experience sections (diamonds). The biplots were utilized through two associations of the top three factors: (A) Factor 1 (F1) versus Factor 2 (F2) and (B) Factor 1 (F1) versus Factor 3 (F3). Greenacre adjusted inertia percentages (Greenacre, 1984) are included on the axes



Supplementary Figure 1. Two-way (participant-variable) hierarchical cluster analysis dendogram based on combined participant keyword count data across all focus group interview (FGI) questions. Participant numbers included on the top x-axis are identified as analytic (blue) or holistic (red) based on their Analysis-Holism Scale (AHS) scores. All non-AHS associated variables are included on the left Y-axis with larger and smaller numerical data (i.e., higher keyword count) being represented by red and blue boxes within the dendogram, respectively. Participant cluster separation is visualized on the bottom Y-axis. The associated distance graph for the analysis is included in the bottom left corner

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CHAPTER 3

COGNITIVE STYLES INFLUENCE EATING ENVIRONMENT-INDUCED VARIATIONS IN CONSUMER PERCEPTION OF FOOD: A CASE STUDY WITH PAD THAI NOODLE

Abstract

Nearly every aspect of the eating environment can impact how consumers perceive their meal, including table setting styles. Previous studies have found that consumers have contrasting thinking styles (analytic versus holistic) and these opposing styles induce consumers to process their surroundings divergently. Thus, this study aimed at determining whether the effect of table setting condition on food perception could differ as a function of cognitive style. A total of 138 healthy adults completed this study, with the cognitive style tendencies gathered through a screening questionnaire using the Analysis-Holism Scale (AHS). Participants evaluated a Pad Thai noodle meal in two conditions: a traditional sensory laboratory table setting and a fine dining table setting. Participants evaluated their perception of the samples through categorical scaling and check-all-that-apply (CATA) questions. Mean comparison and correlation models found a significant relationship between participant cognitive style and table setting effect on food perception ratings, indicating a relationship between analytic-holistic tendencies and the effect of the eating environment. Specifically, as participants had stronger holistic associations, the table setting cues impacted food perception ratings more. These findings support prior theoretical research detailing how analytic and holistic individuals will process environmental cues differently, which contributes to a base of knowledge of applying the analytic-holistic theory to consumer-food scenarios. In future sensory studies, findings should elucidate where these analytic and holistic differences are most prominent. Concurrently, this study opens a new door within the robust eating environment research regarding how prior findings in this area can be influenced by consumers' cognitive styles and their cultural backgrounds.

Keywords: Cognitive style, analytic, holistic, eating environment, culture, table setting

1. Introduction

If you tell the same thing to two people, they will not react identically. This principle of people responding differently to the same stimulus is a core concept of psychological research. Within social and cultural psychology, this variation in responses has sometimes been proposed to be a byproduct of humans having various thinking styles, often researched as "cognitive style". One of these proposed cognitive theories is analytic-holistic (AH) cognitive theory (Nisbett et al., 2001). This theory is more recently developed than other, more niche, cognitive theories, and during its development was proposed as being a modernized theory that can account for more general thinking and cognitive style differences among people compared to many of its predecessors (Na et al., 2010; Nisbett 2003; Norenzayan et al., 2007). In summary, AH theory details analytic thinking as more associated with increased attention given to focal points of a situation, linearized thought, and independent interpretation of events, with holistic thinking being associated with opposite behaviors of contextual attention bias, cyclical interpretation and prediction, and interdependent relationships of events (Ji et al., 2001; Nisbett et al., 2001; Peng & Nisbett, 1999). An additional point made during AH theory development by these researchers was the existence of an AH continuum, rather than a dichotomy, and individuals tending to lean toward one end of the spectrum over the other (Meaux & Vuilleumier, 2016). This prior research has also detailed how during AH theory's development, cultural components maintained a central importance, with analytic tendencies being associated with "Western" cultures (e.g.., United States or Australia) and holistic tendencies being associated with "Eastern" cultures (e.g.., Korea or Japan). One key component of AH theory focused upon for this study is the opposing attention and perception tendencies that have been found between analytic and holistic groups.

Replicated both within and between cultures has been the consistent finding of analytic groups focusing on a more singular, central aspect of situations and stimuli. Holistic groups particularly emphasize multiple and contextual pieces of stimuli, while analytic groups tend to focus upon more singular aspects of identical stimuli (Alotaibi et al., 2017; Nisbett & Masuda, 2003). A paramount example of this concept is from Masuda and Nisbett's (2001) study featuring analytic participants describing the central and focal points of images while holistic participants chose to describe more of the contextual aspects of images they were provided. One area of the food experience that these findings may translate to is the environment of the eating experience. Prior research has detailed how aspects ranging from small cutlery details to the overall theme of the table setting and restaurant, and nearly every environmental variable condition in between, can impact consumer food perception and experience (Carvalho & Spence, 2018; García-Segovia et al., 2015; Singh et al., 2019, Wang et al., 2019). Most often, the food is the focal point in these scenarios, with the eating environment making up the context of the dining situation. Connecting with AH theory, past findings would suggest analytic and holistic groups may not process and respond to the eating environment in the same way. Each cognitive group would be predicted to provide more attention to different aspects of the eating environment and thus be impacted inequivalently. Logically, it makes sense to apply the AH theory in this related scenario, yet some researchers have cautioned extrapolating general cognitive theories into applied situations due to AH tendencies potentially being modulated by specific tasks (Mermelstein & Revenson, 2013; Miyamoto, 2013). Nonetheless, there is a fledgling area of research that supports applying AH theory into consumer perception of the eating environment.

As mentioned, AH theory was developed to incorporate East-West cultural differences, with the association being validated throughout studies to the point where recent papers employ participant groups from traditional Eastern and Western countries to produce analytic holistic and analytic groups, respectively (Koo et al., 2020; Miyamoto et al., 2006; Nisbett et al., 2001). Incorporating a similar cultural comparison was a study by Zhang and Seo (2015) showing how consumers of the Eastern culture group allotted more attention to the contextual pieces of a food image relative to consumers from the Western culture group. These results suggest, via the cultural comparison explored, that AH theory may impact how consumers perceive their eating environment. Further support for applying AH theory comes from recent studies investigating the applications of the theory within consumer food behavior scenarios. Hildebrand et al. (2019) and Vanbergen et al. (2020) employed AH theory in food advertising situations where they found holistic, relative to analytic, consumers were more susceptible to advertising claims and displayed less self-control when these advertising cues were provided in a situational context. Combined, these results match with prior AH psychological theory research detailing how holistic individuals tend to be more influenced by and give more attention to contextual aspects of stimuli in applied food scenarios.

In addition to these prior works, an exploratory focus group study was conducted within our lab to provide baseline information of how and where analytic and holistic consumers may differ in their perceptions of their food experience (Beekman & Seo, 2021). Results of this study found analytic and holistic participants describing how they think about and process their food experience significantly differ from one another along predicted analytic-holistic lines. Collectively, these studies within the food-consumer research area that apply AH theory principles and produce results mirroring expected theoretical findings support the claim that analytic-holistic differences may alter consumer perception of the eating environment. Understanding how these two cognitive groups are divergently impacted by their eating environment can also aid in ensuring researchers are obtaining representative findings. Considering both mean and variability have been found to differ in ratings between analytic and holistic consumer groups, then research could produce misrepresentative findings by combining the AH cognitive groups into a single population and not accounting for respective tendencies of the AH groups (Bacha-Trams et al., 2018; Chrea et al., 2004; Feng & O'Mahony, 2017; Togawa et al., 2019; Yeh et al., 1998). As academic and industry researchers rely on accurate and representative consumer data to help guide research and business decisions and confidently develop and release new products, AH theory can aid in such tasks to lead to a greater probability of future success.

This study aimed to help both areas of academic and industry researchers by elucidating how consumers with more analytic or holistic tendencies differ in their relative impacts from the eating environment (i.e., stimuli other than the food itself). In addition, findings from this study not only contribute to growing interest in cross-cultural research, but also help understand AH theory's within-cultural differences, as the theory has robust inter- and intracultural validation (Ares, 2018; Koo et al., 2018; Lonner, 2018). Paralleling the calls for more cross-cultural research, Jeong et al. (2021) and Masuda et al. (2020) have, respectively, detailed the importance more cross-cultural research in food and consumer settings and how theories such as AH theory offer a great deal of relevance to applied consumer industries. From the aforementioned research, holistic consumers tend to allocate more attention to the environment or context of the situation, with analytic consumers displaying the opposite trend by focusing on the central portion. From the trend of AH cognitive theory translating to the consumer-food experience, these same trends are expected to be paralleled when comparing the impact of the eating environment between analytic and holistic groups. Therefore, when eating, holistic participants in this study are predicted to be more influenced by their eating environment compared to their analytic counterparts due to differential attentional allotment between the groups.

2. Material and methods

The protocol (No. 1902176265) 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 informed written consent indicating voluntary participation was obtained from each participant.

2.1. Participants

Volunteers were recruited from the Northwest Arkansas community through a consumer profile database from the University of Arkansas Sensory Science Center (Fayetteville, AR, USA). Volunteers with known food allergies or clinical histories of major diseases were not included in this study. Volunteer participants were recruited if they stated they did not dislike Pad Thai or Pad Thai noodle dishes and had consumed Pad Thai at least once in the past six months to ensure the food served to them is not novel to minimize familiarity as being a confounding variable (Hong et al., 2014). A total of 138 healthy adults (98 females and 40 males) aged between 18 and 60 [mean age ± standard deviation (SD) = 39 ± 12 years] took part in this study. The large majority (68%) of the participants identified as Caucasian (N = 94), with some participants identifying as Latino (N = 14), African American (N = 13), Asian (N = 10), Native American (N = 3), or other (N = 4). Based on effect and recommended minimum samples sizes from both prior AH theory and sensory evaluation research, this number was seen as more than adequate with respect to stability of sample differences and repeatability of the significance level (Ren et al., 2014; Gacula Jr. & Rutenbeck, 2006; Moskowitz, 1997).

As part of the screening process, participants also answered the Analysis Holism Scale (Choi et al., 2007) to provide a quantitative measure of their AH tendencies prior to arriving at the test session. The AHS is a 24-question tool in which participants must rate their agreement with a variety of statements from 1 (strongly disagree) to 7 (strongly agree), with higher and lower scores (represented as a mean of 24 question-scores) corresponding to stronger holistic and analytic tendencies. The scale has undergone robust validation both between and within cultures, justifying its use within an area that is commonly seen as a more singular culture (Koo et al., 2018; Lechuga et al., 2011; Ren et al., 2014). Prior research used to develop the AHS used a within culture comparison of analytic and holistic groups and found that the analytic group had a mean AHS-score of 5.03 and the holistic group had a mean AHS-score of 5.23 (Study 4 in Choi et al., 2007). In comparison, when using a median split to form the analytic and holistic groups in this study, the analytic and holistic groups had mean AHS-scores of 4.63 and 5.46, respectively. These current AHS scores are similar to those of prior research, while they show a slightly wider range and separation between the AH groups by the analytic score being lower and the holistic score being higher compared to prior research.

2.2. Food samples and preparation

For both table setting conditions (see Section 2.3.), the same Pad Thai noodle dish (Thai Kitchen gluten free Pad Thai rice noodle, McCormick & Company, Hunt Valley, MD, USA) was used. A microwavable, prepared sample was used to increase the consistency of samples across table setting conditions and participants. The Pad Thai sample was prepared in the microwave adhering to package directions and mixed in a glass bowl to for sample consistency. Immediately following heating and mixing the Pad Thai sample, approximately 55 g were placed onto each of the respective control and treatment plates. For visual representation of samples on each table setting condition, see Figure 1. Each sample was also served with a glass containing 118 mL of water (Mountain Valley Springs Co., LLC Hot springs, AR, USA).

2.3. Table setting conditions

To compare the effect of environmental eating condition, two table setting conditions were utilized in this study. Prior research has detailed the significant impact different table settings can have on the food perception of consumers (García-Segovia et al., 2015; Liu et al., 2019; Schouteten et al., 2017). Specifically, a fine dining table setting condition has been shown to induce significantly different consumer perception (i.e., liking ratings) than a traditional sensory booth condition (García-Segovia et al., 2015). Based on these earlier works, the two table setting treatment conditions in this study are a traditional sensory booth table setting [Control, Fig. 1(A)] and a fine dining table setting [Treatment, Fig. 1(B)]. The traditional sensory booth was treated as a control to allow the research question of the potential differential effect of an environmental cue (i.e., Treatment) to be accurately assessed as opposed to considering both table settings as treatments. Each table setting condition had the same elements of a plate, napkin, fork, and glass to maintain consistency. The control condition consisted of a standard plastic plate (diameter: 26 cm) (Dart Container Corporation, Mason, MI, USA), a standard white napkin (Tork Advanced White Paper Napkin, Essity Professional Hygiene, Philadelphia, PA, USA), a plastic white fork (Best Choice Plastic White Fork, Associated Wholesale Grocers, Kansas City, KS, USA), and a plastic cup (266 mL) (Translucent Plastic Drink Cup, Dart

Container Corporation, Mason, MI, USA). Comparatively, the treatment condition consisted of the fine dining setting with a gold-rimmed plastic plate (diameter: 26 cm) (Jolly Chef, Lexington, KY, USA), a gold patterned paper hand towel (Jolly Chef, Lexington, KY, USA), a gold plastic fork (Jolly Chef, Lexington, KY, USA), and a gold-rimmed plastic cup (296 mL) (Jolly Chef, Lexington, KY, USA) to induce a difference in the environmental eating condition relative to the control.

2.4. Procedure

All participants tasted the Pad Thai in both table setting conditions in one experimental session. The sessions took place at the University of Arkansas Sensory Science Center's evaluation booths that align with standard sensory booth design in being separated from one another, a neutral white color, and devoid of any other distracting stimuli (Meilgaard et al., 2016). Thus, the only environmental cues being introduced were the table setting conditions. The Control condition was always served first, followed by the Treatment condition, with a three-minute (180 s) break in between samples. Participants were given each sample with the instructions to rate their overall liking, appearance liking, table setting liking, and overall liking on 9-point hedonic scales from 1 (dislike extremely) to 9 (like extremely) before tasting the sample. Following, they were provided instructions to try enough of the sample to form an opinion and provide responses to their overall liking, emotional attributes using a check-all-that-apply (CATA) question ballot of EsSense25 (Nestrud et al., 2016), sensory attributes using a CATA question ballot, overall flavor liking, noodle texture liking, and overall liking questions. Upon finishing both sample evaluations, all participants also answered the AHS a second time to provide AH data immediately following a sensory evaluation task to provide exploratory insight into how partaking in a specific, applied task may modulate AH tendencies.

All liking questions were evaluated on 9-point hedonic scales from 1 (dislike extremely) to 9 (like extremely) and the sensory CATA question was developed in a preliminary test to reflect accurate consumer perception of the Pad Thai dish with a variety of correct and incorrect sensory flavor descriptors associated with the sample (Ares et al., 2013; Pramudya & Seo, 2018; Schouteten et al., 2017). Figure 2 shows the sensory CATA used here with the correct and incorrect flavor descriptors marked accordingly. Participants were instructed to select all emotions they felt and all flavor attributes they associated with the sample after trying it.

The majority of the questions asked of participants were 9-point standard hedonic scales, and these were employed due to them being one of the most common consumer sensory questions asked during sensory evaluation tasks (Meilgaard et al., 2016, Stone et al., 2020). Using this common question type provides a generalizable baseline of where differences may exist between cognitive groups within sensory evaluation data. As analytic and holistic tendencies align with seeing events and stimuli as independent and interdependent, respectively, then analytic and holistic individuals may differ in how correlated or connected their question answers are within the same food sample (Yang et al., 2019). In addition, overall liking was assessed multiple times during the evaluation process to allow insight into potential differences of how analytic and holistic groups may relate their answers to sensory evaluation questions within one another, often referred to as the halo effect (Meilgaard et al., 2016). Specifically, overall liking was asked immediately upon participants receiving the sample (1st), after participants evaluated sample appearance and table setting liking (2nd), immediately after participants tasted the sample (3rd), and at the conclusion of the questionnaire after all other sensory, emotion, and sample attribute questions (4th) (Fig. 3). CATA questions were included as an additional question type to investigate if analytic and holistic processing differences, such as focusing on either central or contextual aspects, could impact the number of terms chosen or the number of correct sensory attributes selected. Understanding these potential response comparisons between groups offers preliminary insight into how and where in sensory evaluations AH cognitive differences may be most present and influencing consumer responses.

2.5. Data analysis

Data were analyzed using JMP Pro software (version 15.2, SAS Institute Inc., Cary, NC, USA) and XLSTAT software (Addinsoft, New York, NY, USA). To obtain a variable representative of participant AH tendencies while evaluating the samples, the AHS score data from participants collected after they finished the test session (post AHS) was employed as a continuous variable (Miyamoto, 2013). For further information on the relationship between pre and post AHS scores, see Results section 3.3. Due to the goal for this study to identify how eating environment cues may impact individuals unequally depending on the AH tendencies, a single variable was created to represent the impact of the eating environment on consumer food perception separately for each question asked to participants. The new variable was created by taking the absolute value of the Control response data subtracted from the Treatment response data for the hedonic questions (Jarma Arroyo et al., 2020), as well as the total sensory CATA attributes selected, total correct sensory CATA attributes selected, and the total EsSense25 CATA responses selected. Pearson correlation analyses and linear regression analyses were conducted between the post AHS variable and each of the hedonic, summed total selections for the EsSense25 and sensory CATA, and summed total correct attributes for the sensory CATA environmental effect variables (EEVs). Pearson correlation and linear regression analyses allow visualization into how participants with varying AH tendencies are differentially impacted by the eating environment across varying portions of this sensory evaluation task and their eating experience. Partial correlation analyses were also conducted to determine if significant relationships between AHS scores and EEV values could be identified even when holding the other variable conditions constant (i.e., avoiding the halo effect) (Huang, 2010; Fisher, 1992; Meilgaard et al., 2016). The partial correlation therefore considered only the association between the post AHS scores and the respective EEV values for each partial correlation. As mentioned, the correlation analyses treated the AHS as a continuous variable, meaning that the full participant sample (N = 138) was used for both the correlation and partial correlation analyses.

To address questions regarding mean and variance differences between AH groups, a median split of participants based on the post AHS data was conducted. This median split followed prior AH theory research (Hsieh et al., 2020; Koo et al., 2020) and provides a more conservative estimate of AH group contrasts. The median split in this current study resulted in cognitive groups both totaling 69 participants, with no significant differences in gender ratio (P = 0.71) or mean age (P = 1.00). To compare the impact of environmental cues on the eating perception between the cognitive groups, a t-test was conducted between the analytic and holistic groups formed by the median split of the AHS scores. The t-tests compared the responses from each respective cognitive group for each of the questionnaire response questions by employing the EEVs described above. To test for variance differences, a Bartlett's test for equality of variances was also performed between the cognitive groups within each of the EEVs. A statistically significant difference was defined to exist when $P < 0.05$.

3. Results

3.1. Mean and variation comparisons between cognitive style groups

The median split of participants based on their post AHS scores allowed for mean and variability of each response variable to be compared between analytic and holistic cognitive style groups through independent *t*- and Bartlett's tests, respectively. The same EEVs were used in the mean and variance comparisons. All *t*-test analyses between groups were non-significant ($P > 0.05$) except for the number of sensory attributes selected ($t = 2.14$, $P = 0.03$), which detailed a higher mean response in the holistic group (1.54) compared to the analytic group (1.10). This significant difference indicates that eating environment cues, activated through changing the table setting from a standard to a fine dining setting, had a greater impact on the number of sensory attributes in the holistic group compared to in the analytic group. It is important to consider the significant difference for this singular question relative to the overall question data set. The other EEV cognitive style group comparisons support this difference by the general trend, although not always significant, of the holistic group displaying a greater mean rating than the analytic group (Table 1). As mentioned, the employment of the absolute value of the Control subtracted from the Treatment for the response variables provides that greater mean values for these variables are indicative of a greater impact of the eating environment on participant responses.

When conducting the Bartlett's tests between the responses for the cognitive style groups, variances were found to not significantly differ for the variables of overall liking (1st) ($P = 0.05$), appearance liking ($P = 0.13$), overall liking (2nd) ($P = 0.07$), overall liking (3rd) ($P = 0.71$), total number of correct sensory attributes ($P = 0.61$), overall flavor liking ($P = 0.55$), noodle texture liking ($P = 0.53$), and overall liking (4th) ($P = 0.14$). Variances were, however, found to differ between cognitive style groups for the response variables of table setting liking (*P* = 0.03), total number of emotional attributes selected (*P* = 0.007), and total number of sensory attributes selected (*P* = 0.02). An important trend seen from these significantly different variations is that the holistic group exhibited greater variances than the analytic group. This trend was unanimously consistent across all EEVs, regardless of the significance, which is denoted in Figure 4, with all standard deviation values provided with their corresponding mean values in Table 1.

3.2. Associations between Analysis-Holism Scale (AHS) scores and Environment Effect Variable (EEV) values

Pearson correlation analyses were conducted between the post AHS scores and EEV values. Non-significant correlations were found when analyzing post AHS score with the values of EEVs: table setting liking (r = 0.16, P = 0.06), overall liking when first eating [i.e., overall liking (3^{rd}), r = 0.02, P = 0.78], the number of emotion attributes selected (r = 0.05, P = 0.57), the number of correct sensory attributes (r = 0.02, P = 0.86), overall flavor liking (r = -0.08, P = 0.38), noodle texture liking (r = -0.001, P = 0.97), and overall liking when finished eating [i.e., overall liking (4^{th}), r = -0.02, P = 0.85]. Comparatively, significant correlations were found between the post AHS scores and the overall liking when first presented [i.e., overall liking (1^{st}), r = 0.20, P = 0.02], appearance liking (r = 0.21, P = 0.01), overall liking directly before eating [i.e., overall liking (2^{nd}), r = 0.21, P = 0.01], and the number of sensory attributes selected (r = 0.20, P = 0.02). These significant associations were also observed in the results of linear regression analyses: for overall liking (1^{st}), standardized coefficient (β) = 0.20, P = 0.02; for appearance liking, β = 0.21, P = 0.01; for overall liking (2^{nd}), β = 0.21, P = 0.01; and the number of sensory attributes selected, β) = 0.20, P = 0.02). These significant, positive coefficients indicate that as the post AHS score increased, meaning participants were associated with a more dominant holistic cognitive style, they were more influenced by the eating environment.

Partial correlation analyses revealed significant associations of the post AHS scores with the number of sensory attributes selected (r = 0.26, P = 0.003) and the number of correct sensory attributes (r = -0.18, P = 0.04), respectively. The positive partial-correlation indicates that a higher AHS score is associated with selecting more sensory attributes; however, the negative partial-correlation indicates that higher AHS score is associated with less correct sensory responses, both when holding all other EEV responses constant. The post AHS scores were found to exhibit non-significant partial-correlations with other EEV values: overall liking when first presented overall liking when first presented [i.e., overall liking (1^{st}), r = 0.07, P = 0.43], appearance liking (r = 0.09, P = 0.33), table setting liking (r = 0.06, P = 0.49), overall liking directly before eating [i.e., overall liking (2^{nd}), r = 0.01, P = 0.89], overall liking when first eating [i.e., overall liking (3^{rd}), r = 0.02, P = 0.84], the number of emotion attributes selected (r = -0.06, P = 0.52), overall flavor liking (r = -0.09, P = 0.31), noodle texture liking (r = 0.02, P = 0.90), and overall liking when finished eating [i.e., overall liking (4^{th}), r = -0.01, P = 0.93]. A full summary of the correlation coefficients and significance values between the post AHS scores and EEV values is provided in Table 2.

3.3. Relationship between pre and post Analysis-Holism Scale (AHS) scores

A correlation analysis between pre and post AHS scores revealed a significant correlation between the two variable scores (r = 0.79, P < 0.001). An additional Cronbach's α analysis further supported the highly significant correlation by producing a Cronbach's α-value of 0.88, which suggests a high internal consistency and that the AHS is reliable both before and after the sensory evaluation task (Choi et al., 2007; Tavakol & Dennick, 2011). When fitting a linear model between the pre and post AHS variables (Equation 1), the resulting equation shows a coefficient of 0.77 of the pre AHS score and an intercept of 1.17 when modelling for the post AHS score, indicating an unequal relationship between the pre and post AHS scores.

Equation 1: $\text{Post AHS score} = 1.17 + 0.77 \times \text{Pre AHS score}$

4. Discussion

One consistent trend from the combined results is that analytic and holistic cognitive styles can influence how consumers are impacted by their eating environment when evaluating food samples. Specifically, based on the results of the correlation, regression, and mean-comparison analyses, more holistic participants, relative to more analytic participants, had their responses impacted more by their eating environment. Significant correlation and regression coefficients were not only found at the beginning with the initial hedonic responses, but also later in the experience with the total sensory attributes selected (Table 2), suggesting that as individuals have more holistic tendencies, they will be more influenced by their eating environment throughout their eating environment. Even when other responses are held constant, individuals with more holistic tendencies will exhibit a tendency to associate more sensory attributes to their dish (by selecting more sensory terms) when subjected to environmental eating stimuli, as shown in Table 2. Interestingly, an opposite trend is seen with the correct sensory responses. More specifically, while the eating environment effect on holistic individuals induces more sensory associations, they are not necessarily connected to the dish. Such a finding matches with prior research that holistic individuals are more likely to be impacted by their environment, but the impacts are seen through many interwoven personal connections (Masuda & Nisbett, 2001; Nisbett et al., 2001). Thus, the additional sensory terms may be perceived by the holistic individuals due to personal reasons, not the actual dish.

The significant mean difference between cognitive groups was also found after the initial impression (Table 1), consequently supporting AH groups diverging in how they are impacted by the environment throughout the eating experience. When the fine dining treatment condition was provided to participants, those with more holistic tendencies had their responses to an equivalent Pad Thai dish significantly altered. This main finding is in support of the theoretical predictions of this research and can likely be associated to prior research describing how functioning under a holistic cognitive style induces a greater tendency to be impacted by contextual and environmental cues (Alotaibi et al., 2017; Masuda & Nisbett, 2001; Miyamoto et al., 2006). These results further support initial cross-cultural research that demonstrated individuals from an Eastern culture (holistic) provide more attention to the contextual aspects of a table setting, and Western culture participants (analytic) provided more attention to the central food item (Zhang & Seo, 2015). In the eating environment, holistic consumers are therefore predicted to allot more of their attention to the surrounding stimuli, ranging from the smells and sounds of the restaurant down to the individual table setting styles and pieces (i.e., cutlery, dishware, drinkware, etc.). Comparatively, analytic consumers would be predicted to focus more on the central pieces of the eating experience, which is often the food itself as opposed to the surrounding, supplemental dining environmental cues. Considering the robust area of research indicating nearly all aspects of the eating environment can impact consumer food perception, these AH cognitive group findings offer a novel and important addition to this field.

One aspect of the novelty is the question of if the significant impact of the environment consistently applies to both analytic and holistic population groups. Based on the current results, analytic and holistic groups are not equally impacted by their eating environment. This question is of importance due to the large proportion of eating environment research that is conducted in traditionally Western countries and cultures, which unfortunately is symptom of the over-arching psychological and consumer behavior fields (Heine & Norenzayan, 2006; Muthukrishna et al., 2020). There is a small portion of the eating environment research field that has shown the eating environment still impacts consumers within traditionally holistic societies, yet there is still such little understanding if the environmental effects and their causes parallel the findings from traditionally analytic societies (Han, 2017; Yoon et al., 2018). Continuing this trend by applying these findings both intra- and interculturally, as more eating environment research is conducted within traditionally Eastern or holistic cultures, it is anticipated that the trends and significant effects may not replicate prior eating-environment research. One factor is the discussed attentional differences between analytic and holistic consumers, with the latter associated with paying more attention to the eating environment and consequently being impacted more than the former. Holistic, compared to analytic, individuals similarly tend to see events and stimuli as more interconnected, even in applied situations (Shavitt & Barnes, 2020; Tu & Pullig, 2018), which would suggest greater perceived connections between the eating environment and food for holistic individuals. As food is often consumed in a social context, most notably in restaurants, the contrast of the self-view within the culture is an important additional aspect. In holistic cultures, individuals will see themselves as interdependent and connected with others within their culture, while individuals in analytic cultures see themselves as more independent of their culture (Miyamoto et al., 2006; Nisbett & Masuda, 2003). Following, these opposing cultural self-perceptions may induce differences in how individuals of each of these cultures are impacted by their environment when eating with others. By considering these AH theory pieces and their potential application within the eating environment combined with the results of this study, it is justifiable to question the validity of prior eating environments across analytic and holistic populations.

Aside from analytic and holistic individuals and populations exhibiting differences in the effect of the eating environment, these results further support differences in the data between the two groups. The median split to create the two groups allowed for mean and variance comparisons between AH groups (Table 1). More specifically, the variance comparisons (Fig. 4) indicate that the holistic group had higher variability in responses compared to the analytic group. Such differences in variations have been suggested in recent research (Bacha-Trams et al., 2018; Li et al., 2018), while this is the first study to directly showcase significant differences in response variability between AH groups. Returning to initial AH theory development offers insight into why these unequal variances may exist between groups. Masuda and Nisbett (2001) initially discussed how analytic and holistic groups differ in their attention to different aspects of a situation, with holistic individuals focusing on a wider range of stimuli and scenario aspects. These perceptual disparities between the two cognitive groups of AH theory together with the significantly different variances between AH group data found in this study provide a strong argument in the necessity to consider AH cognitive styles in consumer research. If the variance, as seen here, and the mean response ratings both differ between AH groups, which is supported by the current findings and by prior research (Feng & O'Mahony, 2017; Prescott et al., 1992; Yao et al., 2003; Yeh et al., 1998), then not accounting for AH differences can lead to misrepresentative data and inaccurate conclusions. Many companies struggle with unsuccessful product launches and one strategy to increase the success of new products can be to obtain more representative data (Linton, 2011; Yang & Lee, 2019). Accounting for the AH cognitive tendencies of the sample and target populations is subsequently recommended in both academic and industry research. However, it is crucial to ensure accurate assessments of AH tendencies of consumers.

In this study, the AHS was used to measure the AH cognitive tendencies of participants. Throughout prior literature, the AHS has been validated for its accuracy of assessing the constructs of AH theory and its internal consistency, both between and within cultures (Koo et al., 2018). One caveat some researchers have mentioned though has been the potential for AH cognitive tendencies of individuals to be altered through partaking in applied tasks (Lux, 2017; Lux et el., 2021; Miyamoto, 2013). Due to the development of AH theory as a more general and encompassing cognitive theory (Nisbett et al., 2001; Peng & Nisbett, 1999), AH tendencies could change when engaging in highly specific scenarios, such as a sensory evaluation task. Prospective evidence to support this concept comes from the correlation analysis of the pre and post AHS scores. While results indicated that they were highly correlated with one another, the linear model (Equation 1) showed that the relationship between the two measures was not equivalent. A higher pre-AHS score did not indicate an equally high post-AHS score. The linear model therefore suggests that sensory evaluation tasks may modulate participants' AH cognitive tendencies, as the model details how an increase in the pre AHS score does not see an equal increase in the post AHS score. This finding strengthens point made by earlier researchers that argued the AH theory and AHS measurement tools are not optimized for applications within niche scenarios, which are often necessary in consumer behavior research. Therefore, an argument emerges for the development of a new or modified AH measurement tool with the ability to more accurately assess AH cognitive tendencies that are active during the applied task. Nevertheless, this claim should be considered cautiously, as other factors, such as response time of day or location, could also account for the impact on participant AHS scores (Meilgaard et al., 2016).

With the growth of cross-cultural research and the general trend of increasing globalism in many areas, this study provides a strong base to help guide future research (Ares, 2018; Jin, 2018; Pieterse, 2019). Additional studies should compare environmental effects between traditional analytic and holistic cultures (e.g., USA and Korea) that have been consistently studied within AH psychological research. These areas can identify how the eating environmental components consistently shown to impact consumer food perception in prior research may induce differing effects when considering AH differences between these cultures. An important stipulation to keep in mind is if future eating-environment studies within holistic, as opposed to primarily analytic, cultures produce environmental effects contrasting to those reported in the earlier studies, this is not an indication that the earlier theories or results were necessarily incorrect. Rather, these conflicting results could indicate a potential interaction of environmental effects on food perception with the cognitive styles (or cultures) of the sample population (Heine & Norenzayan, 2006; Markus & Kitayama, 1991). A further stipulation that should be considered within this area is as additional populations and variables are considered with analytic-holistic research, there might be a risk of false-positive significant results, which should be acknowledged if the number of comparisons increases drastically with models of increased complexity. Further studies in this area can also provide additional support to the findings of different means and variances between AH groups. Solidifying how the data of these groups contrast to one another bolsters the argument to account for AH cognitive styles in research to aid in the collection of representative data. The current study highlighted AH cognitive differences to the extent of how consumer food perception can be impacted by the eating environment. However, exploratory focus group data from our lab suggests AH cognitive differences may exist throughout the consumer-food experience (Beekman & Seo, 2021). Future studies can build upon this base by identifying specific portions of the food experience where cognitive differences are most apparent and impactful between the AH groups.

5. Conclusion

In conclusion, the findings from this study provide novel insight into how analytic-holistic cognitive differences between consumers can impact how their food perception is altered by their eating environment. Holistic participants were found to be influenced more by their eating environment compared to analytic participants. These results are supported by prior psychological theory research stating that holistic individuals are expected to allot more of their attention to contextual aspects of stimuli and surroundings relative to analytic individuals. Response variances were also found to differ between analytic and holistic participant groups, which, when combined with the differential eating environment effects, offers convincing support to the argument of accounting for analytic-holistic cognitive tendencies in consumer research. Future studies can help clarify where in the eating experience these cognitive differences are most impactful in causing divergent food perception and behaviors. Additional work can also investigate modifications to the AHS that are optimized for applied situations, such as sensory evaluation tasks. Chen and Antonelli (2020) recently provided a review of the importance of cognitive and cultural factors when researching consumer food choice, perception, and behavior. Our study provides a strong base of evidence supporting Chen and Antonello's argument, while showcasing how both academic and industry research can benefit from considering analytic-holistic theory in future works.

Table 1. Mean comparisons between the two cognitive style groups: analytic and holistic, with respect to environmental effect variable (EEV) value[1]

Environmental Effect Variable	Cognitive Style Group		*t*-value	*P*-value
	Analytic (N = 69)	Holistic (N = 69)		
Overall liking (1st)	1.03 (± 1.07)[2]	1.28 (± 1.36)	1.18	0.24
Appearance liking	1.16 (± 1.12)	1.52 (± 1.35)	1.72	0.09
Table setting Liking	2.06 (± 1.21)	2.23 (± 1.58)	0.72	0.47
Overall liking (2nd)	1.03 (± 1.08)	1.33 (± 1.36)	1.46	0.15
Overall liking (3rd)	0.94 (± 1.00)	0.90 (± 1.05)	0.25	0.80
The number of emotion attributes selected	1.46 (± 1.07)	1.62 (± 1.49)	0.72	0.47
The number of sensory attributes selected	1.10 (± 1.02)	1.54 (± 1.35)	2.14	0.03
The number of correct sensory attributes	0.99 (± 0.95)	1.01 (± 1.01)	0.17	0.86
Overall flavor liking	0.96 (± 1.08)	0.88 (± 1.16)	0.38	0.70
Noodle texture liking	0.64 (± 0.91)	0.49 (± 0.98)	0.90	0.37
Overall liking (4th)	0.97 (± 1.04)	1.00 (± 1.25)	0.14	0.88

[1]: Environmental effect variable values were calculated to create a single eating environment effect variable for each question via the absolute value of the Control subtracted from the Treatment participant response.

[2]: Mean ± standard deviation

Table 2. Pearson correlation and partial correlation coefficients (r) between post Analysis-Holism-Scale (AHS) scores and environmental effect variable (EEV) values[1] (N = 138)

Environmental Effect Variable	Correlation coefficient	*P*-value	Partial correlation coefficient[2]	*P*-value
Overall liking (1st)	0.20	0.02	0.07	0.43
Appearance liking	0.21	0.01	0.09	0.33
Table setting Liking	0.16	0.06	0.06	0.49
Overall liking (2nd)	0.21	0.01	0.01	0.89
Overall liking (3rd)	0.02	0.78	0.02	0.84
The number of emotion attributes selected	0.05	0.57	-0.06	0.52
The number of sensory attributes selected	0.20	0.02	0.26	0.003
The number of correct sensory attributes	0.02	0.86	-0.18	0.04
Overall flavor liking	-0.08	0.38	-0.09	0.31
Noodle texture liking	-0.001	0.97	0.02	0.80
Overall liking (4th)	-0.02	0.85	-0.01	0.93

1: Environmental effect variable values were calculated to create a single eating environment effect variable for each question via the absolute value of the Control subtracted from the Treatment participant response.
2: Partial correlation analyses were conducted holding all other variables constant to solely test the associations between the post AHS score and each EEV value.

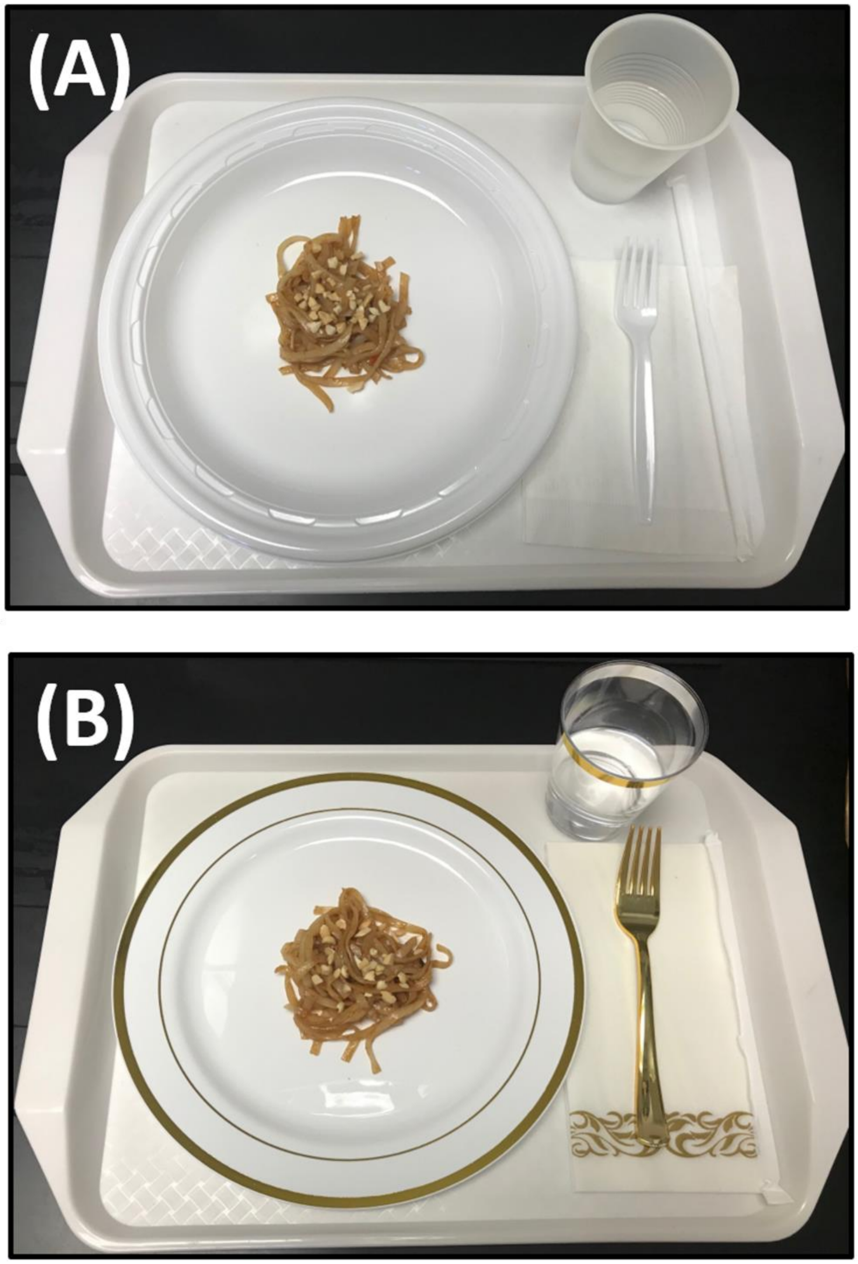

Figure 1. An example of table setting conditions used in this study: (A) a traditional sensory research style representing the control condition and (B) a fine dining style table setting representing the treatment condition

Beef	☐	Peanut*	☐	Salty*	☐	Black Pepper	☐
Onion*	☐	Sesame Oil	☐	Rice*	☐	Fish Sauce*	☐
Corn	☐	Carrot*	☐	Coconut	☐	Broccoli	☐
Lemon*	☐	Soy*	☐	Sour*	☐	Lime	☐
Bitter	☐	Garlic*	☐	Red Pepper*	☐	Savory*	☐
Chicken	☐	Green Bean	☐	Saffron	☐	Mango	☐
Sweet	☐						

Figure 2. Check-all-that-apply (CATA) ballot of sensory attributes for Pad Thai noodle samples. Asterisks (*) represent correct sensory attributes based on preliminary consumer testing and ingredients. All other attributes were treated as incorrect sensory attributes

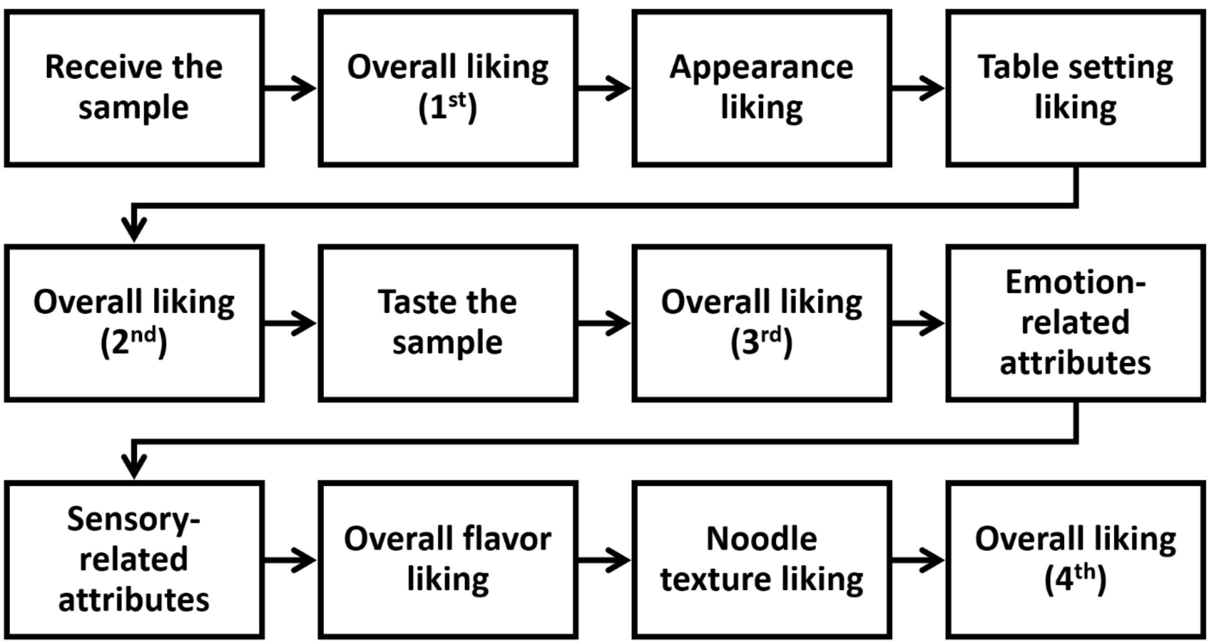

Figure 3. Stepwise visualization of the questionnaire outline for all participants upon receiving each sample

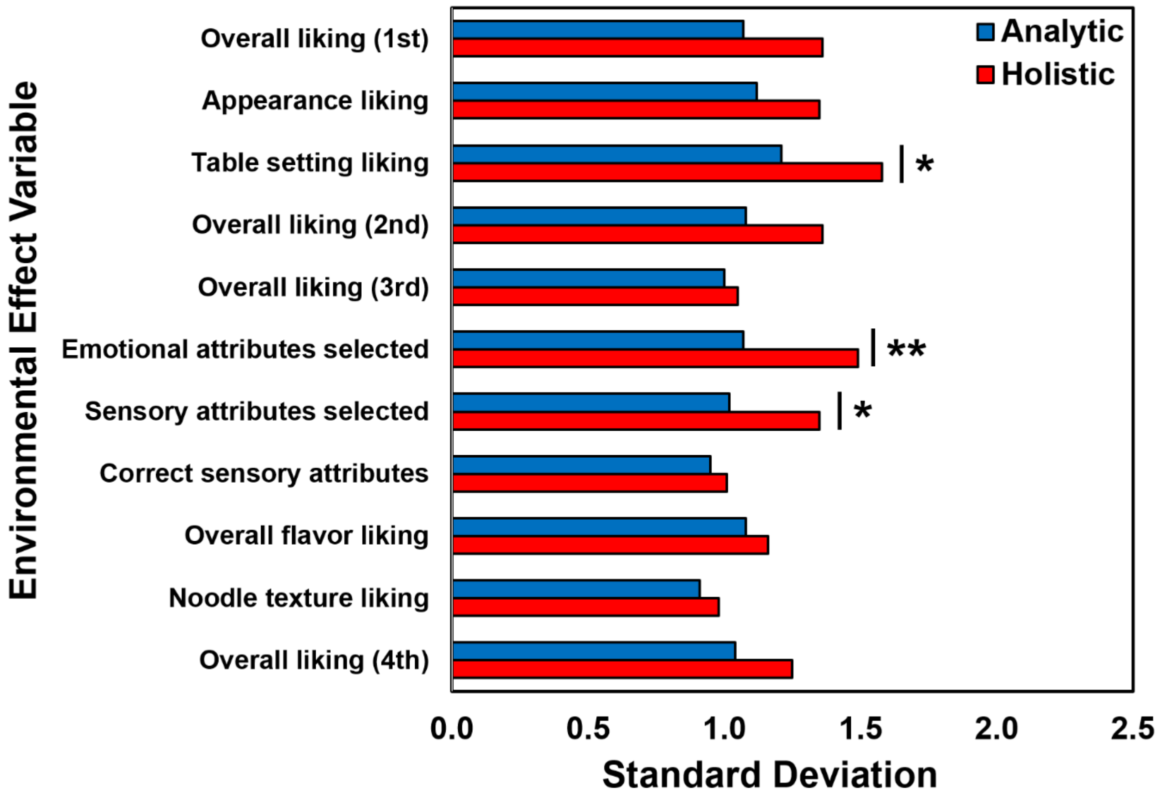

Figure 4. Bartlett test comparisons for equal variance of Environmental Effect Variable (EEV) responses between analytic and holistic cognitive groups. Individual bars and error bars represent means and standard errors of the means (SEM), respectively. * and ** represent a significant difference between the two cognitive style groups at $P < 0.05$ and $P < 0.01$, respectively

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CHAPTER 4

IDENTIFYING ANALYTIC-HOLISTIC COGNITIVE STYLE DIFFERENCES WITHIN CONSUMER SENSORY EVALUATION TASKS

Abstract

Recent literature has shown the analytic-holistic theory, which had previously been confined to psychology-based studies, is applicable in food and sensory science. Analytic and holistic cognitive style groups have been shown to have significantly different, and often opposite, perceptions and behaviors within food-related scenarios. These differences were further investigated and identified within the current study, focusing on identifying specific areas of common sensory tests and analyses where analytic and holistic cognitive groups differed from one another. A total of 130 healthy adults completed this study, with participants separated into cognitive style groups through a screening questionnaire using the Analysis-Holism Scale (AHS). Participants evaluated fruit-flavored beverage and fruit samples for their intensity and hedonic attributes, with the study replicated over two sessions, with each session either having solely category or line scale questions. Analyses focused on mean, variance, correlation, penalty analysis, and pre- and post-AHS score differences between cognitive style groups. Findings indicate holistic participants had a slight significant ($P < 0.05$) trend to display higher hedonic scores, higher variances, greater response correlations between questions, and fewer and smaller penalties compared to analytic participants. In addition, results also suggest sensory evaluation tasks may modulate participants' analytic-holistic tendencies. Together, such findings support analytic-holistic differences existence at a basic, discrimination level of sensory evaluation tasks, and substantial necessity of accounting for analytic-holistic tendencies of consumers during food and sensory research studies.

Keywords: Cognitive style, analytic, holistic, sensory perception, culture, consumer segmentation

1. Introduction

Most cognitive style research focuses on niche aspects of cognition, neurological development, or cognitive ability (Cheung et al., 2016; Kitayama & Park, 2010). Comparatively, the analytic-holistic (AH) cognitive style encompasses general cognitive processing, rather than specific portions of cognition, as it was developed to be a more encompassing cognitive style theory (Koo et al., 2018; Nisbett et al., 2001). The basis of analytic-holistic theory is in cultural psychology, with the analytic and holistic groups being associated to Western (e.g., USA) and Eastern (e.g., Korea), respectively (Ji et al., 2001). Much of the original research on the AH cognitive theory focused on comparing these analytic and holistic cultures, yet researchers expanded on these cross-cultural comparisons to show that analytic and holistic groups can be identified within a singular culture, with results replicating those found in the cross-cultural research (Cheng & Zhang, 2017; Ren et al., 2014). Initial psychology studies detailed how analytic individuals tend to exhibit more attention to a singular focus, see stimuli as more independent of one another, and see change in a more linear fashion. Holistic individuals tend to behave oppositely by considering more contextual information, focusing on the interconnectedness of stimuli, and perceiving change as more circular as opposed to linear (Morris et al., 1999; Masuda & Nisbett, 2001; Peng & Nisbett, 1999). Prior research has further highlighted how individuals categorized as either analytic or holistic may even utilize contrasting pieces of information to make divergent decisions (Apanovich et al., 2018; Hossain, 2018).

Even though these AH differences have been repeatedly replicated, there has been minimal research on the extent to which such cognitive differences apply to consumer sensory tests. This facet is particularly surprising given the growth of and interest in cross-cultural research across industry and academia, which has been specifically noted within the sensory and consumer science field (Ares, 2018; Lonner, 2018). In a recent review paper, Jeong and Lee (2021) further detailed the importance of cross-cultural research, with findings supporting the aforementioned "Eastern" (holistic) and "Western" (analytic) culturally associated differences. Due to these known differences between cultures, it is important to understand how the sensory results of food studies can differ based on categorization of analytic and holistic individuals. A common challenge within cognitive theories is identifying an effective strategy to separate individuals into the corresponding cognitive style groups. For the AH theory, the Analysis-Holism Scale (AHS) was developed to accomplish this task and has been shown to accurately separate analytic and holistic groups in a variety of applications of the AH theory, including separating participants both between and within cultures (Choi et al., 2007; Koo et al., 2018). The AHS relies on participants stating how much they agree or disagree with a series of 24 statements, with higher scores indicating more holistic tendencies and lower scores indicating more analytic tendencies.

When applying the AH theory and its associated findings to consumer-based sensory research, there are multiple areas the AH cognitive style is predicted to produce differences. First, the halo-effect has been found to be a pervasive issue within sensory testing, which, in essence, is when a consumer's answer to a question is impacted by previous answers (Fisher, 1992; Meilgaard et al., 2016). For example, if a sample is rated highly in the first question, then all following questions regarding the sample would be influenced and have a similar highly rated response. As analytic and holistic consumers differ in their perception of stimuli interconnectedness, it would be expected for see contrasting levels of the halo-effect between responses for the two AH groups. Second, there have been found to be differences in scale usage (Feng & O'Mahony, 2017; Yeh et al., 1998), flavor and food perception (Chrea et al., 2004;

Togawa et al., 2019), and variance consistency (Bacha-Trams et al., 2018) between analytic and holistic cultures, which could impact the mean and variance results between the cognitive groups. Another interesting application is that earlier studies suggest potentially divergent food perception between analytic and holistic individuals due to differences in the amount and type of information utilized to make food-related decisions (Choi, 2016; Hildebrand et al., 2019; Vanbergen et al., 2020). This use of differential information to form decisions parallels when participants are asked to rate their overall liking, which has the potential to be influenced by the various attributes of the sample itself. Within a penalty analysis, these processes are taken into consideration, with the corresponding results likely highlighting the mentioned AH differences in how the cognitive groups form decisions and opinions.

Two recent studies have explored the effect of AH cognitive differences on consumer food perception. Beekman and Seo (2021) were able to show through an exploratory focus group paper that analytic and holistic groups having contrasting food perceptions, experiences, and behaviors across the range of food experiences of shopping for food, preparing food, and consuming food. The same research lab has also been able to replicate the findings of Masuda and Nisbett (2001) in a food-related situation, providing validating evidence that holistic individuals provide more attention to and are subsequently affected more by their eating environment (Beekman & Seo, 2022). Recent works by Peng-Li et al. (2020) and Zhang and Seo (2015) have offered further validation to this pillar of AH theory that analytic, compared to holistic, individuals will focus more on the central aspect of the stimuli through these researchers' employment of eye-tracking methodologies. An additional interesting finding Beekman and Seo's paper on the environmental effect between AH groups, was the initial evidence that the pre- and post-AHS scores do not have a 1:1 relationship, suggesting the cognitive tendencies of participants may be modulated by partaking in sensory evaluation tasks. An additional aspect of sensory evaluation tasks potentially influenced by AH consumer groups is the complexity of said task, with prior research indicating more complex tasks may show increased levels of differences between the two cognitive groups (Meaux & Vuilleumier, 2016). Prior literature has detailed how consumers can perceive different scale types as being more or less difficult or complex to answer (Lim, 2011), and other research has shown that the makeup of the sensory attributes of samples can also change the perceived complexity of a food sample (Pérez-Cacho et al., 2005; Yang & Lee, 2019). Specifically, Gupta et al., (2021) found the type of sensory measurement tool used altered if significant effects were seen between analytic and holistic cultures. Both the scale and sample type can thus be applied to alter the perceived task complexity to identify any interactions between AH cognitive groups and task complexity.

Combining these areas of consumer sensory responses that may differ between analytic and holistic cognitive style groups offers notable benefits to all researchers considering consumer responses to sensory and food applications. As the two cognitive groups appear to have divergent tendencies and responses related to how they perceive and interact with food, two distinct populations could be present within the response data. To obtain accurate, meaningful results and conclusions from such consumer data, it would be necessary to segment these consumers into their respective cognitive groups to ensure these sensorial response differences are not overlooked and combined within a single population. Identifying the specific areas of sensory evaluation tasks and the associated data where AH differences are prominent then offer applicability to industry- and academic-orientated researchers to help ensure accurate conclusions based on the consumer populations they are investigating. Therefore, the main objective of this study is to delineate how and where analytic and holistic groups differ in their responses to a food-related sensory evaluation task. To accomplish this objective, it is broken down into sub-portions: (1) Compare mean and variance responses between cognitive groups, (2) identify halo-effect differences through comparing response correlations between cognitive groups, (3) compare penalty analysis findings between analytic and holistic groups to identify overall opinion-forming differences between cognitive groups, and (4) compare pre- and post AHS scores to identify how the AHS performs within a sensory evaluation task. All comparisons will be conducted across samples and tasks with different levels of complexity to further investigate how task complexity may induce additional AH differences.

2. Materials and methods

The protocol (IRB approval No. 2108348528) used in this study was approved by the Institutional Review Board of the University of Arkansas (Fayetteville, AR). 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). 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. In addition, participants also provided responses to the Analysis-Holism Scale (AHS; Choi et al., 2007) to assess their analytic-holistic tendencies. Only individuals with greater and less than one standard deviation above and below the mean AHS score were selected for the holistic and analytic cognitive groups, respectively (Beekman & Seo, 2021; Hildebrand et al., 2019). Through these recruitment and screening steps, a total of 65 analytic (43 females and 22 males; mean age ± standard deviation [SD] = 40 ± 12 years) and 65 holistic (42 females and 23 males; mean age ± standard deviation [SD] = 39 ± 12 years) participants were included in this study. No significant differences were found in age (P = 0.24) or gender ratio (P = 0.85) between the cognitive groups.

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 more or less differences, corresponding to complex versus simple tasks, between cognitive 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 food sample and a simple and complex beverage 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 & Lee, 2019). The simple food sample was frozen pineapple (Great Value frozen pineapple chunks, Walmart, Bentonville, AR, USA) and the complex food sample was a mixed fruit 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 (40 F) prior to serving. Frozen fruit samples were served in 10 oz white foam bowls (10 oz hot or cold insulated food containers, 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 and 1 piece of pineapple, 8 blueberries, 2 strawberries, and 3 blackberries (approximately equal weight of each fruit) in the complex sample. All fruit samples were prepared directly prior to serving to participants and were served at refrigeration temperature (four degrees Celsius). 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 with 0.2% blueberry (Item#248150 Blueberry Natural and Artificial, Gold Coast Ingredients, Commerce, CA, USA), 0.1 % strawberry (Item#444050 Strawberry Flavor N & A, Gold Coast Ingredients, Commerce, CA, USA), and 0.1 % cherry (Item#355058 Cherry Red Flavor, Natural WONF, Gold Coast Ingredients, Commerce, CA, USA) flavorings. All flavored water samples were prepared the day prior to serving to participants in larger quantities and poured into 4 oz clear plastic cups with clear plastic lids (4 oz Clear Portion Containers with Clear Plastic Lids, Dart Container Corporation, Mason, MI, USA) directly prior to serving to participants, with the volume of each beverage sample being 50 mL. Water flavor and percentage selection were conducted via pilot testing with a variety of different flavor and volume concentrations based on recommendations from the manufacturer. Beverage samples were stored and served at room temperature. Within this paper, future mentions of the samples will refer to them as orange water, mixed fruit water, pineapple, and mixed fruit for the four difference samples. Disposable materials were used to best maintain safety for researchers and participants regarding COVID-19 procedures and recommended guidelines.

2.3. Procedure

The procedure for this study involved participants coming two separate days, one for each treatment of either categorical scaling or line scaling questions, with study days at the same time on the same day of the week for each participant, separated by a week. Treatment order presented in a randomized, balanced design, with sample presentation in a balanced, randomized block design, with the beverage and food samples making up the two blocks, respectively, and the beverage samples always being presented before the food samples to prevent carryover. Questions were identical across all samples and sessions, with the only difference being that in the categorical session, all numerical questions were presented on a 9-point categorical scale, while in the line session, all numerical questions were presented on a 15 cm line scale. Categorical and line scale questions were employed as the two treatment methods to also address the potential effect of complexity on analytic-holistic differences in sensory responses. Prior research has demonstrated how consumer participants can perceive a labeled category scale as easier to use than a line scale, which suggests the category scale is a less complex task than the line scale (Lim, 2011). All study details, methods, and procedures were identical between the two scale type treatments, as the only difference for participants was the scale on which they answered the questions.

Across both treatments, participants saw questions in the following order for all samples: flavor liking, flavor intensity, pineapple/ orange flavor liking, pineapple/ orange flavor intensity, sweetness intensity, sourness intensity, bitterness intensity, overall liking, and after all samples were presented and finished, a final question asking the relatedness of all four samples to one another. Questions labeled as pineapple/ orange indicates that if the sample was a beverage sample, then the question asked about orange flavor, and if the sample was a food sample, then the question asked about pineapple flavor. These specific flavors were targeted within questions as they represent the focal or central flavors of each sample, and prior research has indicated analytic, compared to holistic, participants will focus more on the central aspect of stimuli (Masuda & Nisbett, 2001). The question regarding relatedness of samples was included to assess if analytic and holistic cognitive groups saw samples as more or less related to one another to help address the question of if holistic participants exhibit more carryover effects within sensory tests due to their increased tendency to see stimuli as interconnected compared to analytic participants (Li et al., 2018). For the categorical hedonic questions, the categories consisted, with the respective ratings, of 1 (Dislike Extremely), 2 (Dislike Very Much), 3 (Dislike Moderately), 4 (Dislike Slightly), 5 (Neither Like nor Dislike), 6 (Like Slightly), 7 (Like Moderately), 8 (Like Very Much), and 9 (Like Extremely). The intensity questions in the categorical session were based on Just-About-Right (JAR) scales and had the categories, with their respective ratings, consisting of 1 (Extremely too Weak), 2 Much too Weak), 3 (Moderately too Weak), 4 (Slightly too Weak), 5 (Just About Right), 6 (Slightly too Strong), 7 (Moderately too Strong), 8 (Much too Strong), and 9 (Extremely too Strong). The sample relatedness question had ratings and respective category labels of 1 (Extremely Distinct from One Another), 2 (Very Distinct from One Another), 3 (Moderately Distinct from One Another), 4 (Slightly Distinct from One Another), 5 (Neither Distinct nor Related to One Another), 6 (Slightly Related to One Another), 7 (Moderately Related to One Another), 8 (Very Related to One Another), and 9 (Extremely Related to One Another). For the line scale session all questions were identical apart from the line scales for the hedonic questions only had “Dislike Extremely” and “Like Extremely” as the two respective anchors for the scale and for the intensity questions “Extremely too Weak” and “Extremely too Strong” were the two scale anchors. The intensity questions also had “Just About Right” labeled as the middle (7.5 cm) of the scale. The sample relatedness line scale question then only had the 1, 5, and 9 category labels placed at the beginning, middle, and end of the line scale, respectively.

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

2.4. Statistical analyses

Prior to analyzing the data between the scale types and cognitive groups, all data was standardized following the Proportion of Maximum Scaling (POMS) method for the categorical 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 groups and scale types. Following the standardization, a three-way analysis of variance (ANOVA) model was created treating “scale type" and "cognitive group" as fixed effects and "participant" as a random effect to identify any significant interactions between scale type and cognitive group. The quantitative questions for all samples were included as the response variables, which includes all hedonic and JAR intensity questions for all samples, along with the sample relatedness question. All response variables across all samples resulted in a non-significant interaction of scale type and cognitive group ($P > 0.05$); therefore, these variables will be investigated separately and combined across one another moving forward. Specifically, this means cognitive group comparisons will be conducted solely between cognitive groups combined across both scale type's data and scale type comparisons will be conducted solely between scale types and combined across both cognitive group's data. To investigate the effect of cognitive group on sensory mean responses, a two-way ANOVA was conducted across all scale type data treating "cognitive group" as a fixed effect and "participant" as a random effect. If a significant result ($P < 0.05$) 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 quantitative responses between cognitive groups and where they could be found within sensory evaluations across different types of sample questions. To further this area of investigation, Levene's test of equal variances (Levene, 1960; NIST, 2013) was conducted on all hedonic, JAR, and relatedness question variables for all samples between the cognitive groups to identify any variation differences between the cognitive style (CS) groups. Prior analytic-holistic research has indicated that both mean (Feng & O'Mahony, 2017) and variation (Bacha-Trams et al., 2018) can differ between the groups, and these analyses offer the opportunity to confirm these claims, specifically within an applied situation of sensory evaluation tasks.

To be consistent, the same ANOVA and Levene's test methodologies were conducted between scale type treatments. The data was combined across cognitive groups and a two-way ANOVA treating "scale type" as a fixed effect and "participant" as a random effect was conducted on all quantitative response variables. If a significant result ($P < 0.05$) was identified, a post-hoc Student's t-test was performed for mean comparisons. This analysis provided the capabilities of identifying any trends across both cognitive groups regarding if there were differences in how samples were evaluated between the two scale types. To further address this question, the Levene's test of equal variance was conducted between the two scale treatment conditions for all quantitative response variables to identify if the variability of participant responses contained consistent differences between the scale type treatments.

Additional earlier works have detailed how holistic and analytic individuals differ in their tendencies and abilities to see events and stimuli as independent or interdependent of one another (Ji et al., 2000). If participants were to see stimuli (i.e., food and beverage samples) and the respective questions asked about them as more (less) interdependent, then the correlations among these responses would be expected to exhibit a greater (lesser) strength of relationship, often referred to as the halo effect in sensory evaluation (Meilgaard et al., 2016). To assess differences in responses correlations between cognitive groups, Pearson correlations were calculated between all quantitative sample response variables within each cognitive group, combined across scale types. Following, the number of significant correlations ($P < 0.05$) among response variables were counted for each cognitive group and a numerical variable was created by summing the number of significant correlations in each group. The significant correlation counts were separated by number of significant question response correlations (1) within each sample (2) between questions from different samples labeled as "Other", (3) between the sample relatedness question and all other questions, and (4) total number of significant correlations. To statistically compare these count data, a Global chi-square test was performed on the respective correlation count data of the two CS groups making up a frequency table, along with Fisher's Exact Tests performed to compare individual relative proportions of significant correlations between comparison groups (Piqueras-Fiszman, 2015; Beekman & Seo, 2021). This analysis was replicated between scale types combined across cognitive groups.

To further identify over-arching differences between the cognitive groups in how samples are perceived and rated in a sensory evaluation task, penalty analyses were conducted within each group's data. By default, the penalty analysis employs only the non-transformed categorical scale response data, meaning the line scale participant response data are excluded from these analyses following the methods outlined by XLSTAT (Pages et al., 2014; XLSTAT, 2022). The penalty analyses utilized the participant response data from the "overall liking" question for each sample, along with the response data from the "overall flavor", "pineapple/orange flavor", "sweetness", "sourness", and "bitterness" JAR intensity questions. For each food and beverage sample, the penalty analyses 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. This analysis was conducted separately for each of the samples, with cognitive group included as a grouping variable to allow for analytic-holistic comparisons within each sample's penalty analysis. The mean drops, and their relative significance, were compared between cognitive groups. The number of participant responses in each CS group classified as below JAR, JAR, and above JAR was also compared, with Fisher's Exact Tests conducted to identify significant differences in responses counts. This analysis was replicated for each JAR intensity question within each sample.

Work within the cognitive style research space has suggested that individuals may have a general cognitive style that may be modulated during specific tasks, meaning they have a situationally specific cognitive style in some instances (Miyamoto, 2013). As the AHS is a measurement tool for general analytic-holistic tendencies, there may be some differences in participant scores upon partaking in a sensory evaluation task. To address this question of the potential impact of sensory evaluation 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 variable" as the fixed effect (i.e., if the score was a pre- or post AHS score), and "participant" as a random effect. If a significant result ($P < 0.05$) was identified, a post-hoc Student's t-test was performed for mean comparisons. Simple linear regression analyses were also conducted to identify the relationship between pre- and post-AHS scores combined across participants and within each cognitive group separately to expand upon the findings from Beekman and Seo (2022). A statistical significance was defined when $P < 0.05$. Data were analyzed using JMP Pro software (version 16.0, SAS Institute, Inc., Cary, NC) and XLSTAT software (Addinsoft, New York, NY).

3. Results

3.1. Mean comparisons

Mean rating responses were compared between analytic and holistic cognitive groups for all questions across all samples, combined across category and line scale data separately. Table 1 indicates there were five instances of significant differences between mean ratings of CS groups. Two of the five questions show the analytic group having a significantly higher mean rating for the intensity of bitterness JAR question within the orange water and mixed fruit water samples. The bitterness JAR mean response for the analytic group (0.47) is significantly closer (F = 3.97, *P* = 0.049) to JAR than the mean response for the holistic group (0.41) in the orange water sample, while the analytic (0.53) and holistic (0.47) group mean ratings are significantly different (F = 4.25, *P* = 0.41) but nearly equally divided along the JAR rating for the bitterness intensity in the mixed fruit water sample. For the pineapple sample, the holistic CS group has significantly higher mean responses for the flavor liking (F = 4.15, *P* = 0.44), pineapple flavor liking (F = 4.25, *P* = 0.41), and overall liking (F = 11.53, *P* < 0.001) compared to the analytic CS group, with 0.78, 0.77., and 0.77 versus 0.72, 0.70, and 0.66 being the respective mean liking ratings between analytic and holistic groups across the three questions. Figure 1 visually details the mean response ratings between the analytic and holistic groups for question-sample combinations where there was a significant difference across scale types, as the comparisons between analytic and holistic CS groups are the main foci for the current study.

Mean rating responses were also compared between category and line scale data for all questions across all samples, combined across analytic and holistic CS groups. Table 2 indicates there were seven question-sample combinations where category and line scale mean ratings significantly differed. Five of the instances showed the category mean being higher than the line scale mean. Specifically, the orange flavor liking of the orange water sample (0.52 vs. 0.46, F = 7.76, *P* = 0.006), the orange flavor liking of the mixed fruit sample (0.40 vs. 0.34, F = 10.34, *P* = 0.002), the bitterness intensity of the pineapple sample (0.49 vs. 0.47, F = 4.26, *P* = 0.041), the flavor liking of the mixed fruit sample (0.62 vs. 0.55, F = 11.38, *P* = 0.001), and the pineapple flavor liking of the mixed fruit sample (0.71 vs. 0.63, F = 10.50, *P* = 0.002) all show the category scale responses being greater in liking or closer to JAR compared to the line scale responses.

Comparatively, the pineapple flavor intensity (0.44 vs. 0.47, F = 5.45, P = 0.02) and sweetness intensity (0.44 vs. 0.47. F = 4.65, P = 0.03) of the pineapple sample show the line scale data having a mean response significantly closer to JAR than the category scale response data.

3.2. Variance comparisons

To identify if analytic and holistic CS groups differ in the variability of their responses to sensory tasks, the variances of the two groups, combined across category and line scale data were compared. Specifically, the standard deviations of each CS group's response data for each sample-question combination were statistically compared through Levene's test of equal variances. The results shown in Table 3 indicate four questions where the variances were shown to be significantly different between the group. For the sour intensity of the orange water sample (0.20 vs. 0.21, F = 4.03, *P* = 0.046), bitterness intensity of the orange water sample (0.17 vs. 0.21, F = 10.70, *P* = 0.001), overall liking of the mixed fruit sample (0.25 vs. 0.28, F = 4.05, *P* = 0.045), and the sample relatedness (0.25 vs 0.29, F = 10.39, *P* = 0.001) questions the holistic group had a significantly higher standard deviation compared to the analytic group. This suggests a slight trend of holistic participants having greater variability in their responses compared to analytic participants. Figure 2 visually details the variances between the analytic and holistic groups for question-sample combinations where there was a significant difference across scale types, as the comparisons between analytic and holistic CS groups are the main foci for the current study.

Paralleling the mean comparisons, the variances were also compared between category and line scale data, combined across CS groups following the same methods. Table 4 indicates six sample-question combinations where the variance significantly differed between the category and line scale data. In five of the six instances, the category scale data had a greater variance than the line scale data, and in one of the instances the line scale data had a greater variance than the category scale data. The questions with the higher category scale variance were flavor liking of the mixed fruit water sample (0.28 vs. 0.24, F = 8.50, $P = 0.004$), orange flavor liking of the mixed fruit water sample (0.26 vs. 0.24, F = 4.03, $P = 0.046$), flavor intensity of the pineapple sample (0.13 vs. 0.12, F = 4.98, $P = 0.027$), pineapple flavor intensity of the pineapple sample (0.13 vs. 0.10, F = 11.01, $P = 0.001$), and sweetness intensity of the pineapple sample (0.13 vs. 0.10, F = 8.40, $P = 0.004$). The question with the higher line scale variance was pineapple flavor liking of the mixed fruit sample (0.22 vs. 0.25, F = 4.17, $P = 0.042$). The variance comparisons between the scale type data indicate a weak trend of the category scale data having higher variability than the line scale data.

3.3. Response correlation comparisons

When comparing the correlations of responses, both the effect of cognitive style and scale type were considered. There were differences in correlations between analytic and holistic CS groups. A global chi-square analysis indicates a significant difference ($\chi^2 = 15.02$, $P = 0.010$) in the frequencies of correlations between the CS groups (Table 5). The data is combined across category and scale type data, for a sample size of 130 for each cognitive group. When comparing between the different samples for correlated responses within each sample through Fisher's Exact Tests, the analytic and holistic groups did not significantly differ ($P > 0.05$) for all samples, with a similar trend seen for the "Other" correlation group. The analyses show the holistic group, relative to the analytic group, as having significantly more significant correlations for the category of question responses with the sample relatedness question (z = -3.53, $P <$

0.001) and total significant correlations across all question responses (z = -3.26, P = 0.001). For the comparisons between scale type data combined across CS groups, there were no significant effects ($P > 0.05$) seen in the global chi-square test or in any of the Fisher's Exact Tests between any of the individual significant correlation categories (Table 6).

3.4. Penalty analysis comparisons

Using only the category scale data for participants, penalty analyses were conducted by treating the overall liking question (Question 8) as the liking score and the flavor intensity (Question 2), orange/pineapple flavor intensity (Question 4), sweetness intensity (Question 5), sourness intensity (Question 6), and bitterness intensity (Question 7) as the just-about-right scores for each of the four samples separately. Table 7 shows the comparison of the mean drop valuess for both the "too weak" and "too strong" response categories between the analytic and holistic groups for each of the four samples. Red, green, and grey colored values indicate significant, non-significant, and not calculated due to lack of data mean drop values, respectively, for each of the category-question-sample combinations. From Table 7, the analytic group tended to have more significant mean drops with higher magnitude of the mean drops compared to the holistic group for the majority of comparisons. However, this trend was reversed for the mixed fruit sample, where the mean drop results indicate the holistic group had a slight trend of more significant and higher magnitudes of mean drops for multiple questions, such as in the flavor intensity, pineapple flavor intensity, and sourness intensity questions specifically. To further compare the penalty analysis results between groups, the proportion of responses for "too weak", "JAR", and "too strong" were compared between CS groups for each question and sample combination (Table 8). Results show a trend of the holistic group having more JAR and less "too weak" or "too strong" responses compared to the analytic group. This trend is supported by four instances of the Fisher's Exact Test results for the "too weak" category of the flavor intensity of the pineapple sample (z = 2.24, $P = 0.025$), "JAR" category of the flavor intensity of the pineapple sample (z = -2.54, $P = 0.011$), "too weak" category of the pineapple flavor intensity of the pineapple sample (z = 2.02, $P = 0.043$), and "JAR" category of the pineapple flavor intensity of the pineapple sample (z = -2.34, $P = 0.019$).

3.5. Pre and post analysis-holism scale score comparisons

When comparing the pre- and post-AHS scores of participants, the mean scores combined across cognitive groups did not differ between pre- and post-AHS scores (t = 1.37, P = 0.172), indicating no significant differences between pre- and post-AHS score. However, when conducting the mean comparison of pre- and post-AHS scores between analytic and holistic groups separately, the analytic group data indicated no significant differences between the pre and post scores (t = -0.35, $P = 0.728$) but the holistic group indicated a significantly lower post-AHS score (t = 3.14, $P = 0.002$) compared to the pre-AHS score (Figure 3), meaning the holistic group post-AHS scores were significantly more analytic than the pre-AHS scores. Correlation analyses indicate that the pre- and post-AHS scores are significantly correlated ($P < 0.001$) with one another when the CS groups are combined and when the correlation analyses are conducted separately within each cognitive group (Table 9). The holistic CS group seems to have a stronger correlation relative to the analytic group due to its larger correlation coefficient between the pre and post scores. This finding is further supported by the linear regression analyses showing the holistic CS group's pre- and post-AHS scores exhibit a relationship that is closer to 1:1 compared the analytic group's slope. Specifically, when fitting a linear model between the pre and post AHS variables for the holistic group, the resulting equation showed a coefficient of 0.87

of the pre-AHS score and an intercept of 11.40 when modelling for the post AHS score. Comparatively, the resulting equation for the analytic group showed a coefficient of 0.61 of the pre-AHS score and an intercept of 41.89 when modelling for the post-AHS score. Combined across both CS groups, the results show a coefficient of 0.77 of the pre-AHS score and an intercept of 25.51.

4. Discussion

By piecing to together the results from the individual analyses, a relatively weak, common trend can be seen in the significant differences between analytic and holistic CS groups, with minor differences between scale types. With these findings being relatively consistent across samples, these trends encompass all samples used within this study. The first portion of the results connect to the first main objective of this study of identifying mean and variance differences between cognitive groups. Mean comparisons first showed there were no interactions between scale type and cognitive group, which offered the first piece of evidence that the scale type complexity (i.e., category scale being less complex than the line scale) did not interact with any CS differences seen here. One potential reasoning for the lack of interaction between scale type and cognitive differences is that the line scale task may still in fact be more complex than the category scale task, yet they may require different types of cognitive thought to comprehend and respond to, which may void any complexity-related differences. To compare, the category scale consists of verbally labeled categories, while the line scale consists of a continuum with bookends labeled for hedonic questions and the center also labeled for JAR questions (Table 2). In addition, the category scale data also tended to have greater variance values than the line scale data (Table 4). Due to the contrasts between these scales, the category scale could induce more linguistic processing, while the line scale could induce more numerical processing. Cognitive neuroscience research has yet to reach a definitive conclusion on the exact relationship between linguistic and numerical processing; nevertheless, they have been found to have a degree of relatedness with areas of independence (Lachmair et al., 2014; Rath et al., 2015). Because of the overlap between the two types of cognitive processing, additional work may be needed with tasks of varying complexity levels inducing the same style of cognitive processing to identify task-complexity on CS group effects. Additional work could also solidify if the weak trends showing the category scale data having higher mean scores and variances than the line scale data are due to task-complexity differences or cognitive processing differences. However, the fact that minimal differences were seen between the samples of varying complexity suggest that task-complexity may not exhibit any significant effects on AH cognitive differences.

On the other hand, the AH mean and variance outcomes, even though relatively weak trends, due match with expected outcomes and prior literature of the two CS groups exhibiting differences in sensory responses. There is a slight, significant trend of the holistic CS group having higher hedonic scores compared to the analytic group, with one instance of the analytic group being significantly closer to the JAR rating (Figure 1). Holistic individuals reporting greater liking scores is in line with earlier research indicating holistic individuals tend to mediate contradictions and aspire toward harmonious outcomes, which may involve being less critical (Spencer-Rodgers et al., 2010). Furthermore, cultures associated with holistic processing, compared to those with analytic processing, place a greater importance on cultural respect (Triandis et al., 1988). Through being more respectful, holistic participants may then select higher hedonic ratings relative to analytic participants. Another interesting piece of this result may also be influenced by holistic participants allotting more attention to multiple contextual details of food stimuli, while analytic individuals tend to allot more attention to the focal aspect of stimuli (Beekman & Seo, 2021; Zhang & 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 also 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 select the attribute they do not like to base their hedonic rating on. Like the mean comparisons, the variance comparisons indicating the holistic CS group having a weak trend of significantly greater variance compared to the analytic CS group (Figure 2). Prior research suggests a difference in the variability between the CS groups yet indicates the holistic group having a smaller response variability relative to the analytic group (Bacha-trams et al., 2018). The current findings show an opposite trend, which could suggest the findings here are due to a separate latent factor other than CS group that may be impacting the variance differences. One such latent factor could be the type of stimuli or situation in which the CS group responses are compared, as the research by Bacha-Trams and others (2018) involved watching a drama movie and the current study involved evaluating food and beverage samples. Future research expanding on the stimuli and situation in which response variability is compared between CS groups could help address why contrasting results are seen.

When comparing the response correlations, the holistic group exhibited a greater degree of correlation than the analytic group (Table 5), while no differences in correlations were seen between the scale types (Table 6). The lack of differences between the scale types in correlation supports the earlier notion that the scale type complexity, relative to the AH variable, are a minimal contributor to the significant effects seen in the current study. However, the AH correlation differences among response correlations connects with prior research discussing holistic individuals' tendency to see stimuli as more interconnected and related to one another (Li et al., 2018; Varnum et al., 2010). This trend is explicitly supported by the response correlations, as the holistic group, compared to the analytic group, has significantly more significant correlations for the total amount of correlations and between the "sample relatedness" question with all other responses. In addition, the "Other" category shows a trend in the same direction, which indicates the holistic group has a minor trend of having responses more correlated across different samples. These trends combined support holistic individuals having responses more connected to one another than the analytic group, indicating the holistic group may have a significantly greater halo-effect among responses during sensory evaluations.

Looking at the penalty analyses across the samples offers additional corroboration to the existences of AH differences in standard sensory evaluation tasks. The major trend showed the holistic CS group having overall less and smaller penalties, while stating that sample attributes were closer to JAR relative to the analytic group (Tables 7-8). Such a finding pairs well with the earlier theoretical details of holistic individuals and cultures applying a greater emphasis on respect while also minimizing conflict to ensure harmonious relationships (Spencer-Rodgers et al., 2010; Triandis et al., 1988). Through these inclinations, it would be expected to see fewer penalties, which was seen here. In addition, Beekman and Seo (2021) have also recently elucidated holistic individuals showing more concern with the overall experience of food stimuli. Interpreted in the context of the current study that compared to their analytic counterparts, the holistic CS group may not penalize individual attributes as harshly since they are more focused on their overall opinion of the product. However, within the mixed fruit sample, it seemed this trend was not seen, with the holistic group having greater and more frequent significant penalties. Due to the sample consisting of multiple individual fruits and the holistic tendency to focus on a greater variety of aspects of stimuli, the holistic group, in the mixed fruit sample, may have been impacted by the wider array of potential fruits and attributes, thus penalizing the scores more compared to the analytic group (Masuda & Nisbett, 2001; Beekman & Seo, 2021). Digging deeper into this area in the future to identify how the complex matrices of food samples and how easily the portions of a sample can be cognitive separated could impact the AH differences would help clarify these effects.

Another unique aspect of this study was the investigation of the performance of the AHS before and after a sensory evaluation task. Similar to what some researchers have postulated (Miyamoto, 2013), it was seen here that the sensory evaluation task appears to modulate the AH tendencies of individuals. Through the holistic group having significantly lower AHS scores after finishing the study (Figure 3), paired with the CS groups, notably the analytic group, having far from a 1:1 relationship between the pre- and post-AHS score (Table 9), the findings support an effect of food evaluations on participant AHS scores. Together, these findings suggest that (1) the sensory evaluation task itself may induce more analytic thinking of holistic individuals and (2) within such a task, the AHS may not produce consistent scores across a sensory task for analytic individuals. These findings, in conjunction with the results from Beekman and Seo (2022), strengthen the need of a modified AHS specific to the food situations to ensure accurate AH consumer segmentation. Lux et al., (2021) and Lux (2017) offer further support for this notion that in more niche applications, such as sensory evaluation, the AHS may be measuring too general of cognitive tendencies. Therefore, future work can help with accurate AH consumer segmentation by investigating the potential for a food-specific AHS to better assess individuals' cognitive leanings in sensory and consumer research situations. A food-specific AHS may also more clearly separate the respective AH differences that displayed weak trends in these findings.

These findings together offer great insight into the necessity of accounting for AH differences in consumer testing; nevertheless, future testing can explore how these effects can translate to a wider selection of samples and testing situations. Even though prior research has validated the CS tendencies both across and within a variety of cultures, it would be beneficial to identify if these food-related AH contrasts are consistent across multiple populations. Expanding the 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 the more minute and localized food cultures (Reddy & van Dam, 2020; Zhang et al., 2022). Further studies investigating the potential interaction of food cultures within an over-arching food culture could provide unique insights. This burgeoning area of how analytic and holistic consumer groups differ from one another in food situations offers new benefits to industry and academic researchers to ensure accurate consumer segmentation. Ensuring accurate segmentation is crucial for results being representative of what the consumers want and therefore helping ensure meaningful conclusions and product launches being congruent with consumer expectations and needs.

5. Conclusions

Recent work has detailed the divergent perceptions and behaviors analytic and holistic cognitive style groups have in some food-related situations or with food stimuli. The current study digs deeper into this area by investigating the presence and location of analytic-holistic differences within common sensory evaluation tasks, such as hedonic and intensity questions across category and line scales. The findings support weak, but significant, effects of cognitive style on mean, variance, correlation, and assigned penalties. Much of the trends match with psychology work, with holistic individuals displaying trends of greater interconnectedness of stimuli, focusing on a wider variety of attributes, and being less critical compared to analytic individuals. In addition, the comparison of AHS response scores before and after the sensory evaluation indicate a potential area of future research looking into a food-specific analytic-holistic measurement tool to ensure accurate cognitive group segmentation. Both industry and academic researchers can benefit from increasingly accurate consumer segmentation to ensure that any conclusions, next steps, or business decisions based on the data are truly representative of the consumer groups. Further research can also explore how the analytic-holistic differences seen within the current study extend to a wider range of food samples, sensory evaluation tasks, and cultural populations.

Table 1. Mean (± standard deviation (SD)) ratings between cognitive groups for all sample-question combinations combined across scale types based on two-way ANOVA tests (N=130 for each cognitive style group). Bold lettering and numbering indicate a significant difference between cognitive groups when *P* < 0.05.

Question*	Analytic (Mean ± SD)	Holistic (Mean ± SD)	Test statistic (F)	*P*-value
Orange Water 1	0.51 ± 0.22	0.55 ± 0.24	1.77	0.186
Orange Water 2	0.31 ± 0.19	0.30 ± 0.21	0.01	0.933
Orange Water 3	0.47 ± 0.23	0.51 ± 0.27	1.43	0.235
Orange Water 4	0.29 ± 0.18	0.29 ± 0.21	< 0.01	0.959
Orange Water 5	0.31 ± 0.17	0.27 ± 0.19	2.02	0.157
Orange Water 6	0.38 ± 0.20	0.32 ± 0.21	3.00	0.086
Orange Water 7	**0.47 ± 0.17**	**0.41 ± 0.21**	**3.97**	**0.049**
Orange Water 8	0.46 ± 0.26	0.47 ± 0.26	0.12	0.730
Mixed Fruit Water 1	0.39 ± 0.26	0.44 ± 0.26	1.87	0.174
Mixed Fruit Water 2	0.45 ± 0.25	0.43 ± 0.25	0.56	0.457
Mixed Fruit Water 3	0.34 ± 0.25	0.40 ± 0.25	2.95	0.088
Mixed Fruit Water 4	0.34 ± 0.26	0.35 ± 0.24	0.11	0.746
Mixed Fruit Water 5	0.31 ± 0.22	0.32 ± 0.22	0.12	0.731
Mixed Fruit Water 6	0.40 ± 0.22	0.37 ± 0.22	0.85	0.357
Mixed Fruit Water 7	**0.53 ± 0.21**	**0.47 ± 0.23**	**4.25**	**0.041**
Mixed Fruit Water 8	0.32 ± 0.26	0.40 ± 0.27	3.60	0.060
Pineapple 1	**0.72 ± 0.19**	**0.78 ± 0.22**	**4.15**	**0.044**
Pineapple 2	0.46 ± 0.13	0.47 ± 0.12	0.42	0.519
Pineapple 3	**0.70 ± 0.22**	**0.77 ± 0.22**	**4.25**	**0.041**
Pineapple 4	0.45 ± 0.12	0.46 ± 0.10	0.14	0.705
Pineapple 5	0.45 ± 0.12	0.46 ± 0.11	0.21	0.648
Pineapple 6	0.47 ± 0.11	0.48 ± 0.11	0.89	0.348
Pineapple 7	0.48 ± 0.11	0.48 ± 0.12	0.02	0.881
Pineapple 8	**0.66 ± 0.23**	**0.77 ± 0.22**	**11.53**	**0.001**
Mixed Fruit 1	0.55 ± 0.24	0.62 ± 0.27	3.84	0.052
Mixed Fruit 2	0.49 ± 0.16	0.50 ± 0.17	0.01	0.914
Mixed Fruit 3	0.66 ± 0.22	0.69 ± 0.25	0.72	0.399
Mixed Fruit 4	0.44 ± 0.12	0.43 ± 0.15	0.61	0.438
Mixed Fruit 5	0.42 ± 0.13	0.44 ± 0.12	2.32	0.131
Mixed Fruit 6	0.54 ± 0.15	0.55 ± 0.14	0.10	0.748
Mixed Fruit 7	0.53 ± 0.15	0.54 ± 0.13	0.24	0.628
Mixed Fruit 8	0.52 ± 0.25	0.59 ± 0.28	2.56	0.112
Relatedness	0.42 ± 0.25	0.46 ± 0.29	1.28	0.260

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Table 2. Mean (± standard deviation (SD)) ratings between scale types for all sample-question combinations combined across cognitive groups based on two-way ANOVA (N=130 for scale type). Bold lettering and numbering indicate a significant difference between cognitive groups when *P* < 0.05.

Question*	Category (Mean ± SD)	Line (Mean ± SD)	Test statistic (F)	*P*-value
Orange Water 1	0.55 ± 0.22	0.51 ± 0.24	2.98	0.087
Orange Water 2	0.28 ± 0.19	0.32 ± 0.21	3.83	0.053
Orange Water 3	**0.52 ± 0.24**	**0.46 ± 0.27**	**7.86**	**0.006**
Orange Water 4	0.29 ± 0.19	0.30 ± 0.21	1.22	0.272
Orange Water 5	0.28 ± 0.18	0.29 ± 0.18	0.09	0.769
Orange Water 6	0.36 ± 0.20	0.35 ± 0.22	0.35	0.554
Orange Water 7	0.44 ± 0.19	0.43 ± 0.20	0.45	0.502
Orange Water 8	0.49 ± 0.25	0.44 ± 0.27	3.08	0.081
Mixed Fruit Water 1	0.44 ± 0.28	0.340 ± 0.24	3.85	0.052
Mixed Fruit Water 2	0.43 ± 0.24	0.45 ± 0.25	1.28	0.261
Mixed Fruit Water 3	**0.40 ± 0.26**	**0.34 ± 0.24**	**10.34**	**0.002**
Mixed Fruit Water 4	0.35 ± 0.25	0.34 ± 0.25	0.13	0.720
Mixed Fruit Water 5	0.33 ± 0.22	0.31 ± 0.21	2.04	0.156
Mixed Fruit Water 6	0.40 ± 0.22	0.37 ± 0.22	2.01	0.158
Mixed Fruit Water 7	0.51 ± 0.21	0.49 ± 0.23	1.32	0.253
Mixed Fruit Water 8	0.38 ± 0.28	0.34 ± 0.26	3.75	0.055
Pineapple 1	0.76 ± 0.20	0.73 ± 0.21	2.00	0.160
Pineapple 2	0.45 ± 0.13	0.47 ± 0.12	2.68	0.104
Pineapple 3	0.75 ± 0.22	0.72 ± 0.22	2.10	0.150
Pineapple 4	**0.44 ± 0.13**	**0.47 ± 0.10**	**5.45**	**0.021**
Pineapple 5	**0.44 ± 0.13**	**0.47 ± 0.10**	**4.65**	**0.033**
Pineapple 6	0.48 ± 0.11	0.47 ± 0.11	0.27	0.607
Pineapple 7	**0.49 ± 0.11**	**0.47 ± 0.11**	**4.26**	**0.041**
Pineapple 8	0.71 ± 0.25	0.72 ± 0.21	0.11	0.736
Mixed Fruit 1	**0.62 ± 0.25**	**0.55 ± 0.26**	**11.38**	**0.001**
Mixed Fruit 2	0.50 ± 0.15	0.49 ± 0.17	0.08	0.777
Mixed Fruit 3	**0.71 ± 0.22**	**0.63 ± 0.25**	**10.50**	**0.002**
Mixed Fruit 4	0.44 ± 0.13	0.43 ± 0.14	0.16	0.693
Mixed Fruit 5	0.42 ± 0.13	0.44 ± 0.12	1.10	0.296
Mixed Fruit 6	0.55 ± 0.13	0.54 ± 0.16	1.09	0.298
Mixed Fruit 7	0.54 ± 0.13	0.53 ± 0.15	0.62	0.433
Mixed Fruit 8	0.56 ± 0.27	0.55 ± 0.27	0.01	0.936
Relatedness	0.44 ± 0.27	0.45 ± 0.27	0.09	0.763

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Table 3. Variance (standard deviation (SD)) comparisons between analytic and holistic cognitive style groups, with data combined across category and line scale data for a sample size of N=130 for each cognitive group. Differences determined through Levene's test for equal variances and bold font indicates a significant difference between cognitive groups when *P* < 0.05.

Question*	Analytic (SD)	Holistic (SD)	Test statistic (F)	*P*-value
Orange Water 1	0.22	0.24	1.02	0.313
Orange Water 2	0.19	0.21	2.53	0.113
Orange Water 3	0.23	0.27	1.04	0.310
Orange Water 4	0.18	0.21	3.81	0.052
Orange Water 5	0.17	0.19	0.96	0.328
Orange Water 6	**0.20**	**0.21**	**4.03**	**0.046**
Orange Water 7	**0.17**	**0.21**	**10.70**	**0.001**
Orange Water 8	0.26	0.26	< 0.01	0.976
Mixed Fruit Water 1	0.26	0.26	0.23	0.633
Mixed Fruit Water 2	0.25	0.25	0.17	0.684
Mixed Fruit Water 3	0.25	0.25	0.01	0.931
Mixed Fruit Water 4	0.26	0.24	0.94	0.332
Mixed Fruit Water 5	0.22	0.22	0.08	0.783
Mixed Fruit Water 6	0.22	0.22	0.34	0.559
Mixed Fruit Water 7	0.21	0.23	0.64	0.423
Mixed Fruit Water 8	0.26	0.27	0.15	0.698
Pineapple 1	0.19	0.22	3.07	0.081
Pineapple 2	0.13	0.12	2.16	0.143
Pineapple 3	0.22	0.22	0.30	0.587
Pineapple 4	0.12	0.10	1.91	0.168
Pineapple 5	0.12	0.11	0.84	0.360
Pineapple 6	0.11	0.11	0.33	0.565
Pineapple 7	0.11	0.12	< 0.01	0.951
Pineapple 8	0.23	0.22	0.72	0.398
Mixed Fruit 1	0.24	0.27	2.31	0.130
Mixed Fruit 2	0.16	0.16	0.74	0.390
Mixed Fruit 3	0.22	0.25	0.90	0.343
Mixed Fruit 4	0.12	0.15	3.22	0.074
Mixed Fruit 5	0.13	0.12	0.45	0.505
Mixed Fruit 6	0.15	0.14	2.03	0.156
Mixed Fruit 7	0.15	0.13	0.32	0.573
Mixed Fruit 8	**0.25**	**0.29**	**4.05**	**0.045**
Relatedness	**0.25**	**0.29**	**10.39**	**0.001**

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Table 4. Variance (standard deviation (SD)) comparisons between category and line scale data, with data combined across analytic and holistic cognitive style groups for a sample size of N=130 for each scale type. Differences determined through Levene's test for equal variances and bold font indicates a significant difference between scale types when *P* < 0.05.

Question*	Category (SD)	Line (SD)	Test statistic (F)	*P*-Value
Orange Water 1	0.22	0.24	0.90	0.343
Orange Water 2	0.19	0.21	1.98	0.161
Orange Water 3	0.24	0.27	2.49	0.116
Orange Water 4	0.19	0.21	2.48	0.117
Orange Water 5	0.18	0.18	0.19	0.659
Orange Water 6	0.20	0.22	2.42	0.121
Orange Water 7	0.19	0.20	0.04	0.845
Orange Water 8	0.25	0.27	1.77	0.185
Mixed Fruit Water 1	**0.28**	**0.24**	**8.50**	**0.004**
Mixed Fruit Water 2	0.24	0.25	0.15	0.701
Mixed Fruit Water 3	**0.26**	**0.24**	**4.03**	**0.046**
Mixed Fruit Water 4	0.25	0.25	0.01	0.915
Mixed Fruit Water 5	0.22	0.21	0.28	0.598
Mixed Fruit Water 6	0.22	0.22	1.23	0.269
Mixed Fruit Water 7	0.21	0.23	0.89	0.347
Mixed Fruit Water 8	0.28	0.26	2.08	0.150
Pineapple 1	0.20	0.21	1.06	0.304
Pineapple 2	**0.13**	**0.18**	**4.98**	**0.027**
Pineapple 3	0.22	0.22	1.10	0.295
Pineapple 4	**0.13**	**0.10**	**11.01**	**0.001**
Pineapple 5	**0.13**	**0.10**	**8.40**	**0.004**
Pineapple 6	0.11	0.11	0.40	0.530
Pineapple 7	0.11	0.11	0.70	0.403
Pineapple 8	0.25	0.21	3.64	0.057
Mixed Fruit 1	0.25	0.26	0.98	0.322
Mixed Fruit 2	0.15	0.17	1.19	0.277
Mixed Fruit 3	**0.22**	**0.25**	**4.17**	**0.042**
Mixed Fruit 4	0.13	0.14	0.09	0.768
Mixed Fruit 5	0.13	0.12	0.76	0.383
Mixed Fruit 6	0.13	0.16	0.54	0.465
Mixed Fruit 7	0.13	0.15	0.01	0.926
Mixed Fruit 8	0.27	0.27	0.04	0.847
Relatedness	0.27	0.27	1.27	0.260

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Table 5. Frequency counts of significant correlations between analytic and holistic cognitive style groups combined across scale type data for the different correlation categories. Global Pearson chi-square and Fisher's Exact Tests (FET) show results of significance tests between the total table and within individual correlation categories.

Correlation Category*	Analytic Count	Holistic Count	FET Test Statistic (z-value)	*P*-value
Fruit Water	28	29	0.51	0.609
Mixed Fruit	28	28	0.64	0.521
Orange Water	45	44	1.02	0.307
Pineapple	29	28	0.79	0.430
Other	119	161	-1.13	0.260
Relatedness	**0**	**14**	**-3.53**	**<0.001**
Total	**249**	**304**	**-3.26**	**0.001**
Global Chi-Square Value	**15.02**			
Global *P*-Value	**0.010**			

* Individual sample correlation category counts only include significant correlations for question responses within the same sample. The "Other" correlation category counts only include significant correlations between question response from different samples. The "Relatedness" correlation category counts are excluded from all other correlation categories and only include significant correlations between the sample relatedness question and all other questions. The "Total" correlation category is the sum of all other correlation categories.

Table 6. Frequency counts of significant correlations between category and line scale data combined across cognitive style groups for the different correlation categories. Global chi-square and Fisher's Exact Tests (FET) show results of significance tests between the total table and within individual correlation categories.

Correlation Category*	Category Count	Line Count	FET Test Statistic (z-value)	*P*-value
Fruit Water	42	47	-0.58	0.562
Mixed Fruit	29	28	0.00	1.000
Orange Water	32	25	0.75	0.452
Pineapple	30	26	0.34	0.737
Other	141	139	-0.01	0.991
Relatedness	6	8	-0.31	0.754
Total	271	265	0.31	0.760
Global Chi-Square Value	1.66			
Global *P*-Value	0.895			

* Individual sample correlation category counts only include significant correlations for question responses within the same sample. The "Other" correlation category counts only include significant correlations between question response from different samples. The "Relatedness" correlation category counts are excluded from all other correlation categories and only include significant correlations between the sample relatedness question and all other questions. The "Total" correlation category is the sum of all other correlation categories.

Table 7. Mean drop comparisons for all intensity questions between analytic and holistic cognitive style groups from penalty analyses conducted for each sample.*

	JAR Question	**Flavor Intensity**		**Orange/ Pineapple Flavor Intensity****		**Sweetness Intensity**		**Sourness Intensity**		**Bitterness Intensity**	
Sample	**Cognitive Group**	Too Weak	Too Strong	Too Weak	Too Strong	Too Weak	Too Strong	Too Weak	Too Strong	Too Weak	Too Strong
OW	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	2.00
MFW	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	1.48
P	Analytic	1.98	1.96	2.36	1.56	2.56	1.20	0.49	1.579	0.28	1.74
	Holistic	1.67	0.79	2.08	1.23	1.95	0.95	0.82	1.37	0.15	1.95
MF	Analytic	2.00	1.29	1.30	0.87	2.19	3.07	0.29	0.82	-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

* For samples, OW indicates the orange water sample, MFW indicates the mixed fruit water sample, P indicates the pineapple sample, and MF indicates the mixed fruit sample. Red mean drop values indicate a significant mean drop when $P < 0.05$, green values indicate a non-significant drop, and grey indicates not enough data was present to conduct a significance test.
** The intensity JAR question was orange flavor intensity for the orange water and mixed fruit water samples and pineapple flavor for the pineapple and mixed fruit samples.

Table 8. Comparison of responses from the penalty analysis categories of "Too Weak", "Just-About-Right", and "Too Strong" between analytic and holistic cognitive style groups across all samples. Comparisons conducted via Fisher's Exact Tests on only category scale data (N=65) for each cognitive style group for all intensity questions for each sample.*

Question		Flavor Intensity			Orange/ Pineapple Flavor Intensity**			Sweetness Intensity			Sourness Intensity			Bitterness Intensity		
Response Category		Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong
OW	A	50	14	1	55	7	3	46	17	2	36	25	4	19	38	8
	H	48	13	4	49	12	4	48	17	0	34	28	3	18	38	9
	z	0.20	0.00	-0.92	1.10	-1.00	0.00	-0.20	0.00	0.72	0.18	-0.36	0.00	0.00	0.00	0.00
	P	0.84	1.00	0.36	0.27	0.32	1.00	0.84	1.00	0.47	0.86	0.72	1.00	1.00	1.00	1.00
MFW	A	33	12	20	42	10	13	41	18	6	36	21	8	15	32	18
	H	34	18	13	43	10	12	37	21	7	27	32	6	16	33	16
	z	0.00	-1.05	1.22	0.00	0.00	0.00	0.54	-0.38	0.00	1.42	-1.81	0.28	0.00	0.00	0.20
	P	1.00	0.30	0.22	1.00	1.00	1.00	0.59	0.70	1.00	0.16	0.07	0.78	1.00	1.00	0.84
P	A	**30**	**28**	7	**31**	**28**	6	25	35	5	19	39	7	12	43	10
	H	**17**	**43**	5	**19**	**42**	4	21	42	2	13	42	10	8	50	7
	z	**2.24**	**-2.54**	0.30	**2.02**	**-2.34**	0.33	0.55	-1.08	0.78	1.02	-0.36	-0.52	0.73	-1.17	0.52
	P	**0.03**	**0.01**	0.76	**0.04**	**0.02**	0.74	0.58	0.28	0.43	0.31	0.72	0.60	0.46	0.24	0.60
MF	A	22	26	17	28	30	7	36	24	5	10	29	26	7	37	21
	H	15	34	16	27	32	6	26	35	4	6	35	24	6	40	19
	z	1.17	-1.24	0.00	0.00	-0.18	0.00	1.60	-1.79	0.00	0.80	-0.88	0.18	0.00	-0.36	0.19
	P	0.24	0.21	1.00	1.00	0.86	1.00	0.11	0.07	1.00	0.42	0.38	0.86	1.00	0.72	0.85

* For samples, OW indicates the orange water sample, MFW indicates the mixed fruit water sample, P indicates the pineapple sample, and MF indicates the mixed fruit sample. "A" indicates frequency count for analytic group, "H" indicates frequency count for holistic group, "z" indicates the z-value test statistic from the Fisher's Exact Test, and "P" indicates the *P*-value from the Fisher's Exact Test.
** For the orange water and mixed fruit water samples, the question was orange flavor intensity, and for the pineapple and mixed fruit samples, the question was pineapple flavor intensity.

Table 9. Pearson correlation coefficients (*P*-value) and simple linear regression equations (F-value and P-value) between the pre- and post-AHS scores for the analytic cognitive style group (N=65), the holistic cognitive style group (N=65), and both cognitive style groups combined (N=130).

Analytic Cognitive Style Group	**Pearson Correlations**	Pre-AHS Score	Post-AHS Score
	Pre-AHS Score	1.00 (<0.001)	0.46 (<0.001)
	Post-AHS Score	0.46 (<0.001)	1.00 (<0.001)
	Simple linear regression		
	Post-AHS score = 41.89 + 0.61*Pre-AHS score (F = 17.33, *P* < 0.001)		
Holistic Cognitive Style Group	**Pearson Correlations**	Pre-AHS Score	Post-AHS Score
	Pre-AHS Score	1.00 (<0.001)	0.59 (<0.001)
	Post-AHS Score	0.59 (<0.001)	1.00 (<0.001)
	Simple linear regression		
	Post-AHS score = 11.40 + 0.87*Pre-AHS score (F = 33.94, *P* < 0.001)		
Combined Cognitive Style Groups	**Pearson Correlations**	Pre-AHS Score	Post-AHS Score
	Pre-AHS Score	1.00 (<0.001)	0.80 (<0.001)
	Post-AHS Score	0.80 (<0.001)	1.00 (<0.001)
	Simple linear regression		
	Post-AHS score = 25.51 + 0.77*Pre-AHS score (F = 214.10, P < 0.001)		

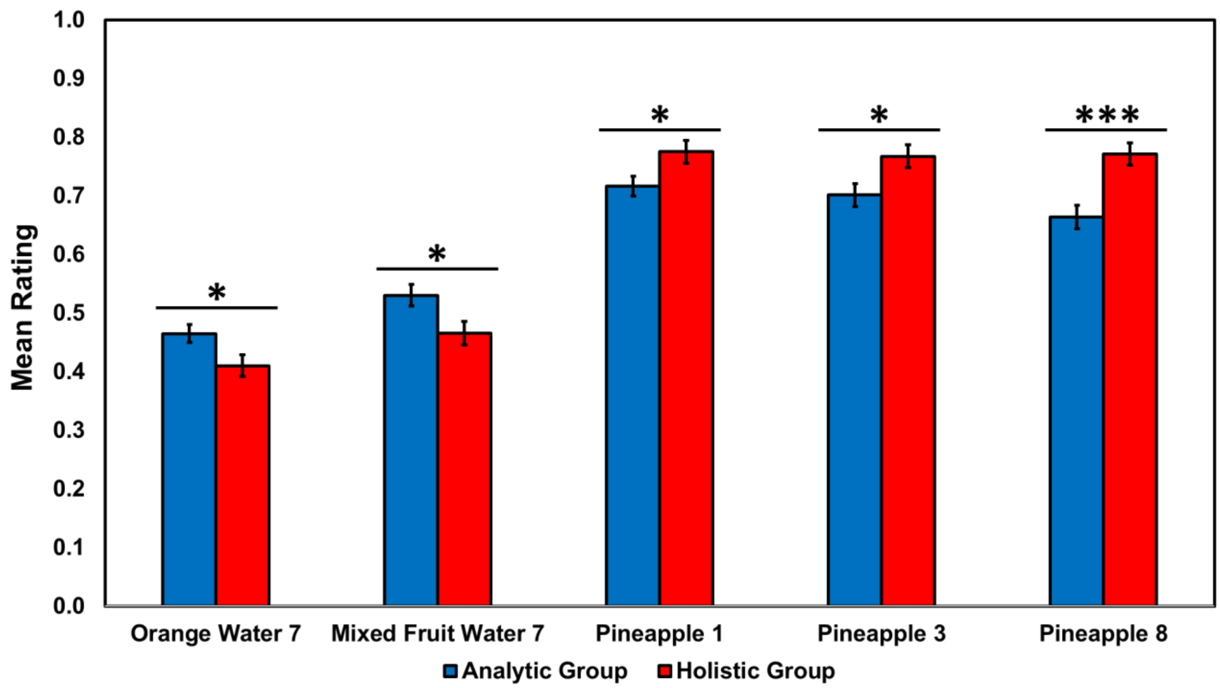

Figure 1. Mean comparisons for between analytic and holistic cognitive groups for sample-question combinations shown to be significantly different through ANOVA results. Individual bars and error bars represent means and standard errors of the means (SEM), respectively. * and * represent a significant difference between the two cognitive style groups at *P* < 0.05 and *P* < 0.001, respectively. Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 3 = Orange/Pineapple Flavor Liking, 7 = Bitterness Intensity, and 8 = Overall Liking**

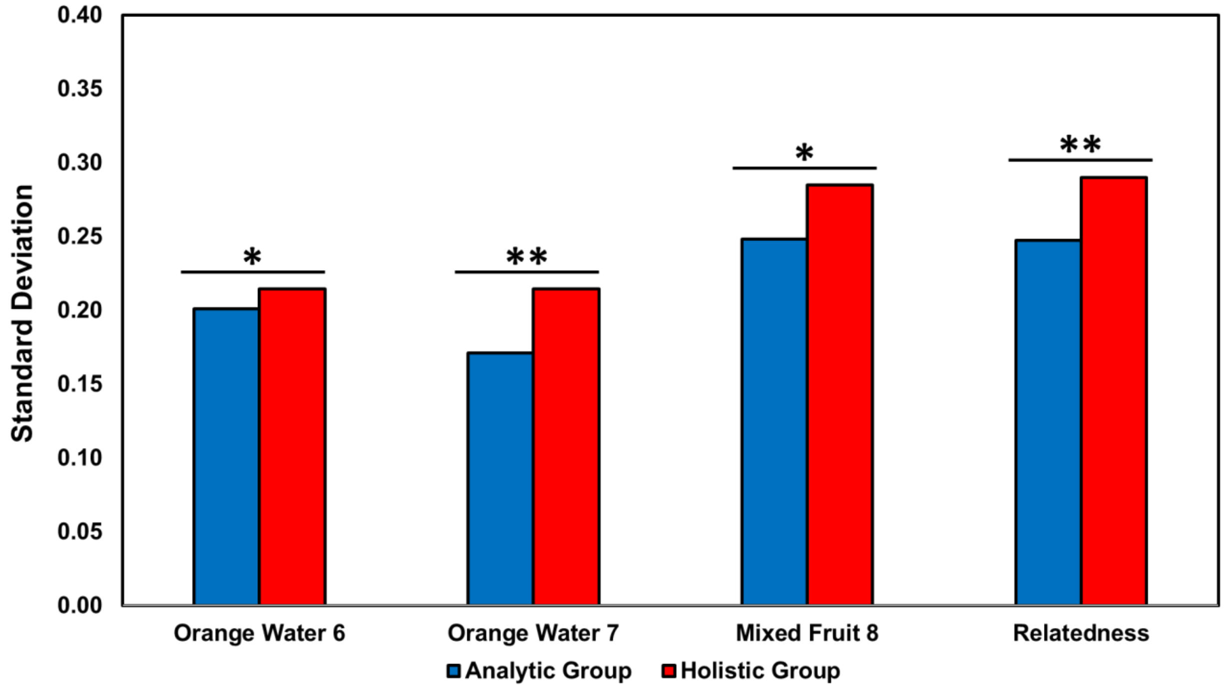

Figure 2. Levene's test comparisons for equal variance of sample-question combinations shown to be significantly different between analytic and holistic cognitive groups. Individual bars and error bars represent the standard deviations. * and ** represent a significant difference between the two cognitive style groups at *P* < 0.05 and *P* < 0.01, respectively. Numbering for questions indicate the following questions for each sample-question combination: 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking, and Relatedness = Sample Relatedness

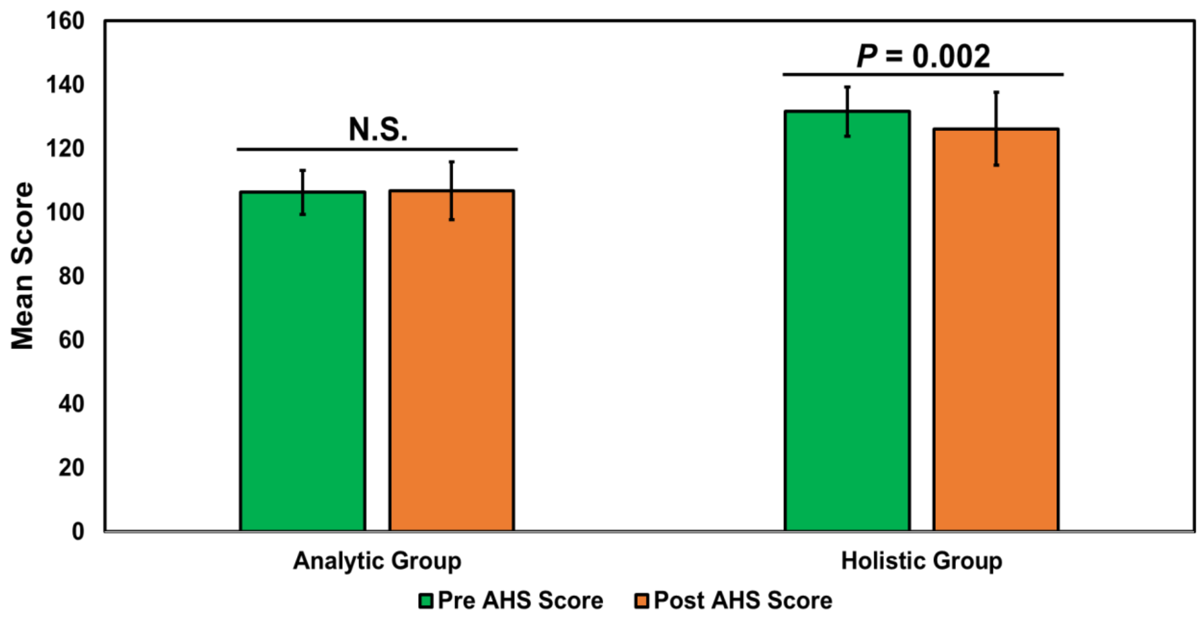

Figure 3. Mean comparisons between the two cognitive style groups: analytic and holistic, with respect to pre- and post-AHS scores. Individual bars and error bars represent means and standard deviations, respectively. N.S. indicates no significance, with significance testing determined via Student's t-tests when $P < 0.05$

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CHAPTER 5

DEVELOPMENT AND VALIDATION OF A FOOD-RELATED ANALYSIS-HOLISM SCALE

Abstract

Recent research has indicated analytic-holistic cognitive style differences of consumers can significantly impact food perceptions, opinions, and behaviors. Interestingly, this research has also offered evidence that the sole measurement tool to assess analytic-holistic tendencies, being the Analysis-Holism Scale (AHS) may not optimized for food- and sensory-related research scenarios. Due to these notions, the first two studies here employed the use of 465 and 487 participants, respectively, to develop, refine, and finalize a food-related Analysis-Holism Scale using exploratory factor analyses, confirmatory factor analyses, and prior analytic-holistic and scale development research. Through these studies and their associated analyses, a 15-question food-related AHS (F-AHS) was developed, with the AH constructs spread across the three food experience categories of shopping, preparing, and consuming. Study 3 offered validation of the newly developed F-AHS by replicating the procedures and analyses from Chapter 4 while using the F-AHS instead of the AHS to segment participants (N = 130). The results of Study 3 provided consistent evidence that the F-AHS better separated participants into analytic and holistic groups than the AHS through larger analytic-holistic differences that more closely aligned with prior analytic-holistic research and more consistent participant score results. Collectively, these three studies show that the F-AHS is capable of separating consumers into analytic and holistic cognitive style groups and better suited in food and sensory applications than the AHS. Through future studies, the F-AHS can undergo additional validations to ensure its applicability across the wide range of research opportunities, while continually expanding the understanding of how analytic-holistic consumer differences can impact consumer research.
Keywords: Cognitive style, Analytic, Holistic, Sensory perception, Scale development, Scale validation

1. Introduction

Analytic and holistic consumers have been shown to have contrasting cognitive processes in response to stimuli, and these findings have been replicated between cultures, within cultures, and specifically within food-related scenarios (Beekman & Seo, 2021, 2022; Li et al., 2018). These differences in cognitive processes impact how individuals perceive food stimuli and situational information, process information, to then form their respective opinions and perception and make decisions. Crucial to separating consumers based on their analytic and holistic tendencies is a tool to measure their cognitive style. The Analysis-Holism Scale (AHS) was developed to fill this research gap and provide psychological researchers with a measurement tool to determine an individual's analytic-holistic (AH) tendencies (Choi et al., 2007). Validation studies of the AHS have proven it to effectively measure AH cognitive styles (CS) of individuals, while remaining more encompassing and independent than more niche cognitive measures (Koo et al., 2018; Lechuga et al., 2011). However, as more applied fields, such as food and sensory science, have begun to utilize this cognitive measurement tool, the general nature of the AHS can be seen as a limitation. In addition, researchers have mentioned some potential shortcomings with using a general scale, such as how individual cognitive styles may fluctuate depending on the specific application or situation (Lux, et al., 2021; Miyamoto, 2013). Specifically, Lux (2017) detailed how when looking at a specific concept (i.e., authentic leadership) the AHS did not perform effectively at separating individuals, while Hildebrand et al. (2019) called for more strategies to effectively measure the impact of AH cognition on food perception and behavior. In addition, the results from Beekman and Seo (2022) and Chapter 4 indicate food and sensory evaluation tasks may further induce different AH tendencies than the AHS was developed to measure.

Therefore, a need exists for a food-related analytic-holistic cognitive style scale to measure consumer CS with respect to food-specific situations. As the need to account for AH CS continues to grow in sensory and consumer sciences, so does the need for an accurate cognitive style measurement tool for such research applications. When developing this scale, it is needed to encompass the main food experience areas of food shopping, preparing, and consuming detailed by Beekman and Seo (2021) where AH differences have been seen between consumers, while still incorporating the backbone of the AHS that is built on the four main AH constructs of causality, locus of attention, perception of change, and attitude toward contradiction (Choi et al., 2007). However, it is, arguably, equally important for the scale to be simple for both researchers and participants, specifically through minimizing its length to produce higher-quality data and measure the desired constructs through greater participant engagement (Ackerman & Kanfer, 2009; Bangcuyo et al., 2015; Hannum & Simmons, 2020). In addition, as the new food-related AHS (F-AHS) is being developed, it is also important to provide initial validation.

One main area of the AHS being trusted is its large body of supporting literature offering further validation of its abilities, with an especially present growing research area of analytic-holistic cross-cultural comparisons (Gupta et al., 2021; Koo et al., 2018; Lonner, 2018). Previous literature also details the need for scale validation to ensure it is not only applicable to its developmental environment through internal consistency, but also valid across various contexts, and independent from individual response biases, especially with the wide variation within human behavior (Hannum & Simons, 2020; Uggioni & Salay, 2012). Thus, the current paper aims to not only develop an F-AHS for use of accurately segmenting the AH tendencies of consumers in food scenarios, but also providing initial validation of the F-AHS by comparing it against prior AHS findings. Based on these goals, the first main objective is to develop the F-

AHS that incorporates both the food experience categories from recent food-related AH research and the foundational AH constructs. Within this first objective, the individual food categories (e.g., shopping) may be considered as viable subscale options when developing the F-AHS to provide researchers with more specific, concise options for more niche needs. The second main objective is to validate the newly developed F-AHS through employing it within a sensory evaluation study. To validate the F-AHS against the AHS, Chapter 4 will be replicated utilizing the F-AHS, with the hypothesis being that the F-AHS will better separate consumer participants than the AHS through greater responses differences that match with prior literature expectations being seen with the F-AHS. Through the F-AHS development and validation, it is expected that a well-fitting model can be developed to better assess AH tendencies within food scenarios. This greater performance of the F-AHS would help ensure researchers across the food, sensory, and consumer science fields can have confidence in applying the AH theory to their research through accurate CS group segmentation. The first two studies within this paper will address the first objective of scale development and the third study will address the second main objective of scale validation.

2. Study 1: Preliminary scale development and exploratory factor analyses

The goal for Study 1 was to leverage prior research from Beekman & Seo (2021) that involve qualitative focus group findings detailing AH differences across food shopping, preparing, and consuming categories into the four main AH constructs outlined by Choi et al. (2007) in the AHS developmental framework. Building on this research through a preliminary study allowed a potential food-related AH question pool to be constructed across the food categories and AH constructs, with consumer participants providing responses to the proposed question list. Through exploratory factor analyses paired with scale development indices, an initial F-AHS was developed to be employed within further scale refinement research (Study 2).

2.1. Materials and methods

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

2.1.1. Participants

For this study, a total of 465 participants fully completed the procedure and provided responses used in data analysis. Participants were recruited from the Northwest Arkansas region area through the University of Arkansas Sensory Science Center consumer database. The average age was (mean ± standard deviation) was 41.52 ± 14.82 years. The participants included 111 males and 354 females.

2.1.2. Pilot testing, question development, and procedure

Prior to testing with consumer participants preliminary pilot testing was conducted internally. Through a literature review of analytic-holistic theory and prior food-related research employing the AHS (Beekman and Seo, 2021; 2022), a potential list of 65 questions was developed as a pool that could be included within the finalized food-related AHS. It was critical to start broadly with a wide variety of potential questions to include within the final questionnaire due to prior scale development research warning against starting scale development too narrowly by limiting potential questions in early stages of development (Costello & Osborn, 2005; Schmitt, 2011). Questions were written to be applicable across the various four main constructs of the AHS (Choi et al., 2007), along with the three main areas of the food experience (i.e., shopping, preparing, and consuming) outlined by Beekman and Seo (2021). Through preliminary testing of those knowledgeable with the concepts surrounding a food-related AHS in conjunction with individuals of a lay audience (N = 27), the number of questions were winnowed based on scale development guidelines of participant understanding and logical connections to prior research, while still maintaining a large enough question list for use within scale development data analysis (Dennis et al., 2019). Questions were also revised based on expert and consumer feedback ensure they are approximately at a fifth to seventh grade reading level to help ensure understanding by participants from the general population (Hadden et al., 2017). The question list, after pilot testing and feedback was narrowed down to a total of 38 questions across the analytic-holistic and food experience constructs (Table 1). All questions were developed to follow the same structure as the original AHS, with question scales consisting of seven category labels from Strongly Disagree (1) to Strongly Agree (7). This question list was then utilized employed for Study 1 in which all participants (N = 465) responded to all questions. However, the instructions provided to participants were modified to include the instructions outlined below (Table 2). Upon receiving the instructions, all participants were then instructed to begin answering the food-related AHS. Once all questions were answered, participants were finished with this study. Individuals participating in the pilot testing were excluded from future rounds of F-AHS development, and participants from Study 1 were excluded from participating in Study 2. All data was collected through Compusense Cloud ® (Compusense Inc., Guelph, ON, Canada). All participants completed the survey remotely at their own convenience.

2.1.3. Data analyses and preliminary food-related analysis-holism scale development

Following the completion of the study, all participant data (N = 465) were quantitatively coded following the same methods outlined by Choi et al. (2007), which included properly reverse coding question data when applicable (Table 1). Following the coding process, exploratory factor analyses (EFA) were conducted using a maximum likelihood factoring method with quartimin rotation methods. Due to the exploratory nature of this research of combing the AH field with food experience, paired with the prior knowledge of the potential factor make-up of the questionnaire (Beekman & Seo, 2021; Choi et al., 2007), a series of potential models were tested. The criteria for determining assessing the model fit of questions were based off the following criteria: Item-total correlations < 0.30, not loading > 0.30 on any factor, cross loadings (> 0.30) on multiple factors, question redundancy, question being easily able to be misinterpreted by consumers, if the question did not affect reliability when excluded, and logical inclusion of the question based on prior research (DeVellis, 2017; Hannum & Simons, 2020). In addition, due to testing multiple EFA models consisting of different construct connections and through the potential removal of questions, the following model fit indices were assessed in addition to the individual question fit indices described above to compare across different EFA models. The model fit indices employed within these analyses are as follows: (1) logical interpretation of factors, (2) scree plot and accounted for variance, (3) chi-square significance testing for number of factors, (4) relatively lower AIC and BIC when comparing models, (5) Tucker-Lewis indexes greater than 0.90 or relatively higher when comparing models, and (6) RMSEA values less than 0.07 or relatively lower when comparing models (Cabrera-Nguyen, 2010; Cattell, 1966; Fabrigar et al., 1999; Schmitt, 2011).

The first EFA model fit strategy was to assume 12 factors and combine all questions into a single EFA due to the four known AH constructs being distributed across the three food experience categories of shopping for, preparing, and consuming food (Beekman & Seo, 2021, Choi et al., 2007). This step involved conducting one factor analysis for all potential questions. Based on this analysis, grouping all questions across all AH construct areas and food experience categories through a combined 12-factor model did not make logical sense, as there was very poor separation of both construct and food experience categories. In addition, the poor model fit here also suggested the potential to conduct EFAs within each food experience and AH constructs separately. This trend was confirmed when separating the potential questions for the survey into their associated AH construct and then conducting an EFA within each of the AH constructs, for a total of four separate EFAs. Due to the three food experience categories being represented within the four AH constructs, the factor structure for these analyses was assumed to be a three-factor model. If the three food categories are separate from one another, then they should separate onto their own factor within each of the constructs. This result was consistently seen within these analyses, which supports the strategy of conducting separate EFAs for each of the three food experience category constructs, for a total of three EFA models for the shopping, preparing, and consuming food experience category constructs, respectively.

Separating the EFAs for the three food experience categories was found to result in better model fits, along with more logical separation of AH constructs within the models. Based on the EFA conducted on the shopping food experience category, four questions were removed, resulting in eight questions spread equally across the four AH constructs remaining. Within the preparing food experience category, seven questions were removed. In addition, it was found that consumer participants had trouble understanding the analytic-holistic construct of "attitude toward contradiction" in terms of the food preparation category. Because of this aspect, that construct was decided to be removed from further testing within the food preparation category, and one of the questions initially from the "attitude toward contradiction" construct was moved to the "perception of change" construct within the preparation food category, as it was found to fit better and make more logical sense within the model in that position. Within the food preparation category, the majority of the questions from the "locus of attention" construct were also found to be difficult to understand by consumer participants, and they were subsequently removed from the model. To account for the removal of three of the four questions of the "locus of attention" construct within the food preparation category, two new and simpler questions were created and added here. As there were not tested within the first round of EFAs, they will first be checked for the model fitting in the next round of analyses (Study 2) prior to confirming the questionnaire factor structure. In the consumption food category, a total of five questions were removed following the EFA, which resulted in an even distribution of the remaining eight questions across the four AH constructs in the consumption food experience category. Through the combined removal of questions across the three food experience category EFAs and the addition of two questions within the food preparation category, a total of 24 questions remained (Table 3) for use in Study 2. All data were analyzed and EFAs conducted using JMP Pro software (version 16.0, SAS Institute, Inc., Cary, NC) and significance was determined using an α-value of 0.05.

2.2. Discussion

Through the exploratory factor analyses, an initial, 24-question F-AHS questionnaire was developed. The questions were split evenly across the three food experience categories, with the four AH constructs equally represented across the food categories, with instructions included to ensure participants were focused on food-related scenarios. Situational priming has been found to be an effective tool when aiming for participants to respond to a stimuli or task in a certain frame of mind, with it necessary here, as the F-AHS is to be employed specifically in food-related scenarios (Rivers & Sherman, 2019). From the findings, the scale itself was found to be well understood by consumer participants. Some exceptions were seen, notably with questions based primarily off AHS question wording, such as questions 18 or 20 from Table 1 that were developed to mirror AHS questions through a food-related lens. However, through the EFAs, and as shown in Table 3, these questions were not found to fit well and be predicted to have been poorly conceptualized by the participants. As the AHS is meant to be a more general, all-encompassing cognitive scale, when applying some of the concepts to a more niche application, such as food and sensory research, it is predicted that such general concepts are not easily translatable. This is supported by psychological theories that detail general concepts can be understood relatively well by the general population, yet when asked to conceptualize general concepts into specific applications or examples, people can often struggle (MacKenzie, 2003).

Another interesting finding from Study 1 was that the individual food categories appear to be distinct from one another in how the AH constructs within each food category are conceptualized by participants. This outcome suggests not only that the food experience categories need to be analyzed through EFAs separate from one another, but also suggests the potential use of the food categories as individual subscales for specific food-related applications. From these findings, further scale refinement may result in some AH constructs applying more directly through easier comprehension across the food experience categories. Reducing the length of the F-AHS to 24 questions is promising; however, scale development research recommends shortening scale length as much as possible to ensure participant engagement is maintained, while also minimizing the impact on researcher time of employing the scale (Dillman et al., 2014). Further, Lux et al. (2021) discussed one of the potential pitfalls of the AHS is that some of the questions exhibit repetitive tendencies and minimizing any repetitiveness within the F-AHS offers a viable question-reduction strategy.

3. Study 2: Finalized scale development and confirmatory factor analyses

From Study 1, an initial, 24-question F-AHS was developed. Study 2 recruited a new sample population to further refine the scale by (1) testing the EFA fit indices with the two added questions from Study 1 and (2) providing an additional opportunity to identify poor fitting questions and further shorten the scale. Following the removal of any remaining poor-fitting questions, a 15-question AHS was developed and then underwent confirmatory factor analyses to confirm the best fitting model for the F-AHS, while also providing insight into the potential to use the individual food category subscales. Results indicate the finalized 15-question F-AHS has a satisfactory model fit, with the three food category subscales able to be employed individually, yet together, they are connected by an over-arching latent factor of food experience.

3.1. Materials and methods

3.1.1. Participants

For this study, a total of 487 participants fully completed the procedure and provided responses used in data analysis. Participants were recruited from the Northwest Arkansas region area through the University of Arkansas Sensory Science Center consumer database. The average age was (mean ± standard deviation) was 40.00 ± 14.98 years. The participants included 129 males and 358 females.

3.1.2. Procedure

All participant data was collected through Compusense Cloud ® (Compusense Inc., Guelph, ON, Canada) and all participants completed the survey remotely at their own convenience. Once beginning the study, participants were provided identical instructions as employed in Study 1 (Table 2). Following the instructions, the participants then answered the questions as shown in Table 3. No other changes to the Study 1 procedure were introduced here.

3.1.3. Data analyses

3.1.3.1. Exploratory factor analyses

Data were processed, coded, and first examined through an EFA, following identical methods outlined in Study 1, specifically employing the finalized strategy of separating the EFA model analyses into three separate models for the shopping, preparing, and consumer food experience categories. The EFAs here were conducted to check the fit of the two added questions following the first found of EFAs, along with verifying the model fit described in Study 1 of the separate food experience EFAs consisting of the AH constructs within each food experience category loading onto their own factor. In addition, the EFAs conducted here provided the opportunity to remove any questions still fitting poorly within the models. EFA model fit and question removal strategies were identical to Study 1. Based on the analyses and mentioned guidelines a total of nine additional questions were removed across the three food experience categories, resulting in a final 15-question food-related AHS questionnaire. During the question removal procedures, it was also found that an unequal balance and structure of AH constructs, along with an unequal number of questions, across the three food experience categories resulted in better fitting models. Furthermore, the "attitude toward contradiction" construct's associated questions were found to consistently exhibit poor fit across the food experience category models and were thus removed altogether from the food-related AHS. The removal of the "attitude toward contradiction" construct resulted in further improved models. Factor loadings and inter-item correlations were also included for each of the questions within their associated food experience categories. Inter-item correlations were calculated for each question with the combined score for each question corresponding EFA food experience category. In addition to the EFA procedures, Cronbach's alphas and Pearson correlations were calculated to assess item reliability and separation of constructs, respectively, for both the food experience constructs and the AH constructs separately following prior scale development research and guidelines (Choi et al., 2007; Hannum et al., 2020, Kim, 2016).

3.1.3.2 Confirmatory factor analyses

The finalized 15-question food-related AHS model then underwent analyses to confirm its factor structure using confirmatory factor analyses (CFAs). Based on prior literature detailing measurement tools should be unidimensional, it was expected that there is one over-arching construct, or latent factor, within the model that connects the food experience and analytic-holistic latent factors (e.g., shopping and causality) across the entire questionnaire (Boateng et al., 2018; Segars, 1997). This over-arching construct here was interpreted to be the food experience, as the AH and food experience constructs are each representing a piece of the consumer food experience (Beekman & Seo, 2021). Consequently, all food-related AHS questions were loaded onto both their associated analytic-holistic latent factor and their associated food experience category latent factor when building the CFA model. All analytic-holistic and food experience category latent factors were then loaded onto the over-arching latent factor of food experience. Following prior guidelines for CFA and SEM scale development model methodologies, a series of model fit indices and strategies were utilized. Due to the variety of bodies of literature contributing to this scale development, such as cultural psychology, survey development, statistical modelling, and food, sensory and consumer sciences, a logical interpretation of the model was consistently considered when developing the final model. Other model fit indices included (1) maximizing the comparative fit index (CFI), with it preferably being greater than 0.90, (2) minimizing the Akaike information criterion (AIC) and Bayesian information criterion (BIC) values between the different model options due to the relative nature of the AIC and BIC indices, (3) minimizing the root mean squared error of approximation (RMSEA) with it being preferably below 0.10, and (4) minimizing the chi-square divided by degrees of freedom (DF) value (Cangur & Irken, 2015; Chen et al., 2008; Hannum & Simons, 2020; Hu & Bentler, 1999). All models were fit using a maximum likelihood estimation method that allowed for a maximum of 5000 iterations to reach model convergence. Also, for all models, the complete Study 2 participant data was used, producing a constant sample size of 487 for all models.

In addition, as the analytic-holistic constructs are not mutually exclusive (Na et al., 2010) and the food experience categories are also related to one another across the food experience (Beekman & Seo, 2021), the model also was predicted to include covariances between the each of the analytic-holistic and food experience constructs, respectively. One could argue that it is not necessary to include the covariances between the respective analytic-holistic and food experience constructs, nor is it necessary to include a secondary, over-arching latent factor of "food experience". Consequently, these alternate models were tested and compared against predicted model that includes the construct covariances and the "food experience" secondary latent factor. These model comparisons were conducted through chi-square tests of significant difference between the models. As the EFAs were conducted individually within the food experience categories, the CFA procedure described above was also replicated within each of the food experience categories, with the only exception being there is no secondary latent factor of food experience within the individual food experience category models. These analyses also pair well with one of the proposed future applications of food-related AHS being the employment of the scale in more specific and applied food settings, such as chefs cooking food or parents shopping for food. In these scenarios, it may not make sense to have participants answer questions about eating behaviors when the study is focused solely on shopping behaviors, for example. Thus, utilizing the most applicable food experience subscale would offer greater benefit to future researchers, making it important to investigate the model fit indices of the food experience subscales in addition to the full food-related AHS. All CFAs, model-building, and model comparisons were conducted within the structural equation modelling (SEM) platform of JMP (version 16.0, SAS, Cary, North Carolina) and significance was determined using an α-value of 0.05.

3.2. Results

3.2.1. Exploratory factor analyses

The EFA results for the finalized 15-question food-related AHS are provided in Table 4 based on the series of EFAs and question removal procedures resulting in a removal of nine total questions and a complete removal of the attitude toward contradiction AH construct. The shopping food experience category includes three questions contributing to the “causality” AH construct and three questions loading onto the “perception of change” AH construct, for a total of six questions. The preparing food experience category includes three questions loading onto the “causality” AH construct and two questions loading onto the “locus of change” AH construct, for a total of five questions. The consuming food experience category includes two questions loading onto the “causality” AH construct and two questions loading onto the “perception of change” AH construct, for a total of four questions. All questions display a factor loading of greater than 0.30 and all but one question (at 0.49) display an inter-item correlation greater than 0.50 within their respective food experience category subscales. In addition, the finalized two-factor EFA models for the shopping, preparing, and consuming food experience categories account for 52%, 61%, and 70% of the respective variances of their associated models.

In Table 5 the Cronbach alpha and Pearson correlations are visualized first between the food experience categories and second between the AH constructs. Within the food experience category analyses, the shopping, preparing, and consuming categories have Cronbach alpha values of 0.51, 0.63, and 0.42, respectively. For all data combined, the Cronbach alpha value is 0.49. There is a non-significant correlation between the shopping and preparing categories ($r = -0.07$, $P = 0.14$), and a weak, yet significant, correlation between the preparing and consuming categories ($r = 0.13$, $P = 0.004$). The shopping and consuming category have a moderate, significant correlation ($r = 0.29$, $P < 0.001$), and the shopping, preparing and consuming food experience categories all have strong, significant correlations with the combined data ($r = 0.73$, $P < 0.001$, $r = 0.52$, $P < 0.001$, and $r = 0.66$, $P < 0.001$, respectively). Within the AH construct comparisons, the causality, perception of change, and locus of attention constructs have Cronbach alpha values of 0.61, 0.56, and 0.42, respectively. Non-significant correlations exist between the causality and perception of change constructs (r = 0.008, $P = 0.86$) and between the perception of change and locus of attention constructs (r = 0.08, $P = 0.06$). A significant correlation exists between the causality and locus of attention constructs (r = 0.65, $P < 0.001$). Significant correlations exist between the causality (r = 0.78, $P < 0.001$), perception of change (r = 0.59, $P < 0.001$), and locus of attention (r = 0.55, $P < 0.001$) constructs and the combined data.

3.2.2. Confirmatory factor analyses

Following the EFAs, the CFAs were conducted within the SEM platform in JMP. The CFA conducted on the full food-related AHS (i.e., all 15 questions is visualized in Figure 1. The full, finalized model had model fit indices of Chi-square/ DF = 2.32, AIC = 25216, BIC = 25493, CFI = 0.92, and RMSEA = 0.05 (Table 6). As Table 6 also denotes, the finalized model was the best fitting model compared to the tested alternative models that did not have the covariances between latent factors, did not have the over-arching food experience latent factor, or did not have the latent factor covariances nor the secondary food experience latent factor. In addition, the relative better fit of the full, finalized model was supported by the chi-square significant difference test between the models indicating a significantly better fit compared to the alternatives ($P < 0.001$). The visualization of the full, food-related AHS model can be seen in Figure 1, which shows the finalized model of the full scale having 15-questions, loading onto three AH latent factors and three food-experience latent factors, all AH and food experience latent factor loading onto a secondary, over-arching latent factor of food experience, and covariances existing within the model between the three AH and food experience latent factors, respectively.

The same CFA procedures and analyses were followed and conducted for the individual food experience category subscales of shopping, preparing, and consuming separately to allow for insight into the potential usage of these subscales in niche food-related situations. Within these models, each question within each of the food experience category subscales loaded onto its respective AH construct. Similar to the full, 15-question food-related AHS, the best fitting models, relative to the tested alternatives, involved covariances between the two AH constructs within each food experience category subscale. As these are the individual subscale, it was also found that including a secondary latent factor of food experience decreased model fit, suggesting the over-arching food experience factor was not appropriate within these separate subscales. Across all three subscales of the food-related AHS, a two-factor model was confirmed, with covariances between the AH constructs in each subscale. For the shopping food category subscale, the model can be visualized in Figure 2, with the model fit indices of Chi-square/ DF = 4.15, AIC = 10582, BIC = 10660, CFI = 0.89, and RMSEA = 0.08. The full comparisons between the final model and other tested alternative that had no AH construct covariance, included a secondary food shopping experience latent factor, or had no AH construct covariance and included a secondary latent factor can be seen in Supplementary Table 1. For the preparing food category subscale, the model can be visualized in Figure 3, with the model fit indices of Chi-square/ DF = 7.67, AIC = 8593, BIC = 8659, CFI = 0.90, and RMSEA = 0.12. The full comparisons between the final model and other tested alternative that had no AH construct covariance, included a secondary food preparing experience latent factor, or had no AH construct covariance and included a secondary latent factor can be seen in Supplementary Table 2. For the consuming food category subscale, the model can be visualized in Figure 4, with the model fit indices of Chi-square/ DF = 3.20, AIC = 6277, BIC = 6331, CFI = 0.99, and RMSEA = 0.07.

The full comparisons between the final model and other tested alternative that had no AH construct covariance, included a secondary food consuming experience latent factor, or had no AH construct covariance and included a secondary latent factor can be seen in Supplementary Table 3. For the consuming subscale, some alternative models were not able to be assessed in whole or for a portion of their model fit indices due to a lack of degrees of freedom.

3.3. Discussion

Following the completion of Study 2, a finalized, 15-question F-AHS was developed. Interestingly, a better model fit was found through further eliminating poorly conceptualized questions, resulting in an uneven distribution of question numbers across the food categories and unequal representation of AH constructs within the F-AHS. The attitude toward contradiction did not fit well within the F-AHS, as the findings from Study 1 detailed how general consumers may have difficulty in conceptualizing AH constructs in food-specific situations. Due to this general nature of the AHS, the attitude toward contradiction may be less applicable in more niche, specific situations, such as the various food experience categories (Nisbett et al., 2001). For example, the idea of a contradiction may generally make sense to consumers; however, when they are imagining shopping for items, the idea of a contradiction or mental conflict may be too extreme for them to imagine when deciding between what food items to choose. The attitude toward contradiction may also be conceptualized as too extreme in the situations of food experiences for consumers. In prior literature, researchers have detailed that food generally elicits positive emotions, with only slight or minor negative emotions (Osdoba et al., 2015). Psychological research has discussed how conflict and contradiction are associated with a negative perception (Rispens & Demerouti, 2016). Thus, the attitude toward contradiction construct may be too strongly associated with negative emotions that consumers struggle in seeing it applicable with generally positive, food-related scenarios.

Through the removal of such poor-fitting questions and constructs, the model of the full F-AHS was found to fit well within common model fit guidelines (Table 6), with the best fitting model including covariances among the AH and food experience latent factors separately and all latent factors loading onto the over-arching latent factor of food experience (Figure 1). The covariances within the model are logical due to the trend of the individual AH or food experience constructs to be correlated with one another, yet the correlations were relatively weak with one another in some cases (Table 5). Finding the model to fit increasingly well with the inclusion of the secondary latent factor further supports that these individual AH constructs and food experience categories are still conceptually connected for the consumer within their overall perception of the food experience (Beekman & Seo, 2021). Even though the model fit was found to be satisfactory according to common indices, it is necessary to still address the Cronbach's alpha values, which were found to be consistently lower than expected. Choi et al. (2007) detailed the Cronbach's alpha of the AHS as 0.68-0.74, with the current F-AHS having a value of 0.49. However, when looking more closely at the individual sub-scales of the AHS reflecting the individual AH constructs, the Cronbach's alpha values ranged from 0.47-0.76, which encompasses the ranges of the Cronbach's alphas seen from the F-AHS. General guidelines often recommend a relatively higher Cronbach's alpha value than was seen for the F-AHS (Tavakol & Dennick, 2011). Comparatively, additional works have detailed how in situations that are measuring responses across a range of potential constructs, Cronbach's alpha scores can sometimes be lower than expected (UCLA: Statistical Consulting Group; Taber, 2018). These researchers also discuss how the Cronbach's alpha is only one tool to assess a scales usefulness, and, though important, should be considered in addition to the other forms of scale performance and model fit indices.

Collectively, Study 2 outcomes show a well-fit, finalized, 15-question F-AHS. In addition, the food category subscales offer promise to be employed within future, more specialized areas of food research, though the model fit indices are relatively lower than the full F-AHS. From this study, a validation of the newly developed F-AHS is necessary. As the main purpose of the F-AHS was to perform the identical function as the AHS yet exhibit superior abilities in food and sensory evaluation research, the F-AHS will then be compared against the AHS's performance for the sensory evaluation tasks from Chapter 4.

4. Study 3: Validation of the food-related analysis-holism scale

Through Studies 1 and 2, the F-AHS has gone through preliminary development and two rounds of further refinement to result in a finalized, 15-question scale. A crucial next step in any scale development methodology is validation. The expected outcome and aim behind developing the F-AHS was to have an analytic-holistic (AH) measurement tool that was specialized for food-related research for more accurate consumer segmentation. To accomplish this validation, Chapter 4 was replicated with the use of the F-AHS instead of the AHS. Through this method, it was found that the F-AHS (1) produced groups that had greater response differences than groups separated by the AHS across the difference analyses and (2) the results match closer to prior AH literature than those from Chapter 4 while producing more consistent participant response scores. Such findings bolster the claim that the F-AHS is a superior tool compared to the AHS when separating AH consumer groups in food and sensory science research.

4.1. Materials and methods

4.1.1. Participants

A total of 383 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). 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. In addition, participants also provided responses to the finalized, 15-question food-related analysis-holism scale (F-AHS) from Study 2 (Table 4, Supplementary Table 14) to assess their analytic-holistic tendencies in food-related situations. Only individuals with greater and less than one standard deviation above and below the mean AHS score were selected for the holistic and analytic cognitive groups, respectively (Beekman & Seo, 2021; Hildebrand et al., 2019). Through these recruitment and screening steps, a total of 65 analytic (42 females; mean age ± standard deviation [SD] = 44 ± 14 years) and 65 holistic (49 females; mean age ± standard deviation [SD] = 40 ± 14 years) participants were included in this study. No significant differences were found in age ($P = 0.11$) or gender ratio ($P = 0.18$) between the cognitive groups.

4.1.2. Samples, preparation, and procedure

The samples and preparation were identical to those details in Chapter 4. The procedure for the current study was also identical to the procedure from Chapter 4, with the exception that participants completed both the F-AHS and AHS after finishing their second session.

4.1.3. Data analyses

For all data analyses within the current data set, identical data processing and statistical analysis steps were conducted as were detailed and completed in Chapter 4, with the exception that the pre- and post-F-AHS scores were compared for the current study, as opposed to the pre- and post-AHS score comparisons done within Chapter 4. This study is included to show the F-AHS as a superior option for consumer segmentation within food-related sensory tests, in addition to offering validation of the F-AHS, with both objectives meant to support one another. Thus, to achieve these objectives, the results of this study will then be compared with the outcomes of Chapter 4 to assess the results of the identical study when either the AHS or F-AHS were used for CS group segmentation.

4.2. Results

4.2.1. Mean comparisons

The initial three-way ANOVA that checked for an interaction effect between the AH and scale type variables showed four instances of significant interaction effects between the variables in the current study. The "orange water sourness intensity" (F = 4.01, $P = 0.047$), "orange water overall liking" (F = 6.72, $P = 0.012$), "mixed fruit water overall liking" (F = 5.66, $P = 0.019$), and "mixed fruit flavor liking" (F = 6.40, P = 0.013) sample-question combinations all indicated a significant interaction effect between the AH and scale type variables. Table 7 further shows the respective break down of the different AH-scale type variable combinations. Minor trends in Table 7 indicate that (1) the holistic cognitive style (CS) group tended to have higher ratings than the analytic CS group and (2) that the holistic CS group tended to have higher line scale than category scale ratings, while the analytic CS had the opposite trend of higher category scale than line scale ratings. All other sample-question combinations resulted in non-significant ($P > 0.05$)

interaction effects and are therefore not discussed. Due to the significant interactions, the results of the analytic-holistic mean comparisons combined across scale types are further broken down within each scale type separately and the category and line scale mean comparisons combined across AH groups are also broken done with each AH group separately.

For the analytic-holistic CS group mean comparisons within the category scale data, the results show twelve sample-question combinations with significant differences ($P < 0.05$) between analytic and holistic group mean ratings (Supplementary Table 4). Of these twelve instances, eleven sample-question combinations show the holistic group having a higher hedonic score, a mean rating closer to the JAR rating, or a higher sample-relatedness rating than the analytic group. The remaining sample-question combination shows a near even split of the analytic rating above the JAR and the holistic rating below JAR. For the line scale data, this trend is also seen, with there being twenty sample-question combinations with significant differences ($P < 0.05$) between analytic and holistic group mean ratings (Supplementary Table 5). In all twenty instances, the holistic group has a higher hedonic score, a mean rating closer to the JAR rating, or a higher sample-relatedness rating than the analytic group. When combining the AH comparisons across the scale type data, there are nineteen sample-questions combinations showing a significant difference ($P < 0.05$) between CS groups (Supplementary Table 6). In all nineteen cases, the holistic group has a higher hedonic score, a mean rating closer to the JAR rating, or a higher sample-relatedness rating than the analytic group. As this trend is similar across both scale types, the results combined across scale types are visualized in Figure 5 that shows the sample-question combinations exhibiting significant differences between AH groups.

The mean comparisons between the scale types showed that for the comparisons within the analytic group (Supplementary Table 7), there were twelve instances of significant mean rating differences between the category and line scales, with eleven of these occurring for hedonic questions and one for a JAR intensity question. In all twelve cases, the category scale data resulted in a significantly higher ($P < 0.05$) mean rating or closer to JAR rating than the line scale data. For the scale comparisons within the holistic group, there were six instances of significant differences ($P < 0.05$) in mean ratings, spread across hedonic and JAR questions (Supplementary Table 8). In the four instances the category scale had higher ratings, the questions were all hedonic-related, while for the two instances that the line scale had higher ratings, the questions were JAR-related. The scale type comparisons combined across both AH groups display eleven sample-question combinations with significantly different ($P < 0.05$) mean ratings, with ten of these from hedonic questions and one from a JAR intensity question (Supplementary table 9). All eleven instances resulted in the category scale having a higher hedonic rating or closer to JAR rating compared to the line scale.

4.2.2. Variance comparisons

For the variance comparisons, the AH group comparisons were combined across the category and line scale data and the scale type comparisons were combined across analytic and holistic participant groups. The variance comparison results between the cognitive groups display fifteen sample-question combinations with significantly different ($P < 0.05$) standard deviations between the CS groups (Supplementary Table 10). In all fifteen cases, the analytic group had greater standard deviation values than the holistic group. Figure 6 visualizes these sample-question combinations where there were significant variation differences between the analytic and holistic groups. When comparing across the scale types, there were five instances of significant variance differences ($P < 0.05$), and in two cases the line scale data had greater standard deviation values and in three cases the category scale data had greater standard deviation values (Supplementary Table 11).

4.2.3. Response correlation comparisons

When comparing the correlations of responses, both the effect of cognitive style and scale type were considered. When looking at the differences in correlations between analytic and holistic CS groups combined across scale type data, a global chi-square analysis indicates no overall significant differences ($P > 0.05$) in the frequencies of correlations between the CS groups (Supplementary Table 12). When comparing between the different samples and response categories for correlated responses through Fisher's Exact Tests, the analytic and holistic groups displayed a significant difference in significant correlation frequencies for the "Other" category (z = -2.56, $P = 0.010$), with the holistic group having a greater number of significant correlations. For the comparisons between scale type data combined across CS groups, the global chi-square test indicates no overall significant differences ($P > 0.05$) in the frequencies of correlations between the scale types (Supplementary Table 13). When comparing between the different samples and response categories for correlated responses through Fisher's Exact Tests, the category and scale types displayed a significant difference in significant correlation frequencies for the "Other" category (z = 2.05, $P = 0.041$), with the category scale data exhibiting a greater number of significant response correlations.

4.2.4. Penalty analysis comparisons

Using only the category scale data for participants, penalty analyses were conducted by treating the overall liking question (Question 8) as the liking score and the flavor intensity (Question 2), orange/pineapple flavor intensity (Question 4), sweetness intensity (Question 5), sourness intensity (Question 6), and bitterness intensity (Question 7) as the just-about-right scores for each of the four samples separately. Table 8 shows the comparison of the mean drops for both the “too weak” and “too strong” response categories between the analytic and holistic groups for each of the four samples. Red, green, and grey colored values indicate significant, non-significant, and not calculated due to lack of data mean drop values, respectively, for each of the category-question-sample combinations. The analytic group tended to have more significant mean drops with higher magnitude of the mean drops compared to the holistic group for most of the comparisons. However, this trend was slightly reversed for the mixed fruit sample, where the mean drop results indicate the holistic group had a weak trend of more significant and larger penalties for the sweetness, sourness, and bitterness JAR intensity questions. To further compare the penalty analysis results between groups, the proportion of responses for “too weak”, “JAR”, and “too strong” were compared between CS groups for each question and sample combination (Table 9). Results show a trend of the holistic group having more JAR and less “too weak” or “too strong” responses compared to the analytic group. From the proportion comparisons of “Too Weak”, “JAR”, and “Too Strong”, there are eleven cases of significant differences ($P < 0.05$) in proportions between the CS groups, and in all cases the analytic group either has more “Too Weak/ Too Strong” responses or the holistic group has more “JAR” responses.

4.2.5. Pre and post food-related analysis-holism scale score comparisons

When comparing the pre- and post-F-AHS scores of participants, the mean scores combined across cognitive groups did not differ between pre- and post-F-AHS scores (t = 0.39, P = 0.70), indicating no significant differences between pre- and post-F-AHS scores combined across CS groups. This finding was also replicated within the analytic (t = 0.54, P = 0.59) and holistic (t = 0.47, P = 0.64) CS groups separately. Correlation analyses indicate that the pre- and post-AHS scores are significantly correlated (P < 0.001) with one another when the CS groups are combined and when the correlation analyses are conducted separately within each cognitive group (Table 10). Specifically, when fitting a linear model between the pre- and post-F-AHS variables for the holistic group, the resulting equation showed a coefficient of 0.85 of the pre-AHS score and an intercept of 11.77 when modelling for the post-AHS score. Comparatively, the resulting equation for the analytic group showed a coefficient of 0.90 of the pre-AHS score and an intercept of 6.55 when modelling for the post-AHS score. Combined across both CS groups, the results show a coefficient of 0.96 of the pre-AHS score and an intercept of 3.20.

4.3. Discussion

Across the conducted analyses and corresponding results, the consistent finding is a superior performance of the F-AHS, relative to the AHS. This main finding is shown through results from the F-AHS segmentation resulting in greater AH response differences that more closely match with prior AH literature compared to the AHS segmentation employed in Chapter 4. When first looking solely at the mean rating differences, the results first show an interaction between scale types and CS groups (Table 7), which was hypothesized but not seen in Chapter 4. Here, these findings suggest a minor trend of the mean effect differences being slightly more exaggerated in the line scale data compared to the category scale data between the two AH groups (Supplementary Tables 4-5). This finding matches with earlier works suggesting that more complex tasks, such as the line scale compared to the category scale, may induce greater AH group differences (Beekman & Seo, 2021; Meaux & Vuilleumier, 2016). In addition, the mean ratings show a strong, consistent trend of the holistic group having higher hedonic, closer to JAR, and greater sample relatedness ratings than the analytic group (Fig. 5). All three of these findings would be expected from prior AH research suggesting that holistic, relative to analytic, individual tend to be less critical and see a greater connectedness among events (Li et al., 2018; Spencer-Rodgers et al., 2010 Triandis et al., 1988). Related to the variance equivalence results, both Chapter 4 and this study support significant differences in variances between the CS groups. While Chapter 4 shows a weak trend of the holistic participants exhibiting greater variance, the findings here show a strong trend of the analytic participants having significantly greater variance (Fig. 6). Supporting the F-AHS performing better than the AHS is the fact that Bacha-Trams et al. (2018) detailed how the analytic participants displayed a greater response variance in their psychology study, which matches with the F-AHS showing the analytic group having greater standard deviation values in the current, food-related study.

The significant response correlations of the current study show the analytic and holistic CS groups differing in their proportions of "Other" significant correlations, meaning the holistic group had responses more often significantly correlated between questions of different samples compared to the analytic group (Supplementary Table 12). This finding matches with Chapter 4, which indicates that regardless of if the AHS or F-AHS was employed in CS group segmentation, the holistic group consistently had more correlated responses. Within the penalty analysis comparisons, the AHS and F-AHS methods also had a similar finding. Both scales showed the analytic group having more significant penalties, that were often of greater magnitude compared to the holistic group (Table 8). One differentiating point of the F-AHS though is that for the mixed fruit sample, the AHS resulted in a near consistent switch of this trend with the holistic group having more significant and larger penalties. While the F-AHS results show a relatively milder trend of the holistic group having greater, more significant penalties for two JAR categories, the AHS results indicated five instances of this trend. Another differentiating facet of the F-AHS results can be seen from the holistic group displaying a consistent trend across all samples and questions of having significantly less (more) "Too Weak/Too Strong" ("JAR") responses compared to the analytic group (Table 9). Comparatively, this result was only seen as a minor trend within Chapter 4. These consistent findings connect back to the AH literature of holistic individuals being less likely to be critical or more focused on respect than their analytic counterparts, which further echoes the mean rating findings.

Lastly, the comparison of the pre- and post-F-AHS scores addresses the issue of pre-and post-AHS scores exhibiting a relatively weak relationship with one another, which was seen in both Beekman & Seo (2022) and Chapter 4. Specifically, Table 10 details that not only are the F-AHS scores more significantly correlated to one another before and after a sensory evaluation task than was seen in Chapter 4, but the pre- and post-scores also exhibit a relationship that is closer to 1:1 through greater prediction coefficients. Chapter 4 indicated that the AHS scores were significantly lower (more analytic) for the holistic CS group after the sensory evaluation tasks, with this effect mitigated through the F-AHS where no mean F-AHS score differences were seen. Taken together, these findings show a near unanimous effect of the F-AHS more effectively separating analytic and holistic CS groups than the AHS, thus offering a successful initial validation of the F-AHS.

5. General discussion

Through the three studies within this paper, an F-AHS has been both developed and validated. The finalized F-AHS resulted in 15 questions spread across the three food experience categories of shopping (six questions), preparing (five questions), and consuming (four questions) (See Supplementary Table 14 for F-AHS). The AH constructs were spread across the food experience categories, yet, in contrast to the AHS, the scale development steps employed within these studies indicated not all AHS constructs are applicable and well understood by general consumers within food-specific situations. This can first be seen through the attitude toward contradiction questions continually fitting poorly, predictably through the difficult conceptualization of this construct within food scenarios (MacKenzie, 2003; Miller et al., 2009). Moreover, the AH constructs not equally applying to all food experience categories can be seen through each food experience category subscale only having two of the four main AHS constructs represented. Rather than forcing equivalent representation of all constructs across the food categories, a better fitting model was found through only utilizing the best fitting AH constructs and their questions, as shown in Table 4 (Supplementary Table 14), resulting in an uneven distribution of questions and AH constructs across the food experience categories. Even though the food experience subscales showed relatively lower model fit indices than the full model (Supplementary Tables 1-3), the models still show adequate model fits for the individual subscales, which offers promise for future research in applying and potentially validating these subscales in the respective, specific food scenarios and research areas. For example, future research could consider only using the shopping subscale in research investigating consumer food shopping behavior. Interestingly, the food experience subscales were still found to fit well within the full F-AHS, as the model visualization (Fig. 1) and model fit indices (Table 4) show the secondary latent factor of "food experience" connecting the AH constructs and food experience categories.

From these studies not only did the F-AHS have adequate model fit, it also was found to perform better than the AHS when separating CS groups for an identical sensory evaluation task. Across nearly all the question types and analyses, when the F-AHS was employed to segment the analytic and holistic groups in Study 3, the expected AH differences based on prior research were seen compared to when the AHS segmented the groups in Chapter 4. Specific instances include the mean ratings showing a clear, significant effect of AH groups, with the holistic group having responses higher in liking, closer to JAR, and higher sample relatedness (Fig. 5), which are all expected based on prior literature (Nisbett et al., 2001; Norenzayan et al., 2007). In addition, the variance responses of the analytic group having consistently greater values than the holistic group matches mirrors past research (Bacha-Trams et al., 2018). Both the correlation and penalty analysis findings are closely matched with the findings from Chapter 4 and the AHS, yet still support the F-AHS performing well in separating CS groups. However, one of the clear advantages of the F-AHS over the AHS within this sensory evaluation study is its comparison of pre- and post-scores (Table 10). These pre- and post-score comparisons show that the F-AHS is both more consistent before and after a sensory evaluation task and able to predict its own scores from before a sensory study to after one. The greater consistency of the scores addresses one of the main concerns of findings from Beekman and Seo (2022) and Chapter 4 suggesting significant differences in scores depending on when participants answered the AHS. Furthermore, the enhanced ability to predict post-F-AHS scores from the pre-F-AHS scores offers greater flexibility to researchers in when they employ the scale.

When looking at the F-AHS relative to the AHS, arguments may arise that is too short and not representative of the desired constructs. However, the critique of the AHS by Lux (2017) and Lux et al., (2021) discussed that some questions are repetitive within the AHS. Such repetitive questions they argue potentially inflate some of its model fit indices, while also putting an unnecessary burden on both the researchers and participants through the scale being too long. The F-AHS helps address these concerns by being relatively shorter, which is further supported by Dillman et al. (2014) who go into great detail about the benefit, and often times necessity, of having a shorter survey that focuses on the main research goals. A second area of critique can still be from researchers raising concern over not all AH constructs represented across the food experience categories. Here, it must be considered that the AH theory exists on a continuum, meaning not all AH differences are seen between all populations in all scenarios (Nisbett et al., 2001). Rather, the AH theory and its supporting psychological literature offer guidelines as to where and how analytic and holistic consumer groups may differ. Through these studies, the areas and constructs outlined in the finalized F-AHS offer initial insight into which of the specific AH areas of difference may be most applicable across the difference food categories. Studies building on these findings can explore through both quantitative and qualitative measures how and why certain AH constructs may be differentially applicable in various food and sensory scenarios.

As introduced and discussed by Beekman & Seo (2021, 2022), the area of AH applicability in food, sensory, and consumer sciences is an infant research area offering multitudes of promising areas to explore. One such area from this study, that built on the findings from Beekman and Seo (2021), is to continue to investigate the effect of task and stimuli complexity. Within this study, it was found that an interaction effect between scale type and AH group existed, with there being more significant AH group differences within the line scale data (Supplementary Tables 4-5). With the line scale potentially offering a more complex cognitive task (Lim, 2011) and prior literature supporting increased cognitive tasks may induce greater AH differences (Meaux & Vuilleumier, 2016), this finding offers preliminary support to that notion within sensory studies. Similarly, there was an interesting finding of the penalty analysis results for the mixed fruit sample. The trend of analytic participants exhibiting greater penalties switched in some cases for this sample to the holistic group having greater penalties. Digging deeper into the different types of sample complexity and how they are perceived offers another offshoot of related studies. Importantly, it must also be remembered that this is the first validation of the F-AHS. Relative to the AHS, which has been validating in a phenomenal amount of research, the F-AHS still has many of these avenues to be applied within (Koo et al., 2018). A short list of these additional areas includes applying the F-AHS across a wider variety of sensory tasks, with different types of food samples, within and between multiple types of cultures, and to translations to other languages. Bakhchina et al. (2021) even outlined that analytic and holistic CS groups may differ in their physiological responses to stimuli, suggesting pairing the F-AHS with physiological measures could offer potential in better understanding AH group differences in food scenarios. As the main outcome of these studies was to develop a new AH measurement tool to use within food, sensory, and consumer applications, the objective was accomplished, as shown with the F-AHS. Therefore, researchers within these fields can now apply the F-AHS in future research to build a better understanding of food-related AH consumer differences, while also more effectively segmenting consumers and obtaining more representative data.

6. Conclusion

From these three studies, a 15-question F-AHS was able to be developed, refined, finalized, and validated. Model fit indices support an acceptable fit of the question and latent factor structure of the F-AHS, along with the food category subscales, while comparisons with Chapter 4 results indicate a superior performance of the F-AHS in separating analytic and holistic groups in sensory evaluation research. The final, 15-question scale offers researchers a concise strategy to accurately assess consumer participant's AH tendencies in applied research situations within the food, sensory, and consumer areas. As the F-AHS is new, a wide collection of potential applications and future studies exist. Some of these areas include further replicating the findings of AHS supporting and validating literature through testing across a diversity of samples, tasks, populations, languages, and cultures. The area of cultural comparisons is an especially interesting area for further F-AHS research due to the rich, diverse, and often intertwined aspects of geographical culture (i.e., country) and food culture (i.e., local community). Investigating and potentially identifying unexpected differences in how the analytic and holistic groups can be separated within food and sensory research applications offers great promise in growing this burgeoning area of study.

Table 1. List of 38 potential questions based on preliminary testing and prior literature to be employed in first round of consumer exploratory factor analysis testing for the development of the food-related AHS*

Q. #**	Question***
1 SC	When deciding what foods to purchase, I focus on a single aspect of each item (R)
2 SC	I let my feelings decide what I will buy when shopping for food
3 SC	Promotions and coupons influence what food I buy
4 SA	If I cannot decide what food to buy, I must always make a compromise between my options
5 SA	I need multiple opinions and pieces of information before purchasing food
6 SA	I cannot both like and dislike a purchased food item at the same time (R)
7 SP	I will only buy a food if I know I already like it (R)
8 SP	I only purchase items that are on my grocery list (R)
9 SP	I do not repurchase the same items from the grocery store
10 SL	The surrounding store environment determines what I will buy when shopping for food
11 SL	Advertisements and displays never impact what foods I buy (R)
12 SL	Foods I purchase should focus on being used in overall meals instead of as individual ingredients
13 PC	Preparing one part of a meal is dependent on all other aspects of the meal
14 PC	A small change when cooking can have significant impacts on all other aspects of the food
15 PC	Everything is independent and unconnected when preparing food (R)
16 PA	All aspects of a meal I make must be connected to one another
17 PA	I avoid going to extremes when cooking
18 PA	I must compromise when cooking because people have different preferences
19 PP	My cooking preferences can change at any time
20 PP	If my recipe turns out how I planned, it will turn out the same way every single time (R)
21 PP	All parts of my meals should be prepared at the same time
22 PP	Recipes cannot be changed or modified (R)
23 PL	It is more important to focus on the individual details than the overall meal when cooking (R)
24 PL	Every part of a meal I make must be balanced
25 PL	When I cook, I view the whole meal as greater than the sum of its parts
26 CC	My feelings and experiences determine my perception of food I am eating
27 CC	Food liking is dependent on my overall perception of the food
28 CC	I use all my senses to form an opinion about something I am eating
29 CA	I cannot have opposing opinions about a single food (R)

* All questions were asked participants to answer how much they agreed/ disagreed with the statement from 1 (Strongly Disagree) to 7 (Strongly Agree).

Table 1. List of 38 potential questions based on preliminary testing and prior literature to be employed in first round of consumer exploratory factor analysis testing for the development of the food-related AHS* (continued)

30 CA	My opinions about foods I eat should avoid going to the extremes
31 CA	I can both like and dislike a food that I eat
32 CP	If I currently like a food product, I will always like that food in the future (R)
33 CP	My opinions of food products are continuously changing
34 CP	I focus on the positive more than the negative aspects of the food
35 CL	My overall experience determines if I will eat something again
36 CL	All food aspects are equally important when I am eating
37 CL	I am not influenced by my eating environment (R)
38 CL	A single aspect of what I eat decides if I will consume something again (R)

* All questions were asked participants to answer how much they agreed/ disagreed with the statement from 1 (Strongly Disagree) to 7 (Strongly Agree).

Table 2. Food-related AHS instructions provided to participants directly before providing responses to the questionnaire

Instructions provided to participants prior to responding to the food-related AHS questions
Please put yourself in the mindset of dealing with food products. Specifically, imagine yourself going through your normal process of shopping for food-related products. Please think about how you will prepare, use, or cook the food and ingredients at home, and the mindset you have when regularly consuming food products. Please maintain these states of mind in these food-related situations while you are answering all the following questions. As a reference, whenever "food" is mentioned in questions, it is referring to the general category of consumed food products that includes all foods and beverages. In addition, when "aspects" are mentioned, that can include any portion or characteristic of the food or situation that the statement is referencing. It is up to you to interpret the statements however they make the most sense to you. Now please read the following statements and select your response to each statement ranging from 1 (Strongly Disagree) to 7 (Strongly Agree).

Table 3. 24-question food-related AHS from Study 1 based on exploratory factor analysis results to be employed for further scale refinement in Study 2*

Q. #**	Question***
1 SC	I let my feelings decide what I will buy when shopping for food
2 SC	Promotions and coupons influence what food I buy
3 SA	If I cannot decide what food to buy, I must always make a compromise between my options
4 SA	I need multiple opinions and pieces of information before purchasing food
5 SP	I will only buy a food if I know I already like it (R)
6 SP	I only purchase items that are on my grocery list (R)
7 SL	The surrounding store environment determines what I will buy when shopping for food
8 SL	Advertisements and displays never impact what foods I buy (R)
9 PC	Preparing one part of a meal is dependent on all other aspects of the meal
10 PC	A small change when cooking can have significant impacts on all other aspects of the food
11 PC	All aspects of a meal I make must be connected to one another
12 PP	All parts of my meals should be prepared at the same time
13 PP	Recipes cannot be changed or modified (R)
14 PL	I view the whole meal as greater than the sum of its ingredients when I cook
15 PL	When I prepare a meal, I focus on featuring a single attribute or ingredient of the meal (R)[1]
16 PL	When I prepare a meal, I also focus on table setting that will go with the meal[1]
17 CC	My feelings and experiences determine my perception of food I am eating
18 CC	Food liking is dependent on my overall perception of the food
19 CA	I cannot have opposing opinions about a single food (R)
20 CA	I can both like and dislike a food that I eat
21 CP	If I currently like a food product, I will always like that food in the future (R)
22 CP	My opinions of food products are continuously changing
23 CL	All food aspects are equally important when I am eating
24 CL	I am not influenced by my eating environment (R)

* All questions were asked participants to answer how much they agreed/ disagreed with the statement from 1 (Strongly Disagree) to 7 (Strongly Agree).
** Abbreviations for which constructs each question is associated with are as follows: S=Shopping, P=Preparing, C=Consuming; C=Causality, A=Attitude toward Contradiction, P=Perception of Change, L=Locus of Attention. The first letter indicates which food experience construct, and the second letter indicates which analytic-holistic construct.
*** (R) indicates this question is reverse coded when scored.
[1] Indicates question was not included in data collection and will be checked for model fit in Study 2

Table 4. Finalized 15-question food-related AHS questionnaire after second round of exploratory factor analyses with each question's respective food experience category, analytic-holistic construct, factor loading score, and inter-item correlation

Question*	Food Category	Analytic-Holistic Construct	Factor Loading	Item-Total Correl.
1) The surrounding store environment determines what I will buy when shopping for food	Shopping	Causality	0.61	0.51
2) I let my feelings decide what I will buy when shopping for food	Shopping	Causality	0.46	0.52
3) Promotions and coupons influence what food I buy	Shopping	Causality	0.37	0.50
4) I only purchase items that are on my grocery list (R)	Shopping	Perception of Change	0.69	0.63
5) I will only buy a food if I know I already like it (R)	Shopping	Perception of Change	0.56	0.49
6) Advertisements and displays never impact what foods I buy (R)	Shopping	Perception of Change	0.40	0.59
7) Preparing one part of a meal is dependent on all other aspects of the meal	Preparing	Causality	0.50	0.66
8) A small change when cooking can have significant impacts on all other aspects of the food	Preparing	Causality	0.56	0.60
9) All aspects of a meal I make must be connected to one another	Preparing	Causality	0.68	0.75
10) When I prepare a meal, I also focus on table setting that will go with the meal	Preparing	Locus of Attention	0.67	0.61
11) When I prepare a meal, I focus on featuring a single attribute or ingredient of the meal (R)	Preparing	Locus of Attention	0.45	0.45
12) My feelings and experiences determine my perception of food I am eating	Consuming	Causality	0.71	0.65
13) Food liking is dependent on my overall perception of the food	Consuming	Causality	0.58	0.52
14) If I currently like a food product, I will always like that food in the future (R)	Consuming	Perception of Change	0.45	0.61
15) My opinions of food products are continuously changing	Consuming	Perception of Change	0.73	0.65

*(R) indicates this question is reverse coded when scored.

Table 5. Pearson correlation coefficients (*P*-values) among food experience category factor food-related AHS question response scores (summed for each food experience category) and their respective Cronbach α-values within each food experience category and within each analytic-holistic construct separately

Food Experience Category Analyses

	Cronbach's α (Reliability)	Shopping	Preparing	Consuming	Combined
Shopping	0.51	1.00 (<0.001)	-0.07 (0.14)	0.29 (<0.001)	0.73 (<0.001)
Preparing	0.63		1.00 (<0.001)	0.13 (0.004)	0.52 (<0.001)
Consuming	0.42			1.00 (<0.001)	0.66 (<0.001)
Combined	0.49				1.00 (<0.001)

Analytic-Holistic Construct Analyses

	Cronbach's α (Reliability)	Causality	Perception of Change	Locus of Attention	Combined
Causality	0.61	1.00 (<0.001)	0.008 (0.86)	0.65 (<0.001)	0.78 (<0.001)
Perception of Change	0.56		1.00 (<0.001)	0.08 (0.06)	0.59 (<0.001)
Locus of Attention	0.46			1.00 (<0.001)	0.55 (<0.001)
Combined	0.49				1.00 (<0.001)

Table 6. Model fit indices and comparisons between full, 15-question, finalized food-related AHS and the alternative models

Model	Chi-Square	Chi-Square/DF	AIC	BIC	CFI	RMSEA
Covariances between AH constructs and food categories and Food Experience latent factor*	145.87	2.32	25216.63	25492.80	0.92	0.05
Covariances between AH constructs and food categories and no Food Experience latent factor	191.07	2.77	25244.51	25499.87	0.88	0.06
No covariances between AH constructs and food categories and Food Experience latent factor	179.64	2.60	25233.07	25488.44	0.89	0.06
No covariances between AH constructs and food categories and no Food Experience latent factor	296.07	3.95	25333.62	25567.74	0.77	0.08

Table 7. Question-sample combinations with a significant interaction effect between analytic-holistic and scale type variables and the associated mean comparisons between the analytic-holistic and scale type combinations shown through Student's t-Test post-hoc comparisons

Sample and Question	Interaction F-Statistic	Interaction *P*-Value	Cognitive Group	Scale Type	Mean ± S.D.*
Orange Water Sourness Intensity	4.01	0.0473	Holistic	Line	0.38 ± 0.17a
			Holistic	Category	0.33 ± 0.21ab
			Analytic	Category	0.31 ± 0.21b
			Analytic	Line	0.29 ± 0.20b
Orange Water Overall Liking	6.72	0.0106	Holistic	Line	0.53 ± 0.22a
			Holistic	Category	0.49 ± 0.24ab
			Analytic	Category	0.44 ± 0.26b
			Analytic	Line	0.37 ± 0.26c
Mixed Fruit Water Overall Liking	5.66	0.0189	Analytic	Category	0.39 ± 0.27a
			Holistic	Line	0.32 ± 0.24ab
			Analytic	Line	0.32 ± 0.26ab
			Holistic	Category	0.32 ± 0.25b
Mixed Fruit Flavor Liking	6.40	0.0126	Holistic	Category	0.69 ± 0.21a
			Holistic	Line	0.69 ± 0.19a
			Analytic	Category	0.62 ± 0.24a
			Analytic	Line	0.52 ± 0.21b

* Values with different letters within the same sample-question combination indicate significantly different mean ratings based on post-hoc Student's t-Test results between the analytic-holistic and scale type combinations.

Table 8. Mean drop comparisons for all intensity questions between analytic and holistic cognitive style groups from penalty analyses conducted for each sample*

	JAR Question	**Flavor Intensity**		**Orange/ Pineapple Flavor Intensity****		**Sweetness Intensity**		**Sourness Intensity**		**Bitterness Intensity**	
Sample	**Cognitive Group**	Too Weak	Too Strong	Too Weak	Too Strong	Too Weak	Too Strong	Too Weak	Too Strong	Too Weak	Too Strong
OW	Analytic	1.98	3.07	2.64	0.00	1.31	0.00	1.83	4.16	2.60	1.59
	Holistic	0.81	0.88	1.19	1.79	1.30	0.69	1.06	0.98	0.84	0.80
MFW	Analytic	1.77	2.41	2.16	1.50	2.48	2.20	1.44	1.50	1.57	2.59
	Holistic	1.55	2.75	1.53	2.00	0.88	0.38	0.64	0.86	1.40	1.56
P	Analytic	1.61	0.99	1.14	-0.55	1.36	0.61	1.00	1.25	1.31	-0.20
	Holistic	1.79	1.98	1.09	1.02	1.17	1.40	0.71	1.00	0.54	1.11
MF	Analytic	2.71	2.11	2.13	1.69	1.28	0.38	1.25	0.57	1.94	1.60
	Holistic	1.68	1.82	1.18	0.88	1.73	1.47	1.81	1.52	2.13	2.48

* For samples, OW indicates the orange water sample, MFW indicates the mixed fruit water sample, P indicates the pineapple sample, and MF indicates the mixed fruit sample. Red mean drop values indicate a significant mean drop, green values indicate a non-significant drop, and grey indicates not enough data was present to conduct a significance test.
** The intensity JAR question was orange flavor intensity for the orange water and mixed fruit water samples and pineapple flavor for the pineapple and mixed fruit samples.

Table 9. Comparison of responses from the penalty analysis categories of "Too Weak", "Just-About-Right", and "Too Strong" between analytic and holistic cognitive style groups across all samples. Comparisons conducted via Fisher's Exact Tests on only category scale data (N=65) for each cognitive style group for all intensity questions for each sample*

Question		Flavor Intensity			Orange/ Pineapple Flavor Intensity**			Sweetness Intensity			Sourness Intensity			Bitterness Intensity		
Response Category		Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong	Too Weak	JAR	Too Strong
OW	A	**57**	**5**	3	**61**	**3**	1	**50**	15	0	40	21	4	25	32	8
	H	**39**	**21**	5	**43**	**19**	3	**38**	26	1	36	24	5	22	32	11
	z	**3.57**	**-3.46**	-0.37	**3.97**	**-3.71**	-0.51	**2.10**	-1.92	0.00	0.53	-0.37	0.00	0.37	0.00	-0.50
	P	**0.00[1]**	**0.00[1]**	0.71	**0.00[1]**	**0.00[1]**	0.61	**0.04**	0.05	1.00	0.59	0.71	1.00	0.71	1.00	0.62
MFW	A	37	10	18	51	6	8	51	10	4	**44**	18	3	23	23	19
	H	37	8	20	47	6	12	41	16	8	**31**	24	10	19	31	15
	z	0.00	0.25	-0.19	0.61	0.00	-0.73	1.76	-1.10	-0.91	**2.18**	-0.94	-1.78	0.56	-1.26	0.60
	P	1.00	0.80	0.85	0.54	1.00	0.46	0.08	0.27	0.36	**0.03**	0.35	0.07	0.57	0.21	0.55
P	A	14	46	5	29	33	3	17	44	4	14	42	9	9	**35**	**21**
	H	22	41	2	20	42	3	21	39	5	14	44	7	10	**52**	**3**
	z	-1.39	0.75	0.78	1.46	-1.43	0.00	-0.58	0.73	0.00	0.00	-0.19	0.27	0.00	**-3.10**	**4.11**
	P	0.17	0.45	0.43	0.14	0.15	1.00	0.56	0.46	1.00	1.00	0.85	0.79	1.00	**0.00[1]**	**0.00[1]**
MF	A	22	26	17	26	31	8	**34**	**26**	5	8	32	25	5	31	**29**
	H	21	26	18	35	24	6	**20**	**38**	7	12	36	17	11	42	**12**
	z	0.00	0.00	0.00	-1.42	1.07	0.28	**2.37**	**-1.96**	-0.30	-0.73	-0.53	1.32	-1.35	-1.79	**3.15**
	P	1.00	1.00	1.00	0.16	0.28	0.78	**0.02**	**0.05**	0.76	0.46	0.60	0.19	0.18	0.07	**0.00[1]**

* For samples, OW indicates the orange water sample, MFW indicates the mixed fruit water sample, P indicates the pineapple sample, and MF indicates the mixed fruit sample. "A" indicates frequency count for analytic group, "H" indicates frequency count for holistic group, "z" indicates the *z*-value test statistic from the Fisher's Exact Test, and "P" indicates the *P*-value from the Fisher's Exact Test.

** For the orange water and mixed fruit water samples, the question was orange flavor intensity, and for the pineapple and mixed fruit samples, the question was pineapple flavor intensity.

[1] Indicates a *P*-value < 0.01

Table 10. Pearson correlation coefficients (*P*-value) and simple linear regression equations (F-value and P-value) between the pre- and post-F-AHS scores for the analytic cognitive style group (N=65), the holistic cognitive style group (N=65), and both cognitive style groups combined (N=130)

Analytic Cognitive Style Group	**Pearson Correlations**	Pre-F-AHS Score	Post-F-AHS Score
	Pre-F-AHS Score	1.00 (<0.001)	0.78 (<0.001)
	Post-F-AHS Score	0.78 (<0.001)	1.00 (<0.001)
	Simple linear regression		
	Post-F-AHS score = 6.55 + 0.90*Pre-FAHS Score (F = 100.39, *P* < 0.001)		
Holistic Cognitive Style Group	**Pearson Correlations**	Pre-F-AHS Score	Post-F-AHS Score
	Pre-F-AHS Score	1.00 (<0.001)	0.89 (<0.001)
	Post-F-AHS Score	0.89 (<0.001)	1.00 (<0.001)
	Simple linear regression		
	Post-F-AHS score = 11.77 + 0.85*Pre-FAHS Score (F = 227.65, *P* < 0.001)		
Combined Cognitive Style Groups	**Pearson Correlations**	Pre-F-AHS Score	Post-F-AHS Score
	Pre-F-AHS Score	1.00 (<0.001)	0.95 (<0.001)
	Post-F-AHS Score	0.95 (<0.001)	1.00 (<0.001)
	Simple linear regression		
	Post-F-AHS score = 3.20 + 0.96*Pre-FAHS Score (F = 1145.73, *P* < 0.001)		

Supplementary Table 1. CFA model of the shopping food experience category sub-scale with a two-factor model representing the two analytic-holistic constructs within the shopping sub-scale, with model fit indices compared against alternative models.

Model	Chi-Square	Chi-Square/DF	AIC	BIC	CFI	RMSEA
Questions separated onto two A-H constructs, construct covariance, no shopping latent factor*	33.18	4.15	10582.03	10659.98	0.89	0.08
Questions separated onto two A-H constructs, construct covariance, shopping latent factor	33.18	5.53	10586.39	10672.36	0.88	0.10
Questions separated onto two A-H constructs, no construct covariance, shopping latent factor	33.18	4.74	10584.20	10666.17	0.89	0.09
Questions separated onto two A-H constructs, no construct covariance, no shopping latent factor	44.76	4.97	10591.44	10665.37	0.84	0.09

* Indicates this model was selected as the best fitting model based on both the combination of model fit indices and logical structure of the shopping food category sub-scale.

Supplementary Table 2. CFA model of the preparing food experience category sub-scale with a two-factor model representing the two analytic-holistic constructs within the shopping sub-scale, with model fit indices compared for different model fit options

Model	Chi-Square	Chi-Square/DF	AIC	BIC	CFI	RMSEA
Questions separated onto two A-H constructs, construct covariance, no preparing latent factor*	30.71	7.67	8592.79	8658.65	0.90	0.12
Questions separated onto two A-H constructs, construct covariance, preparing latent factor	30.68	15.34	8597.07	8671.00	0.90	0.17
Questions separated onto two A-H constructs, no construct covariance, preparing latent factor	31.33	10.44	8595.57	8665.46	0.90	0.14
Questions separated onto two A-H constructs, no construct covariance, no preparing latent factor	63.47	12.69	8623.41	8685.22	0.79	0.16

* Indicates this model was selected as the best fitting model based on both the combination of model fit indices and logical structure of the preparing food category sub-scale.

Supplementary Table 3. CFA model of the consuming food experience category sub-scale with a two-factor model representing the two analytic-holistic constructs within the shopping sub-scale, with model fit indices compared for different model fit options*

Model	Chi-Square**	Chi-Square/DF	AIC	BIC	CFI	RMSEA
Questions separated onto two A-H constructs, construct covariance, no consuming latent factor***	3.20	3.20	6277.33	6331.01	0.99	0.07
Questions separated onto two A-H constructs, no construct covariance, consuming latent factor	N/A	N/A	6279.45	6337.20	N/A	N/A
Questions separated onto two A-H constructs, no construct covariance, no consuming latent factor	38.67	19.34	6310.69	6360.29	0.78	0.19

* Assuming a covariance between analytic-holistic constructs and an additional latent factor of consuming over both constructs was not feasible due to a lack of available degrees of freedom when building the model.
** Some fit indices were not able to be calculated for certain models due to lack of available degrees of freedom and are thus noted by "N/A".
*** Indicates this model was selected as the best fitting model based on both the combination of model fit indices and logical structure of the consuming food category sub-scale.

Supplementary Table 4. Mean (± standard deviation (SD)) ratings between cognitive groups for all sample-question combinations within category scale data based on two-way ANOVA tests (N=65 for each cognitive style group). Bold lettering and numbering indicate a significant difference between cognitive groups when *P* < 0.05.

Question*	Analytic (Mean ± S.D)	Holistic (Mean ± S.D)	Test statistic (F)	*P*-value
Orange Water 1	**0.48 ± 0.24**	**0.66 ± 0.18**	**24.73**	**<0.001**
Orange Water 2	**0.25 ± 0.18**	**0.37 ± 0.17**	**14.55**	**<0.001**
Orange Water 3	0.49 ± 0.25	0.56 ± 0.20	2.76	0.099
Orange Water 4	**0.20 ± 0.17**	**0.36 ± 0.16**	**27.48**	**<0.001**
Orange Water 5	**0.26 ± 0.18**	**0.38 ± 0.15**	**16.25**	**<0.001**
Orange Water 6	0.31 ± 0.21	0.33 ± 0.21	0.22	0.643
Orange Water 7	0.39 ± 0.22	0.43 ± 0.20	1.43	0.235
Orange Water 8	0.44 ± 0.26	0.49 ± 0.24	1.30	0.257
Mixed Fruit Water 1	0.39 ± 0.26	0.46 ± 0.26	2.02	0.158
Mixed Fruit Water 2	0.39 ± 0.23	0.43 ± 0.25	0.78	0.380
Mixed Fruit Water 3	0.35 ± 0.24	0.43 ± 0.24	2.95	0.088
Mixed Fruit Water 4	0.30 ± 0.22	0.31 ± 0.24	0.19	0.666
Mixed Fruit Water 5	**0.28 ± 0.20**	**0.37 ± 0.20**	**5.50**	**0.021**
Mixed Fruit Water 6	**0.31 ± 0.18**	**0.40 ± 0.20**	**7.21**	**0.008**
Mixed Fruit Water 7	0.48 ± 0.23	0.47 ± 0.19	0.04	0.838
Mixed Fruit Water 8	0.39 ± 0.27	0.32 ± 0.25	2.67	0.105
Pineapple 1	0.77 ± 0.19	0.79 ± 0.13	0.76	0.385
Pineapple 2	0.48 ± 0.11	0.45 ± 0.08	2.18	0.142
Pineapple 3	**0.72 ± 0.20**	**0.81 ± 0.14**	**8.90**	**0.003**
Pineapple 4	0.42 ± 0.13	0.46 ± 0.10	0.37	0.058
Pineapple 5	0.47 ± 0.09	0.46 ± 0.10	0.12	0.729
Pineapple 6	0.47 ± 0.12	0.47 ± 0.11	0.01	0.926
Pineapple 7	**0.53 ± 0.15**	**0.47 ± 0.11**	**5.60**	**0.020**
Pineapple 8	0.75 ± 0.20	0.79 ± 0.15	1.79	0.183
Fruit 1	0.62 ± 0.24	0.69 ± 0.21	3.21	0.075
Fruit 2	0.49 ± 0.16	0.49 ± 0.17	0.02	0.893
Fruit 3	0.69 ± 0.23	0.69 ± 0.19	<0.01	<0.999
Fruit 4	0.44 ± 0.15	0.40 ± 0.14	2.17	0.143
Fruit 5	**0.40 ± 0.15**	**0.47 ± 0.11**	**11.75**	**<0.001**
Fruit 6	**0.57 ± 0.16**	**0.51 ± 0.13**	**4.72**	**0.032**
Fruit 7	**0.58 ± 0.16**	**0.49 ± 0.14**	**10.96**	**0.001**
Fruit 8	0.61 ± 0.25	0.69 ± 0.22	3.43	0.066
Relatedness	**0.34 ± 0.24**	**0.46 ± 0.24**	**7.19**	**0.008**

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 5. Mean (± standard deviation (SD)) ratings between cognitive groups for all sample-question combinations within line scale data based on two-way ANOVA tests (N=65 for each cognitive style group). Bold lettering and numbering indicate a significant difference between cognitive groups when *P* < 0.05.

Question*	Analytic (Mean ± S.D)	Holistic (Mean ± S.D)	Test statistic (F)	*P*-value
Orange Water 1	**0.37 ± 0.22**	**0.60 ± 0.18**	**42.47**	**<0.001**
Orange Water 2	**0.24 ± 0.21**	**0.33 ± 0.17**	**7.76**	**0.006**
Orange Water 3	**0.39 ± 0.24**	**0.53 ± 0.23**	**11.19**	**0.001**
Orange Water 4	**0.20 ± 0.17**	**0.34 ± 0.17**	**20.53**	**<0.001**
Orange Water 5	**0.20 ± 0.17**	**0.37 ± 0.15**	**37.02**	**<0.001**
Orange Water 6	**0.29 ± 0.20**	**0.38 ± 0.17**	**9.40**	**0.003**
Orange Water 7	0.35 ± 0.22	0.41 ± 0.18	2.89	0.091
Orange Water 8	**0.37 ± 0.26**	**0.53 ± 0.22**	**14.25**	**<0.001**
Mixed Fruit Water 1	**0.29 ± 0.20**	**0.40 ± 0.26**	**8.66**	**0.004**
Mixed Fruit Water 2	**0.37 ± 0.25**	**0.46 ± 0.23**	**4.06**	**0.046**
Mixed Fruit Water 3	0.28 ± 0.23	0.36 ± 0.25	3.73	0.056
Mixed Fruit Water 4	**0.29 ± 0.21**	**0.38 ± 0.24**	**4.88**	**0.029**
Mixed Fruit Water 5	**0.25 ± 0.21**	**0.38 ± 0.21**	**12.92**	**<0.001**
Mixed Fruit Water 6	**0.29 ± 0.20**	**0.42 ± 0.20**	**12.56**	**<0.001**
Mixed Fruit Water 7	0.46 ± 0.24	0.48 ± 0.22	0.25	0.616
Mixed Fruit Water 8	0.32 ± 0.26	0.32 ± 0.24	0.01	0.920
Pineapple 1	0.67 ± 0.22	0.73 ± 0.19	3.08	0.081
Pineapple 2	0.48 ± 0.15	0.48 ± 0.12	0.01	0.923
Pineapple 3	**0.62 ± 0.21**	**0.73 ± 0.21**	**10.43**	**0.002**
Pineapple 4	**0.41 ± 0.13**	**0.47 ± 0.09**	**7.60**	**0.007**
Pineapple 5	0.46 ± 0.11	0.45 ± 0.10	0.18	0.675
Pineapple 6	0.46 ± 0.14	0.48 ± 0.11	0.49	0.485
Pineapple 7	0.50 ± 0.16	0.48 ± 0.13	0.24	0.625
Pineapple 8	0.67 ± 0.25	0.71 ± 0.22	0.89	0.346
Fruit 1	**0.52 ± 0.21**	**0.69 ± 0.19**	**24.41**	**<0.001**
Fruit 2	0.50 ± 0.15	0.50 ± 0.15	0.10	0.757
Fruit 3	0.62 ± 0.22	0.65 ± 0.22	0.43	0.516
Fruit 4	0.44 ± 0.13	0.44 ± 0.13	0.03	0.870
Fruit 5	**0.40 ± 0.11**	**0.45 ± 0.10**	**9.38**	**0.003**
Fruit 6	**0.58 ± 0.15**	**0.51 ± 0.14**	**6.55**	**0.012**
Fruit 7	**0.58 ± 0.13**	**0.51 ± 0.12**	**11.01**	**0.001**
Fruit 8	**0.51 ± 0.20**	**0.64 ± 0.23**	**13.61**	**<0.001**
Relatedness	**0.32 ± 0.21**	**0.48 ± 0.23**	**16.53**	**<0.001**

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 6. Mean (± standard deviation (SD)) ratings between cognitive groups for all sample-question combinations combined across scale types based on two-way ANOVA tests (N=130 for each cognitive style group). Bold lettering and numbering indicate a significant difference between cognitive groups when *P* < 0.05.

Question*	Analytic (Mean ± S.D)	Holistic (Mean ± S.D)	Test statistic (F)	*P*-value
Orange Water 1	**0.43 ± 0.23**	**0.63 ± 0.18**	**44.99**	**<0.001**
Orange Water 2	**0.25 ± 0.20**	**0.35 ± 0.17**	**16.60**	**<0.001**
Orange Water 3	**0.44 ± 0.25**	**0.54 ± 0.21**	**8.79**	**0.004**
Orange Water 4	**0.20 ± 0.17**	**0.35 ± 0.16**	**32.96**	**<0.001**
Orange Water 5	**0.23 ± 0.17**	**0.37 ± 0.15**	**35.63**	**<0.001**
Orange Water 6	**0.30 ± 0.21**	**0.36 ± 0.19**	**4.17**	**0.043**
Orange Water 7	0.37 ± 0.22	0.42 ± 0.19	2.91	0.090
Orange Water 8	**0.40 ± 0.26**	**0.51 ± 0.23**	**7.74**	**0.006**
Mixed Fruit Water 1	**0.34 ± 0.24**	**0.43 ± 0.26**	**6.11**	**0.015**
Mixed Fruit Water 2	0.38 ± 0.24	0.44 ± 0.24	2.96	0.088
Mixed Fruit Water 3	**0.32 ± 0.24**	**0.39 ± 0.25**	**4.57**	**0.034**
Mixed Fruit Water 4	0.29 ± 0.21	0.34 ± 0.24	2.30	0.132
Mixed Fruit Water 5	**0.27 ± 0.20**	**0.37 ± 0.20**	**11.86**	**<0.001**
Mixed Fruit Water 6	**0.30 ± 0.19**	**0.41 ± 0.20**	**13.47**	**<0.001**
Mixed Fruit Water 7	0.47 ± 0.24	0.47 ± 0.20	0.04	0.849
Mixed Fruit Water 8	0.36 ± 0.27	0.32 ± 0.24	0.72	0.398
Pineapple 1	0.72 ± 0.21	0.76 ± 0.17	2.75	0.010
Pineapple 2	0.48 ± 0.13	0.47 ± 0.10	0.49	0.484
Pineapple 3	**0.67 ± 0.21**	**0.77 ± 0.18**	**16.15**	**<0.001**
Pineapple 4	**0.42 ± 0.13**	**0.46 ± 0.10**	**8.42**	**0.004**
Pineapple 5	0.56 ± 0.10	0.46 ± 0.10	0.24	0.626
Pineapple 6	0.47 ± 0.13	0.47 ± 0.11	0.16	0.687
Pineapple 7	0.51 ± 0.15	0.48 ± 0.12	2.73	0.101
Pineapple 8	0.71 ± 0.23	0.75 ± 0.19	1.86	0.175
Fruit 1	**0.57 ± 0.23**	**0.69 ± 0.20**	**15.15**	**<0.001**
Fruit 2	0.50 ± 0.16	0.49 ± 0.16	0.01	0.917
Fruit 3	0.65 ± 0.23	0.67 ± 0.21	0.16	0.688
Fruit 4	0.44 ± 0.14	0.42 ± 0.14	1.14	0.287
Fruit 5	**0.40 ± 0.13**	**0.46 ± 0.10**	**17.98**	**<0.001**
Fruit 6	**0.57 ± 0.15**	**0.52 ± 0.13**	**9.84**	**0.002**
Fruit 7	**0.58 ± 0.14**	**0.50 ± 0.13**	**17.11**	**<0.001**
Fruit 8	**0.56 ± 0.23**	**0.67 ± 0.22**	**10.24**	**0.002**
Relatedness	**0.33 ± 0.23**	**0.47 ± 0.23**	**13.04**	**<0.001**

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 7. Mean (± standard deviation (SD)) ratings between scale types for all sample-question combinations within the analytic cognitive style group based on two-way ANOVA tests (N=65 for each scale type group). Bold lettering and numbering indicate a significant difference between scale types when *P* < 0.05.

Question*	Category (Mean ± SD)	Line (Mean ± SD)	Test statistic (F)	*P*-value
Orange Water 1	**0.48** ± 0.24	**0.37** ± 0.22	**14.95**	**<0.001**
Orange Water 2	0.25 ± 0.18	0.24 ± 0.21	0.16	0.693
Orange Water 3	**0.49** ± 0.25	**0.39** ± 0.24	**7.75**	**0.007**
Orange Water 4	0.20 ± 0.17	0.20 ± 0.17	0.03	0.862
Orange Water 5	**0.26** ± 0.18	**0.20** ± 0.17	**9.58**	**0.003**
Orange Water 6	0.31 ± 0.21	0.29 ± 0.20	0.73	0.395
Orange Water 7	0.39 ± 0.22	0.35 ± 0.22	1.28	0.262
Orange Water 8	**0.44** ± 0.26	**0.37** ± 0.26	**4.45**	**0.039**
Mixed Fruit Water 1	**0.39** ± 0.26	**0.29** ± 0.20	**19.16**	**<0.001**
Mixed Fruit Water 2	0.39 ± 0.23	0.37 ± 0.25	0.46	0.501
Mixed Fruit Water 3	0.35 ± 0.24	0.28 ± 0.23	6.78	0.011
Mixed Fruit Water 4	0.30 ± 0.22	0.29 ± 0.21	0.07	0.789
Mixed Fruit Water 5	0.28 ± 0.20	0.25 ± 0.21	1.70	0.197
Mixed Fruit Water 6	0.31 ± 0.18	0.29 ± 0.20	0.66	0.420
Mixed Fruit Water 7	0.48 ± 0.23	0.46 ± 0.24	0.41	0.524
Mixed Fruit Water 8	**0.39** ± 0.27	**0.32** ± 0.26	**9.24**	**0.003**
Pineapple 1	**0.77** ± 0.19	**0.67** ± 0.22	**11.82**	**0.001**
Pineapple 2	0.48 ± 0.11	0.48 ± 0.25	0.00	0.999
Pineapple 3	**0.72** ± 0.20	**0.62** ± 0.21	**10.72**	**0.002**
Pineapple 4	0.42 ± 0.13	0.41 ± 0.13	0.02	0.900
Pineapple 5	0.47 ± 0.09	0.46 ± 0.11	0.14	0.708
Pineapple 6	0.47 ± 0.12	0.46 ± 0.14	0.33	0.566
Pineapple 7	0.53 ± 0.15	0.50 ± 0.16	2.00	0.162
Pineapple 8	**0.75** ± 0.20	**0.67** ± 0.25	**6.53**	**0.013**
Fruit 1	**0.62** ± 0.24	**0.52** ± 0.21	**11.59**	**0.001**
Fruit 2	0.49 ± 0.16	0.50 ± 0.15	0.36	0.548
Fruit 3	**0.69** ± 0.23	**0.62** ± 0.22	**4.10**	**0.047**
Fruit 4	0.44 ± 0.15	0.44 ± 0.13	0.01	0.939
Fruit 5	0.40 ± 0.15	0.40 ± 0.11	0.03	0.873
Fruit 6	0.57 ± 0.16	0.58 ± 0.15	0.15	0.704
Fruit 7	0.58 ± 0.16	0.58 ± 0.13	0.02	0.884
Fruit 8	**0.61** ± 0.25	**0.51** ± 0.20	**10.65**	**0.002**
Relatedness	0.34 ± 0.24	0.32 ± 0.21	0.41	0.525

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 8. Mean (± standard deviation (SD)) ratings between scale types for all sample-question combinations within the holistic cognitive style group based on two-way ANOVA tests (N=65 for each scale type group). Bold lettering and numbering indicate a significant difference between scale types when *P* < 0.05.

Question*	Category (Mean ± SD)	Line (Mean ± SD)	Test statistic (F)	*P*-value
Orange Water 1	**0.66** ± 0.18	**0.60** ± 0.18	**5.73**	**0.020**
Orange Water 2	0.37 ± 0.17	0.33 ± 0.17	1.97	0.166
Orange Water 3	0.56 ± 0.20	0.53 ± 0.23	1.03	0.314
Orange Water 4	0.36 ± 0.16	0.34 ± 0.17	0.75	0.389
Orange Water 5	0.38 ± 0.15	0.37 ± 0.15	0.30	0.588
Orange Water 6	**0.33** ± 0.21	**0.38** ± 0.17	**4.31**	**0.042**
Orange Water 7	0.43 ± 0.20	0.41 ± 0.18	0.50	0.482
Orange Water 8	0.49 ± 0.24	0.53 ± 0.22	2.27	0.136
Mixed Fruit Water 1	0.46 ± 0.26	0.40 ± 0.26	2.28	0.136
Mixed Fruit Water 2	0.43 ± 0.25	0.46 ± 0.23	0.64	0.427
Mixed Fruit Water 3	0.43 ± 0.24	0.36 ± 0.25	3.47	0.067
Mixed Fruit Water 4	**0.31** ± 0.24	**0.38** ± 0.24	**5.37**	**0.024**
Mixed Fruit Water 5	0.37 ± 0.20	0.38 ± 0.21	0.44	0.510
Mixed Fruit Water 6	0.40 ± 0.20	0.42 ± 0.20	0.26	0.611
Mixed Fruit Water 7	0.47 ± 0.19	0.48 ± 0.22	0.10	0.757
Mixed Fruit Water 8	0.32 ± 0.25	0.32 ± 0.24	0.15	0.701
Pineapple 1	**0.79** ± 0.13	**0.73** ± 0.19	**6.40**	**0.014**
Pineapple 2	0.45 ± 0.08	0.48 ± 0.12	2.36	0.130
Pineapple 3	**0.81** ± 0.14	**0.73** ± 0.21	**6.81**	**0.011**
Pineapple 4	0.46 ± 0.10	0.47 ± 0.09	1.06	0.306
Pineapple 5	0.46 ± 0.10	0.45 ± 0.10	0.32	0.575
Pineapple 6	0.47 ± 0.11	0.48 ± 0.11	0.14	0.708
Pineapple 7	0.47 ± 0.11	0.48 ± 0.13	0.49	0.487
Pineapple 8	**0.79** ± 0.15	**0.71** ± 0.22	**6.27**	**0.015**
Fruit 1	0.69 ± 0.21	0.69 ± 0.19	0.00	0.984
Fruit 2	0.49 ± 0.17	0.50 ± 0.15	0.02	0.894
Fruit 3	0.69 ± 0.19	0.65 ± 0.22	2.71	0.105
Fruit 4	0.40 ± 0.14	0.44 ± 0.13	3.92	0.052
Fruit 5	0.47 ± 0.11	0.45 ± 0.10	1.09	0.300
Fruit 6	0.51 ± 0.13	0.51 ± 0.14	0.00	0.989
Fruit 7	0.49 ± 0.14	0.51 ± 0.12	0.49	0.486
Fruit 8	0.69 ± 0.22	0.64 ± 0.23	2.52	0.117
Relatedness	0.46 ± 0.24	0.48 ± 0.23	0.86	0.356

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 9. Mean (± standard deviation (SD)) ratings between scale types for all sample-question combinations combined across cognitive groups based on two-way ANOVA tests (N=130 for each scale type). Bold lettering and numbering indicate a significant difference between scale types when *P* < 0.05.

Question*	Category (Mean ± SD)	Line (Mean ± SD)	Test statistic (F)	*P*-value
Orange Water 1	**0.57 ± 0.23**	**0.49 ± 0.23**	**19.81**	**<0.001**
Orange Water 2	0.31 ± 0.18	0.29 ± 0.19	1.56	0.214
Orange Water 3	**0.52 ± 0.23**	**0.46 ± 0.24**	**8.09**	**0.005**
Orange Water 4	0.28 ± 0.18	0.27 ± 0.18	0.59	0.442
Orange Water 5	**0.32 ± 0.17**	**0.28 ± 0.18**	**6.51**	**0.012**
Orange Water 6	0.32 ± 0.21	0.33 ± 0.19	0.48	0.488
Orange Water 7	0.41 ± 0.21	0.38 ± 0.20	1.75	0.189
Orange Water 8	0.47 ± 0.25	0.45 ± 0.25	0.63	0.428
Mixed Fruit Water 1	**0.43 ± 0.26**	**0.34 ± 0.24**	**13.76**	**<0.001**
Mixed Fruit Water 2	0.41 ± 0.24	0.42 ± 0.24	0.024	0.878
Mixed Fruit Water 3	**0.39 ± 0.24**	**0.32 ± 0.24**	**9.57**	**0.002**
Mixed Fruit Water 4	0.30 ± 0.23	0.33 ± 0.23	1.90	0.170
Mixed Fruit Water 5	0.32 ± 0.20	0.32 ± 0.22	0.12	0.730
Mixed Fruit Water 6	0.36 ± 0.20	0.36 ± 0.21	0.04	0.845
Mixed Fruit Water 7	0.47 ± 0.21	0.47 ± 0.23	0.07	0.793
Mixed Fruit Water 8	0.35 ± 0.26	0.32 ± 0.25	3.19	0.076
Pineapple 1	**0.78 ± 0.16**	**0.70 ± 0.20**	**18.14**	**<0.001**
Pineapple 2	0.47 ± 0.10	0.48 ± 0.13	1.20	0.275
Pineapple 3	**0.76 ± 0.18**	**0.68 ± 0.21**	**17.51**	**<0.001**
Pineapple 4	0.44 ± 0.12	0.44 ± 0.12	0.26	0.613
Pineapple 5	0.46 ± 0.09	0.46 ± 0.11	0.43	0.511
Pineapple 6	0.47 ± 0.12	0.47 ± 0.13	0.06	0.800
Pineapple 7	0.50 ± 0.13	0.49 ± 0.14	0.52	0.471
Pineapple 8	**0.77 ± 0.18**	**0.69 ± 0.24**	**12.88**	**<0.001**
Fruit 1	**0.65 ± 0.23**	**0.60 ± 0.22**	**6.27**	**0.014**
Fruit 2	0.49 ± 0.16	0.50 ± 0.15	0.27	0.604
Fruit 3	**0.69 ± 0.21**	**0.63 ± 0.22**	**0.68**	**0.010**
Fruit 4	0.42 ± 0.15	0.44 ± 0.13	1.69	0.197
Fruit 5	0.43 ± 0.13	0.43 ± 0.11	0.37	0.544
Fruit 6	0.54 ± 0.15	0.54 ± 0.14	0.07	0.795
Fruit 7	0.53 ± 0.15	0.54 ± 0.13	0.39	0.536
Fruit 8	**0.65 ± 0.24**	**0.57 ± 0.22**	**12.29**	**<0.001**
Relatedness	0.40 ± 0.24	0.40 ± 0.24	0.02	0.900

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 10. Variance (standard deviation (SD)) comparisons between analytic and holistic cognitive style groups, with data combined across category and line scale data for a sample size of N=130 for each cognitive group. Differences determined through Levene's test for equal variances and bold font indicates a significant difference between cognitive groups when *P* < 0.05.

Question*	Analytic (SD)	Holistic (SD)	Test statistic (F)	*P*-value
Orange Water 1	**0.23**	**0.18**	**14.14**	**<0.001**
Orange Water 2	0.20	0.17	1.78	0.184
Orange Water 3	**0.25**	**0.21**	**5.69**	**0.018**
Orange Water 4	0.17	0.16	0.51	0.476
Orange Water 5	**0.17**	**0.15**	**10.92**	**0.001**
Orange Water 6	**0.21**	**0.19**	**4.13**	**0.043**
Orange Water 7	**0.22**	**0.19**	**9.75**	**0.002**
Orange Water 8	**0.26**	**0.23**	**6.63**	**0.011**
Mixed Fruit Water 1	0.24	0.26	1.79	0.182
Mixed Fruit Water 2	0.24	0.24	0.10	0.754
Mixed Fruit Water 3	0.24	0.25	0.50	0.480
Mixed Fruit Water 4	0.22	0.24	2.27	0.133
Mixed Fruit Water 5	0.20	0.21	0.27	0.601
Mixed Fruit Water 6	0.19	0.20	0.07	0.799
Mixed Fruit Water 7	**0.24**	**0.20**	**7.36**	**0.007**
Mixed Fruit Water 8	0.27	0.25	0.39	0.534
Pineapple 1	**0.21**	**0.17**	**4.83**	**0.029**
Pineapple 2	0.13	0.10	0.74	0.391
Pineapple 3	0.21	0.18	2.94	0.087
Pineapple 4	**0.13**	**0.10**	**11.50**	**<0.001**
Pineapple 5	0.10	0.10	0.09	0.763
Pineapple 6	0.13	0.11	1.53	0.218
Pineapple 7	**0.15**	**0.12**	**7.80**	**0.006**
Pineapple 8	**0.23**	**0.19**	**4.22**	**0.041**
Fruit 1	**0.23**	**0.20**	**3.99**	**0.047**
Fruit 2	0.16	0.16	0.004	0.953
Fruit 3	0.23	0.21	0.60	0.438
Fruit 4	0.14	0.14	0.03	0.856
Fruit 5	**0.13**	**0.10**	**9.01**	**0.003**
Fruit 6	**0.15**	**0.13**	**8.48**	**0.004**
Fruit 7	**0.14**	**0.13**	**10.42**	**0.001**
Fruit 8	0.23	0.23	0.18	0.668
Relatedness	0.23	0.24	0.61	0.435

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 11. Variance (standard deviation (SD)) comparisons between category and line scale data, with data combined across analytic and holistic cognitive style groups for a sample size of N=130 for each cognitive group. Differences determined through Levene's test for equal variances and bold font indicates a significant difference between scale types when *P* < 0.05.

Question*	Category (SD)	Line (SD)	Test statistic (F)	*P*-Value
Orange Water 1	0.23	0.23	0.02	0.888
Orange Water 2	0.18	0.19	0.4	0.527
Orange Water 3	0.23	0.24	0.81	0.369
Orange Water 4	0.18	0.18	0.04	0.847
Orange Water 5	0.17	0.18	2.22	0.138
Orange Water 6	0.21	0.19	2.76	0.098
Orange Water 7	0.21	0.20	0.04	0.847
Orange Water 8	0.25	0.25	0.3	0.585
Mixed Fruit Water 1	0.26	0.24	2.6	0.108
Mixed Fruit Water 2	0.24	0.24	0.02	0.880
Mixed Fruit Water 3	0.24	0.24	0.08	0.782
Mixed Fruit Water 4	0.23	0.23	0.02	0.883
Mixed Fruit Water 5	0.21	0.22	1.55	0.214
Mixed Fruit Water 6	0.20	0.21	0.2	0.652
Mixed Fruit Water 7	0.21	0.23	1.27	0.261
Mixed Fruit Water 8	0.26	0.25	0.54	0.461
Pineapple 1	**0.16**	**0.21**	**7.97**	**0.005**
Pineapple 2	0.10	0.13	2.52	0.113
Pineapple 3	**0.18**	**0.21**	**7.14**	**0.008**
Pineapple 4	0.12	0.12	0.56	0.454
Pineapple 5	0.09	0.11	0.22	0.637
Pineapple 6	0.12	0.13	0.14	0.713
Pineapple 7	0.13	0.14	0.63	0.426
Pineapple 8	**0.18**	**0.24**	**16.41**	**<0.001**
Fruit 1	0.23	0.22	0.56	0.454
Fruit 2	0.16	0.15	3.39	0.067
Fruit 3	0.21	0.22	0.97	0.326
Fruit 4	**0.15**	**0.13**	**5.35**	**0.022**
Fruit 5	**0.13**	**0.11**	**7.53**	**0.007**
Fruit 6	0.15	0.15	0.11	0.737
Fruit 7	0.16	0.13	0.79	0.375
Fruit 8	0.24	0.23	0.91	0.342
Relatedness	0.24	0.24	0.65	0.420

* Numbering for questions indicate the following questions for each sample-question combination: 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking

Supplementary Table 12. Frequency counts of significant correlations between analytic and holistic cognitive style groups combined across scale type data for the different correlation categories. Global Pearson chi-square and Fisher's Exact Tests (FET) show results of significance tests between the total table and within individual correlation categories

Correlation Category*	Analytic Group Count	Holistic Group Count	FET Test Statistic (z value)	*P*-value
Fruit Water	51	44	1.179	0.238
Mixed Fruit	37	30	1.191	0.234
Orange Water	35	32	0.678	0.498
Pineapple	29	27	0.520	0.603
Other	**139**	**188**	**-2.560**	**0.010**
Relatedness	12	13	0.000	1.000
Total	303	334	-1.683	0.092
Global Chi-Square Value	7.34			
Global *P*-Value	0.196			

* Individual sample correlation category counts only include significant correlations for question responses within the same sample. The "Other" correlation category counts only include significant correlations between question response from different samples. The "Relatedness" correlation category counts are excluded from all other correlation categories and only include significant correlations between the sample relatedness question and all other questions. The "Total" correlation category is the sum of all other correlation categories.

Supplementary Table 13. Frequency counts of significant correlations between category and line scales combined across analytic and holistic cognitive groups for the correlation categories. Global Pearson chi-square and Fisher's Exact Tests (FET) show results of significance tests between the total table and within individual correlation categories

Correlation Category*	Category Scale Count	Line Scale Count	FET Test Statistic (z value)	*P*-value
Fruit Water	44	51	-0.419	0.675
Mixed Fruit	33	34	0.000	1.000
Orange Water	28	39	-1.093	0.275
Pineapple	25	31	-0.516	0.606
Other	**173**	**154**	**2.045**	**0.041**
Relatedness	8	17	-1.528	0.127
Total	311	326	-0.785	0.433
Global Chi-Square Value	7.34			
Global *P*-Value	0.196			

* Individual sample correlation category counts only include significant correlations for question responses within the same sample. The "Other" correlation category counts only include significant correlations between question response from different samples. The "Relatedness" correlation category counts are excluded from all other correlation categories and only include significant correlations between the sample relatedness question and all other questions. The "Total" correlation category is the sum of all other correlation categories.

Supplementary Table 14. Food-related AHS with each question's respective food experience category and analytic-holistic construct*

Question**	Food Category	Analytic-Holistic Construct
1) The surrounding store environment determines what I will buy when shopping for food	Shopping	Causality
2) I let my feelings decide what I will buy when shopping for food	Shopping	Causality
3) Promotions and coupons influence what food I buy	Shopping	Causality
4) I only purchase items that are on my grocery list (R)	Shopping	Perception of Change
5) I will only buy a food if I know I already like it (R)	Shopping	Perception of Change
6) Advertisements and displays never impact what foods I buy (R)	Shopping	Perception of Change
7) Preparing one part of a meal is dependent on all other aspects of the meal	Preparing	Causality
8) A small change when cooking can have significant impacts on all other aspects of the food	Preparing	Causality
9) All aspects of a meal I make must be connected to one another	Preparing	Causality
10) When I prepare a meal, I also focus on table setting that will go with the meal	Preparing	Locus of Attention
11) When I prepare a meal, I focus on featuring a single attribute or ingredient of the meal (R)	Preparing	Locus of Attention
12) My feelings and experiences determine my perception of food I am eating	Consuming	Causality
13) Food liking is dependent on my overall perception of the food	Consuming	Causality
14) If I currently like a food product, I will always like that food in the future (R)	Consuming	Perception of Change
15) My opinions of food products are continuously changing	Consuming	Perception of Change

*Participants must answer each question by stating their opinion of each statement ranging from Strongly Disagree (1) to Strongly Agree (7). Scores are then summed across all questions, with higher and lower scores indicating more holistic and analytic tendencies, respectively.
**(R) indicates this question is reverse coded when scored.

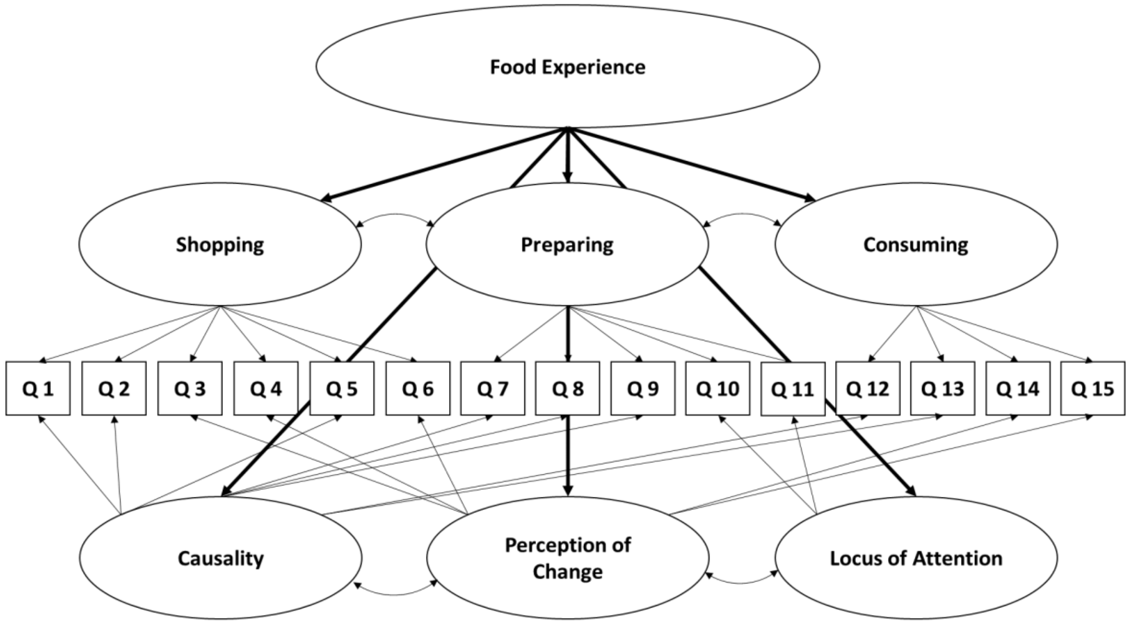

Figure 1. Full, 15-question food-related AHS model visualized from confirmatory factor analysis and structural equation modelling. Questions are visualized through rectangles and loaded onto their respective food experience categories and analytic-holistic constructs, visualized as ovals, through one-sided arrows. Double-sided arrows between food categories or analytic-holistic constructs indicate a covariance within the model. All food experience categories and analytic-holistic constructs load onto an over-arching latent factor of food experience through bolded, one-sided arrows

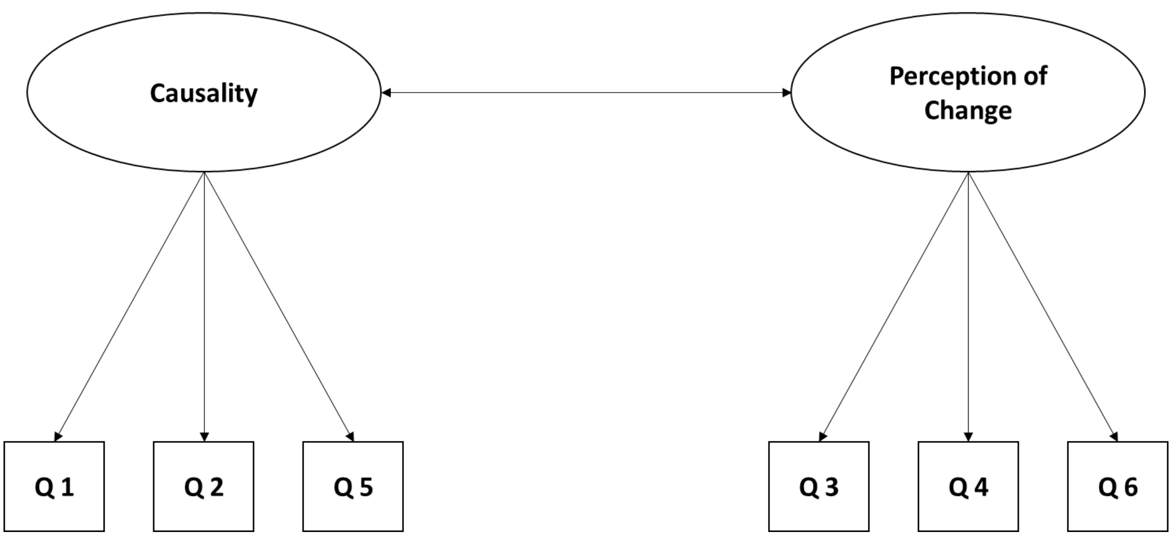

Figure 2. Shopping food-related AHS sub-scale model visualized from confirmatory factor analysis and structural equation modelling. Questions are visualized through rectangle and loaded onto their respective analytic-holistic constructs, shown through ovals, within the shopping food experience category. Double-sided arrows between constructs indicate a covariance

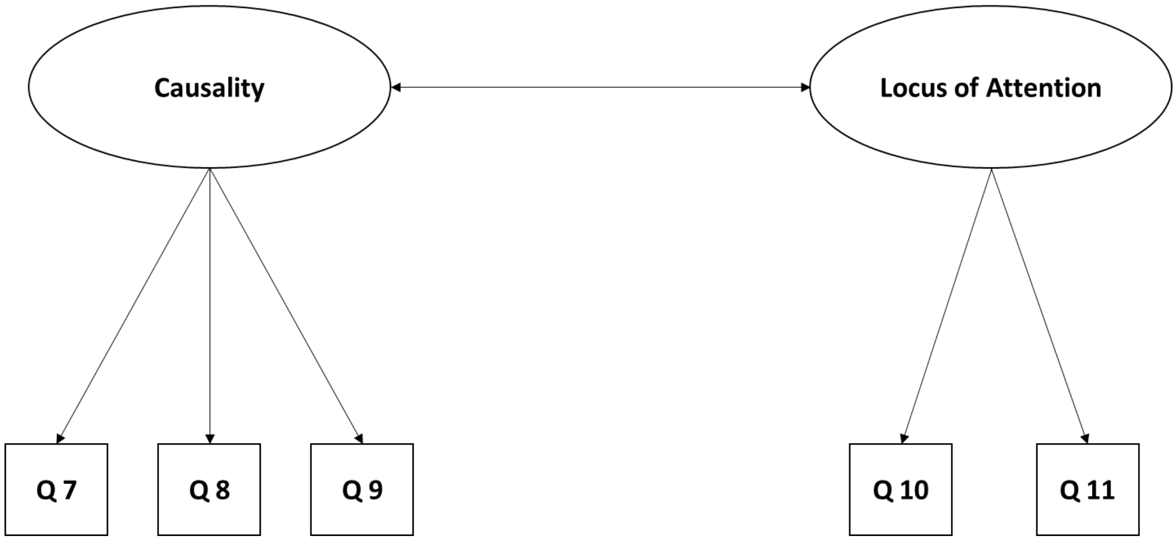

Figure 3. Preparing food-related AHS sub-scale model visualized from confirmatory factor analysis and structural equation modelling. Questions are visualized through rectangle and loaded onto their respective analytic-holistic constructs, shown through ovals, within the shopping food experience category. Double-sided arrows between constructs indicate a covariance

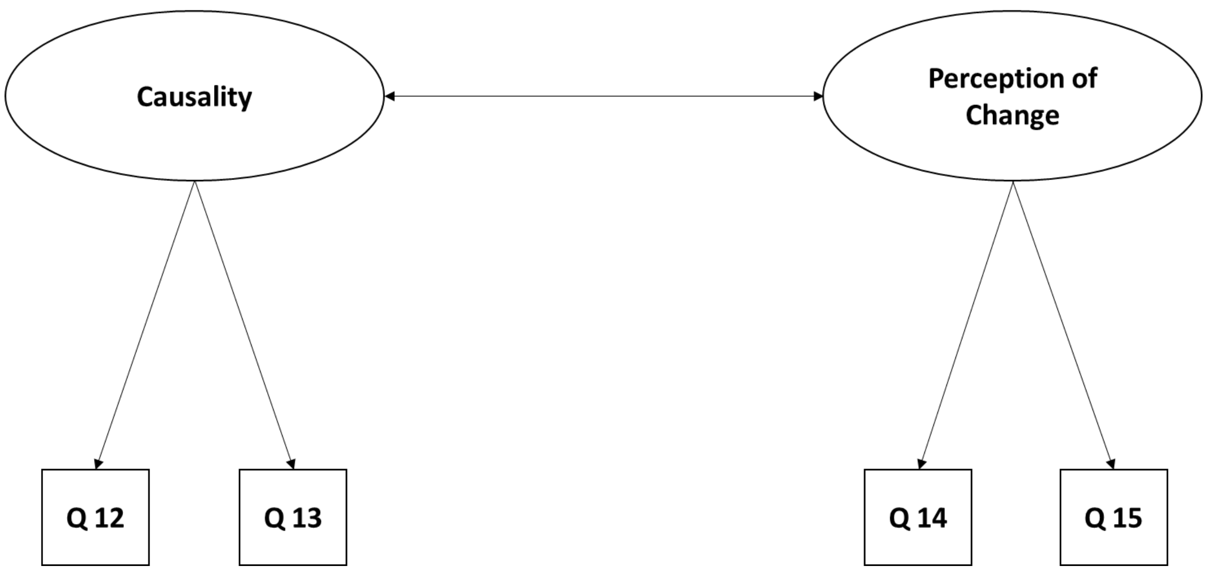

Figure 4. Consuming food-related AHS sub-scale model visualized from confirmatory factor analysis and structural equation modelling. Questions are visualized through rectangle and loaded onto their respective analytic-holistic constructs, shown through ovals, within the shopping food experience category. Double-sided arrows between constructs indicate a covariance

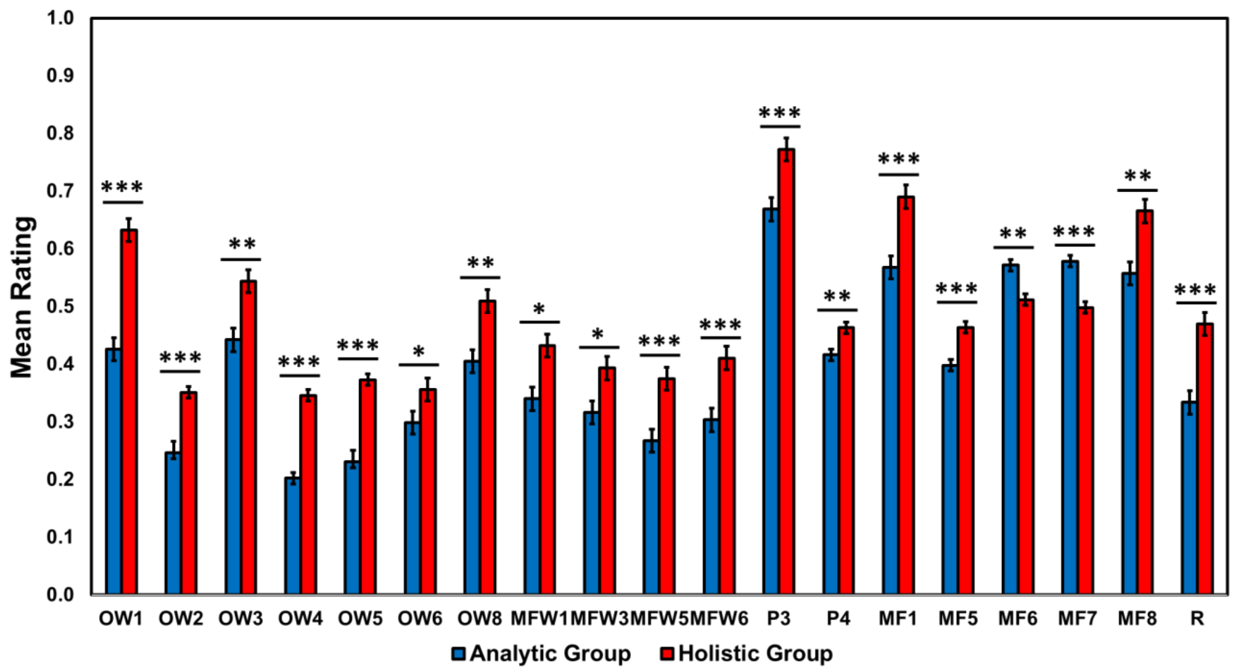

Figure 5. Mean comparisons (+/- standard error) between cognitive groups combined across scale type data for sample-question combination mean rating significantly differing between analytic and holistic groups. OW = Orange Water, MFW = Mixed Fruit Water, P = Pineapple, MF = Mixed Fruit, R = Relatedness Question, 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/ Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

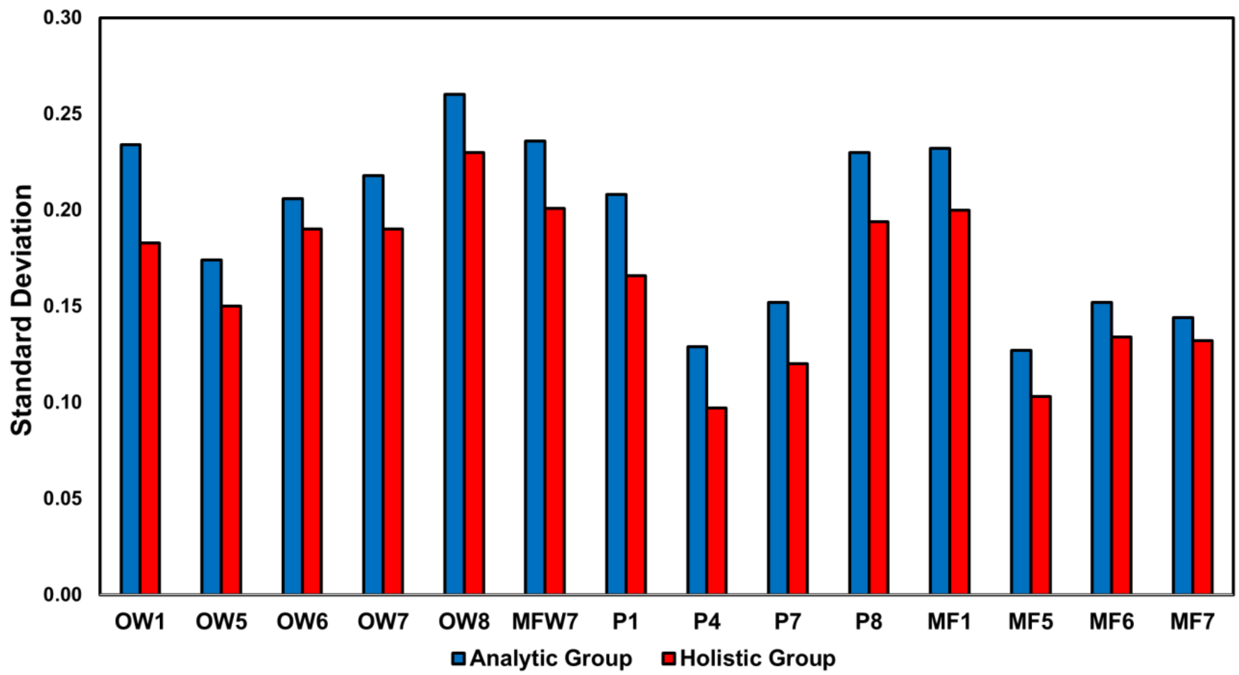

Figure 6. Variance comparisons (Standard deviations) through Levene's tests of unequal variances between cognitive groups combined across scale type data for questions found to have significantly difference variances. OW = Orange Water, MFW = Mixed Fruit Water, P = Pineapple, MF = Mixed Fruit, R = Relatedness Question, 1 = Flavor Liking, 2 = Flavor Intensity, 3 = Orange/Pineapple Flavor Liking, 4 = Orange/ Pineapple Flavor Intensity, 5 = Sweetness Intensity, 6 = Sourness Intensity, 7 = Bitterness Intensity, 8 = Overall Liking, ****$P < 0.05$, *****$P < 0.01$**, ******$P < 0.001$

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GENERAL CONCLUSION

To summarize, the findings from Chapter 2 offer the first concrete evidence that analytic and holistic consumers perceive and respond to their shopping, preparing, and consuming food experiences in significantly different ways. Specifically, the holistic group was found focus much more on the overall, experiential, and multiple aspects of the food experience, while the analytic group emphasized the singular and individual aspects of their food experiences. Such findings then support the application of the analytic-holistic cognitive theory within food, sensory, and consumer sciences and warrant the additional studies of this dissertation in furthering this area of study. Chapter 3 directly builds off these outcomes by showing that individuals with more holistic tendencies are more likely to be impacted by their eating environment relative to those with more analytic tendencies. While showing these findings, Chapter 3 also confirms a paramount finding from earlier analytic-holistic psychology research, which further supports the application of analytic-holistic theory in food, sensory, and consumer research. Following, Chapter 4 was able to provide basic research findings into specifically how and where analytic and holistic groups and their associated response data differ across a variety of common types of sensory evaluation tasks and samples. Within these findings, the differences between cognitive style groups were confirmed through findings suggesting analytic-holistic differences across the difference indices. Chapter 5 then built on prior research and results from Chapters 3 and 4 suggesting that the Analysis-Holism Scale (AHS) may not be the most effective tool within food and sensory applications. Chapter 5 developed a new food-related AHS (F-AHS) and it was also able to validate the F-AHS by showing superior consumer segmentation and outcomes in sensory research settings when compared to the AHS consumer segmentation findings from Chapter 4. Through employing the F-AHS in future studies, researchers can gain a more clear and cohesive understanding of how analytic-holistic differences impact the wide range of scenarios involving food, sensory and consumer areas. Collectively, these dissertation studies provide unanimous support that the analytic-holistic cognitive theory is important when conducting food and consumer research, while also providing future researchers a measurement tool capable of accurately separating consumers into cognitive groups within these settings. Through employing the F-AHS and accounting for analytic-holistic consumer differences, researchers can more accurately segment consumers to obtain more representative data. Subsequently, with data better representing the consumers, data-driven decisions can be more precise, and, specifically within the food and consumer industry, product development projects can create products more representative of consumers' needs and wants. Together, by researchers building off the findings from this dissertation, future research exploring how analytic-holistic differences can affect the consumer food experience offers promising opportunities to continue to grow the field of food, sensory, and consumer sciences.

APPENDIX

RESEARCH COMPLIANCE PROTOCOL LETTERS – APPROVAL LETTER

UNIVERSITY OF ARKANSAS

To:	Han-Seok Seo
From:	Justin R Chimka, Chair IRB Expedited Review
Date:	08/23/2021
Action:	**Exemption Granted**
Action Date:	08/23/2021
Protocol #:	2108348528
Study Title:	Effect of cognitive style on consumer responses to food samples

The above-referenced protocol has been determined to be exempt.

If you wish to make any modifications in the approved protocol that may affect the level of risk to your participants, you must seek approval prior to implementing those changes. All modifications must provide sufficient detail to assess the impact of the change.

If you have any questions or need any assistance from the IRB, please contact the IRB Coordinator at 109 MLKG Building, 5-2208, or irb@uark.edu.

cc: Thadeus L Beekman, Investigator