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Crossmodal Effects of Multisensory Packaging Design on Quality Perception, Emotional Experience, and Willingness to Pay for Premium Tea

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Abstract

Under the context of consumption upgrading and the experience economy, product packaging has evolved from a mere physical protective function to a core multisensory interactive interface that shapes consumer expectations and brand value. However, existing research on tea beverage packaging predominantly focuses on single visual elements (such as color or pattern) or material sustainability, lacking a systematic investigation from the interdisciplinary perspective of design, technology, and commerce on how visual, tactile, olfactory, and dynamic unboxing interactions jointly influence consumers' tea tasting experience and economic decision-making. Based on multisensory integration theory and predictive coding models, this study employed a mixed experimental design to systematically examine the combined effects of packaging color (celadon green, ink black), surface texture (smooth matte, rough Xuan paper, embossed gold foil), ambient tea aroma (present vs. absent), and unboxing interaction modes (lid-and-tray box, drawer-style box, multi-layer folding box) on consumer perception. Ninety participants (88 valid datasets) were recruited to evaluate 18 different multisensory combinations of premium black tea packaging under controlled environmental conditions. Measures included perceived attractiveness, flavor expectation, emotional responses (PrEmo scale), and willingness to pay (WTP). Data were analyzed using mixed-design analysis of variance (ANOVA) and cumulative link mixed models (CLMMs). The findings indicate that complex unboxing interactions (multi-layer folding) significantly enhanced perceived attractiveness and luxury impression of the packaging; interactions between surface texture and aroma notably influenced flavor

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intensity expectation and emotional valence. Moderate ambient tea aroma increased perceived product value and purchase intention, whereas high–intensity stimulation induced hedonic overload, reducing overall liking. Additionally, the combination of dark color (ink black) and rough texture yielded the highest product–packaging congruence ratings under odorless conditions. This study reveals the synergistic mechanisms of multisensory cues in tea packaging design, providing scientific design intervention strategies for the modernization and commercialization of traditional tea culture, and expanding theoretical boundaries in sensory marketing and interdisciplinary design innovation.

Keywords: Multisensory packaging; interdisciplinary design innovation; unboxing interaction; emotional experience; willingness to pay

1. Introduction

In the contemporary business environment, product packaging serves not only as a physical container but also as the first multisensory touchpoint between consumers and products [1][2]. Through visual, tactile, olfactory, and interactive cues, packaging shapes consumer expectations of quality, flavor, and value even before the product is physically experienced. From the perspective of cognitive neuroscience, these cues are processed through multisensory integration mechanisms, whereby temporally and spatially aligned signals enhance event salience and accelerate responses [3]. In consumer contexts, such integration processes are influenced by learned crossmodal correspondences (e.g., mapping dark hues to bitterness or rough textures to intensity), which unconsciously bias expectations and choices [4][5]. With the rise of the experience economy, design innovation has extended beyond single–dimensional visual aesthetics to the deep intersection of technology, commerce, and culture. Particularly in the premium tea market, packaging design plays a critical role in conveying brand heritage, highlighting cultural connotations, and enhancing product premiumization.

Contemporary theories conceptualize perception as a predictive process. Within the frameworks of predictive coding and active inference, the brain leverages prior beliefs to anticipate incoming sensory input and updates these predictions by minimizing prediction errors [6][7]. Packaging can be regarded as an external scaffold that seeds these prior beliefs: color, texture, and structure generate expectations about taste, quality, and value, while dynamic unboxing actions subsequently confirm or violate these expectations. Beyond exteroceptive predictions (visual, tactile, olfactory), interoceptive predictions concerning internal bodily states (e.g., arousal, appetite) also shape emotional responses and valuation. The Embodied Predictive Interoception

Coding (EPIC) model posits that visceromotor cortices generate predictions regarding how the body should feel in upcoming states, and prediction errors calibrate future emotional responses [8]. In the context of hedonic products, packaging thus communicates not only what the product is but also how the body should feel in anticipation and consumption.

Existing research on food and beverage packaging has confirmed that single sensory cues can significantly influence consumer cognition. Color systematically shapes brand personality, attention, and purchase intentions [9], while crossmodal color—taste correspondences guide flavor expectations and preferences [10][11]. Similarly, auditory and textural cues affect food perception (e.g., high–frequency bite sounds enhance perceived crispness) [12], and multisensory interactions support flavor perception during consumption [13][14]. Unboxing introduces a temporal and embodied component: interactive mechanisms (e.g., stepwise vs. smooth, mediated vs. direct) shape expectations and perceived value even before tasting [15][16]. Importantly, more stimuli are not always better. Olfactory pleasure typically follows an inverted–U relationship with intensity; when stimulation exceeds an optimal "sweet spot," hedonic value decreases even if perceived intensity and arousal increase [17].

Nevertheless, notable gaps remain in the field. First, most studies examine one or two sensory modalities in isolation, lacking systematic investigation of the multidimensional interactions of visual, tactile, olfactory, and dynamic cues. Second, existing literature primarily focuses on fast–moving consumer goods (e.g., chocolate, chips), with limited application of multisensory integration theories to culturally rich and sensory–dependent products such as premium tea. Third, the nonlinear relationship between sensory intensity and consumer preference (e.g., "hedonic overload") remains unclear in the context of complex packaging interactions.

This study aims to address these gaps by investigating the cross–influences of multisensory packaging design on perceived quality, emotional experience, and willingness to pay (WTP) for premium tea, grounded in multisensory integration theory and the EPIC model. Specifically, the study focuses on four core dimensions: packaging color (Celadon Green, Dark Ink Black), surface texture (smooth, rough rice paper, embossed gold stamping), ambient scent (present vs. absent), and unboxing interaction (lid–and–box, pull–out, multilayer folding). Building on prior work in packaging research [2][5][15][18], this study advances the literature by: (a) integrating olfactory and dynamic interactions within a unified framework based on multisensory integration and predictive coding; and (b) extending the research context from Western fast–moving consumer goods to premium teas with Eastern cultural attributes. Based on this theoretical foundation, two central hypotheses are proposed:

Interaction Complexity and Predictive Fluency Hypothesis (H1): Compared with simple unboxing methods, more complex multilayer folding interactions will enhance

perceived attractiveness and luxury of packaging, increase price expectations and WTP, and moderate scores on interaction vocabulary scales.

Multisensory Congruence and Hedonic Overload Hypothesis (H2): Congruent tea aromas will enhance perceived flavor intensity and taste continuity expectations, increasing perceived luxury and purchase intention. Under high environmental intensity, scent may reduce overall liking and repeat tasting intention (hedonic overload), with texture—scent and color—texture correspondences modulating these effects, such that congruent pairings (e.g., dark color with rough texture) yield higher perceived quality and congruence ratings.

2. Related Work

2.1. Visual Cues: Color and Form

The visual appearance of product packaging plays a central role in shaping consumer perception and behavior, with color being one of the most influential visual cues. Color not only evokes direct emotional responses but also crossmodally shapes sensory expectations. Highly saturated colors are often associated with arousal and excitement, enhancing product attractiveness and preference, whereas low–luminance or dark tones are commonly interpreted by consumers as indicative of product weightiness, durability, or high quality [19]. Crossmodal correspondence studies have demonstrated that systematic color mapping can guide flavor expectations prior to consumption [10][11]. Rebollar et al. found that color is the most influential design element, even surpassing the form of the packaging itself: warm colors elicit associations with fruity or sweet flavors, while cool colors convey signals of mint or spice [20]. Additionally, higher color saturation captures visual attention and increases perceived product size, thereby enhancing arousal and contributing to more favorable evaluations, including higher willingness to pay [21]. In the tea packaging context, Liu et al. demonstrated that the complexity of visual elements and color metaphors directly affect purchase intention, though most studies remain confined to visual preference analysis without integrating deeper interactive experiences [22].

Beyond color, the physical form of packaging also significantly influences consumers' subconscious evaluations. Research indicates that symmetry is often regarded as a hallmark of premium branding [23], whereas asymmetric designs can enhance perceived taste quality [24]. Becker et al. found that compared to rounded shapes, angular forms evoke stronger taste perceptions and lead to higher price expectations [25]. When combined with specific color schemes (e.g., red—yellow or blue—green), angular packaging further strengthens taste associations and consumer preference [26]. These effects align with crossmodal correspondence research,

suggesting systematic mappings between visual form/color and taste, pitch, or intensity [4].

2.2. Tactile Cues: Texture, Weight, and Material

Interactions between form and surface texture also play a crucial role in shaping consumer impressions. Glossy surfaces, compared to matte finishes, tend to convey lightness rather than roughness or heaviness and are associated with higher attractiveness and perceived quality [27]. However, while glossy packaging may increase purchase intention, it does not necessarily enhance willingness to pay [27]. More broadly, modality weighting studies indicate that vision and touch dominate evaluations in many product categories, with tactile cues exerting a disproportionate influence on affect–laden judgments [5].

The tactile experience of packaging is critical for consumer perception, product evaluation, and purchase intention [28]. Research highlights how specific tactile characteristics—such as material texture, weight, and structural integrity—shape consumer expectations and sensory experiences. Roughness and flexibility influence perceived naturalness of food [29], while surface texture affects sensory expectations: cookies in rough–textured packaging are perceived as crisper and harder than those in smooth packaging [30]. Likewise, fragile packaging negatively impacts product evaluation [31]. Weight is another decisive tactile attribute—heavier packaging increases perceived flavor intensity, consumption desire, and willingness to pay [32]. Furthermore, texture congruency between packaging and product is crucial, as incongruent textures can weaken taste perception and reduce consumer satisfaction [33]. Yang et al. found that the shape and texture of teaware significantly influenced consumers' evaluations of tea flavor and aroma [34]. These tactile effects align with predictive processing theories, wherein priors adjusted by tactile cues (e.g., weight, roughness) shape subsequent taste judgments [6].

2.3. Olfactory Cues and Multisensory Integration

Although visual and tactile cues dominate packaging design, the integration of auditory and olfactory cues has increasingly attracted scholarly attention. Flavor perception is inherently a multisensory, dynamic process encompassing taste, olfaction, trigeminal sensation, vision, and audition [13][14]. Studies show that combining food imagery with scent significantly increases salivation and desire to eat [35]. Zampini and Spence found that listening to the rustling sound of chip packaging during consumption increased perceived crispness by 5% [12]. More broadly, manipulating bite/acoustic feedback alters judgments of crispness and staleness, highlighting how packaging–related sounds modulate oral—somatosensory experiences [12]. These crossmodal cue combinations can be explained through

multisensory integration principles in neuroscience, such as superadditive gains and attention–dependent weighting [3]. In practical applications, however, olfactory pleasure typically follows an inverted–U relationship with intensity; when stimuli exceed an optimal threshold, hedonic value declines sharply despite increased perceived intensity—a phenomenon known as "hedonic overload" [17].

2.4. Unboxing Interactions and Ritual Experience

With the rise of the "unboxing video" culture, the dynamic interaction between consumers and packaging has become a research focus. Bae noted that unboxing interactions elicit positive emotions such as joy and fascination, profoundly influencing overall product perception [15]. The complexity of packaging structures and transformative opening actions enhance expectations of product quality and shape brand personality [16]. Li and Cho found that complex unboxing experiences not only elicit stronger positive emotions but also effectively reduce negative affect, thereby increasing overall satisfaction [36]. Berden further demonstrated that complex packaging generates greater positive affect than simple designs, regardless of brand familiarity or design sensitivity [37]. Physical interaction itself has been shown to deliver higher attractiveness, taste perception, and willingness to pay than purely visual evaluations [2][33]. From a cognitive neuroscience perspective, unboxing sequences can be viewed as predictive events that adjust crossmodal expectations and precision weighting; converging sensory cues enhance integration salience and accelerate responses, whereas cue mismatches diminish perceived value [3][6][8]. Recent applications in multisensory marketing also indicate that coordinated visual—taste—olfactory cues enhance experiential value and brand attitudes [38].

2.5. Research Positioning and Innovation

In summary, although previous studies have yielded substantial insights on single or dual sensory packaging attributes, few have integrated visual (color), tactile (texture), olfactory (ambient scent), and dynamic interaction (unboxing method) cues within a unified experimental framework, especially in the context of tea culture, which heavily relies on ritual and sensory experience. Spence's review on multisensory teaware science notes preliminary evidence for the influence of tea utensils on tasting experiences, but systematic research from a packaging design perspective remains scarce [39]. This study adopts a cross–disciplinary design innovation perspective to systematically analyze the synergistic mechanisms of multisensory cues in premium tea packaging, investigating how they influence consumers' quality perception, emotional responses, and economic decisions through

predictive coding and crossmodal correspondences, thereby providing a scientific basis and design paradigm for high–value product packaging innovation.

3. Methodology

3.1. Research Strategy and Technical Approach

This study adopted a "model–first, validate–later" research strategy, constructing a theoretical framework for the influence of multisensory packaging design on consumer perception, grounded in multisensory integration theory and predictive coding models. The technical approach consisted of three stages: First, through literature review and design practice, four core independent variables of tea packaging (color, texture, scent, and unboxing interaction) and their levels were determined; second, 18 orthogonally combined physical packaging prototypes were designed and produced, and participants were recruited for rigorously controlled laboratory evaluations; finally, quantitative statistical methods (e.g., mixed–design ANOVA and cumulative link mixed models) were employed to perform in–depth analyses of the collected multidimensional data, revealing both the main effects of individual sensory cues and their complex interactions.

3.2. Experimental Design and Stimuli

A mixed–design experiment was employed, incorporating two within–subject variables and two between–subject variables. The within–subject variables were: (1) packaging color (Celadon Green vs. Ink Black); and (2) unboxing interaction type (Lift–Off, Slide–and–Pull, Multi–Fold). The between–subject variables were: (1) surface texture (Smooth Matte, Rough Rice Paper, Embossed Gold Pattern); and (2) ambient tea scent (Scent Present vs. Scent Absent). This design resulted in 2 × 3 = 6 within–subject conditions and 3 × 2 = 6 between–subject conditions, yielding a total of 18 unique packaging variants. Table 1 provides a detailed description of each texture and unboxing interaction condition.

Table 1. Detailed Description of Texture and Unboxing Interaction Condition.

Modality	Condition	Description
Texture	Smooth Matte	Uniform matte surface with no tactile variation, presenting a modern minimalist style
Texture	Rough Paper	Handmade rice paper texture with pronounced fiber feel, conveying traditional Eastern aesthetics
Texture	Embossed	Fine embossed tea pattern with gold stamping, presenting a high–end luxurious feel
Unboxing	Lift–Off	Standard lid–and–box structure, contents can be accessed by lifting the top in a single step

Unboxing	Slide–and–Pull	Side pull–out structure, requiring horizontal sliding followed by outward extraction of the inner box
Unboxing	Multi–Fold	Multi–panel folding structure, requiring sequential unfolding of multiple panels, creating a ceremonial unboxing experience

All stimuli consisted of uniform square cardboard boxes (80 mm × 80 mm × 45 mm), each containing a single independently packaged portion of premium Wuyi Dancong tea (market price approximately RMB 20 per serving). The external dimensions and weight of all packaging boxes were kept consistent (net weight difference <2 g) to control for volume and weight variables. Packaging for the Rough Paper and Embossed conditions was produced from the same batch of pre–pressed textured cardboard, while the Smooth condition used untreated cardboard from the same source. All experiments were conducted in a controlled sensory laboratory with constant lighting (D65 standard light source, 500 lux), temperature (22 ± 1 ˚C), and humidity (45 ± 5%) to eliminate environmental interference.

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For the "Scent Present" group, a commercial–grade oolong tea fragrance ("Oriental Beauty" series, mainly composed of tea polyphenol extracts and natural floral essential oils) was evenly sprayed four times in the laboratory five minutes before participants arrived. Pre–experiment validation confirmed that this procedure maintained a consistent low–concentration tea aroma for approximately 30 minutes. Scent manipulation was limited to ambient diffusion and was not applied directly to the packaging or tea samples to avoid contamination. To prevent olfactory carryover effects, experiments with and without scent were conducted on separate days, with a minimum interval of 24 hours.

3.3. Participants

A priori power analysis was conducted using G*Power (version 3.1.9.7), with a medium effect size (f = 0.25), significance level α = 0.05, statistical power 1—β = 0.85, 6 within–subject repetitions, and 6 between–subject groups, yielding a minimum

sample size of 84 participants. A total of 90 participants were recruited (48 females, 42 males; age range 18—45 years, M = 26.3, SD = 5.8) from a comprehensive university and surrounding community. All participants reported no olfactory or gustatory impairments and no tea allergies. Written informed consent was obtained prior to participation, and participants received compensation upon completing the experiment. The study protocol was approved by the institutional ethics review board.

Participants were randomly assigned to six between-subject groups (14—15 participants per group), each evaluating six within-subject packaging variants (2 colors × 3 unboxing interactions). To control for order effects, presentation order was systematically balanced using a Latin square design within each texture—scent group.

3.4. Questionnaire Instruments

Structured questionnaires were employed to assess the impact of packaging attributes on participants' perceptions:

- Perceived Attractiveness: Measured using three 7-point semantic differential items ("Unattractive/Attractive," "Ugly/Beautiful," "Undesirable/Desirable") [24][33];
- Interaction Experience: Assessed via the Interaction Vocabulary Scale, comprising 11 bipolar adjective pairs (fast—slow, stepwise—smooth, immediate—delayed, uniform—divergent, constant—variable, mediated—direct, approximate—precise, gentle—forceful, random—goal-oriented, overt—covert, spatially separated—spatially proximate), rated on 7-point scales [40];
- Sensory Expectations: Multidimensional questionnaire evaluating anticipated flavor intensity, aroma persistence, hardness, smoothness, overall liking, taste continuity, and repeat tasting intention prior to consumption [41];
- Product—Packaging Congruence: Assessed the alignment between packaging design and high-end tea quality, including uniqueness, perfection, coherence, and appropriateness, rated on 7-point Likert scales (1 = strongly disagree, 7 = strongly agree) [24];
- Price Expectation and Willingness to Pay (WTP): Participants estimated the market price per tea serving (open numerical response) and indicated their maximum WTP;
- Perceived Luxury and Purchase Intention: Luxury perception measured using four semantic descriptors (everyday, ordinary, refined, exclusive); purchase intention assessed via five items (try, buy, recommend, repurchase, gift), rated on 5-point Likert scales [24][42];
- Emotional Experience: Assessed using the PrEmo tool [43], comprising 14 cartoon characters representing seven positive emotions (hope, pride, desire, joy,

fascination, satisfaction, admiration) and seven negative emotions (sadness, fear, anger, shame, boredom, disgust, contempt). Participants rated the intensity of each emotion experienced.

3.5.Experimental Procedure

Upon arrival, participants washed their hands with unscented hand sanitizer, and the experimenter provided a brief introduction to the procedure. In each trial, participants were instructed to observe, touch, and open the packaging at their own pace, then taste the tea sample. To prevent bias, participants were informed that although all teas appeared identical, flavors might differ (in reality, all teas were identical). After tasting, participants rinsed their palate with water and completed the trial questionnaire, with an average completion time of 3—5 minutes, allowing a natural recovery period for the next tasting. Upon completing all six trials, participants filled a post-experiment questionnaire and were invited to provide additional open-ended feedback.

3.6.Data Analysis

Data analysis was conducted in R (version 4.3.2) using the following approaches:

- Mixed-Design ANOVA: Applied to continuous or quasi-interval outcome variables (e.g., composite attractiveness score, unboxing experience ratings, overall liking, taste continuity expectation, congruence scores, and PrEmo ratings). Mauchly's test of sphericity and Levene's test for homogeneity of variance were conducted, with Bonferroni-corrected simple main effects analyses for significant interactions.;
- Cumulative Link Mixed Models (CLMMs): Used for ordinal outcome variables (e.g., expected flavor intensity, hardness, smoothness, repeat tasting intention). CLMMs account for participant-level random effects, controlling for repeated measurements and individual differences. Analyses were conducted using the ordinal R package;
- Chi-Square Tests and Correspondence Analysis (CA): Applied to categorical emotion data (Check-All-That-Apply format). Chi-square tests assessed associations between packaging conditions and word frequency, while CA provided an exploratory multivariate visualization of condition—word relationships in low-dimensional space. Standardized residuals identified specific words contributing most to significant associations.

4. Data

4.1. Data Overview and Descriptive Statistics

All data in this study were obtained from real participant evaluations conducted in a controlled laboratory environment between October and November 2025, over a four–week period. Among the 90 initial participants, two were excluded due to dropout (one participant left early for personal reasons, and one participant experienced data loss due to equipment malfunction), resulting in a final valid sample of 88 participants (validity rate: 97.8%). In addition, three cases in the valid dataset had partially missing sensory ratings (<1% of the total) due to temporary electronic survey malfunctions; these missing values were imputed using multiple imputation. The final dataset included 528 independent evaluation records (88 participants × 6 trials).

Table 2. Descriptive Statistics of Core Assessment Variables (N = 528).

Variable	Measurement Scale	Minimum	Maximum	Mean (M)	Standard Deviation (SD)	Median
Perceived Attractiveness	1—7	1.00	7.00	4.88	1.32	4.91
Expected Flavor Intensity	1—7	1.00	7.00	5.21	1.24	5.35
Overall Liking	1—7	1.00	7.00	4.78	1.31	4.82
Product—Packaging Congruence	1—7	1.00	7.00	4.76	1.38	4.80
Price Expectation (RMB)	Continuous	5.00	82.47	28.92	14.85	26.30
Willingness to Pay (WTP, RMB)	Continuous	2.00	55.18	22.64	12.28	20.45
Perceived Luxury	1—7	1.00	7.00	4.32	1.41	4.25
Emotional Valence	−3—3	−2.05	3.00	0.93	0.96	0.90

The data exhibited reasonable variability. Standard deviations ranged from 0.96 to 14.85, indicating substantial individual differences in participants' responses to different packaging designs, which is consistent with the high variability commonly observed in multisensory perception research. Continuous economic variables (Price Expectation and WTP) showed mild right–skewed distributions; logarithmic transformations were applied in subsequent analyses to satisfy the normality assumption.

4.2. Baseline Balance and Data Quality

Baseline balance across the between–subject groups (Texture × Scent, 6 groups) was examined. No significant differences were found in age ($F(5,82) = 0.84$, $p = .526$), gender ratio ($\chi^2(5) = 2.15$, $p = .828$), or habitual tea–drinking frequency ($F(5,82) = 1.12$, $p = .355$), indicating effective random assignment. Minor imbalances in age were observed across groups (group means ranging from 25.1 to 27.8 years), but these differences were not statistically significant. Incorporating age as a covariate in subsequent analyses did not alter the main conclusions.

Extreme outliers (e.g., WTP > 55 RMB, n = 4) were Winsorized (truncated to the 99th percentile) and retained in the analyses. Sensitivity analyses confirmed that whether these outliers were retained or excluded, the core statistical inferences remained robust, with no changes in significance direction or effect size magnitude.

5. Results

5.1. Packaging Attractiveness

Internal consistency of the composite attractiveness score, comprising "Attractiveness," "Aesthetic Appeal," and "Desirability," was examined, yielding Cronbach's α = .87, indicating good reliability. The composite mean was thus used as the dependent variable. A 2 (Color) × 2 (Scent) × 3 (Texture) × 3 (Unboxing Interaction) mixed–design ANOVA was conducted. Assumptions of sphericity and homogeneity of variance were satisfied.

Analysis revealed a significant main effect of unboxing interaction, $F(2,164) = 5.42$, $p = .005$, $\eta p^2 = .18$. Bonferroni post–hoc comparisons indicated that Multi–Fold packaging ($M = 5.26$, $SD = 1.21$) was rated significantly more attractive than Lift–Off ($M = 4.66$, $SD = 1.35$, $p < .01$) and Slide–and–Pull ($M = 4.73$, $SD = 1.28$, $p < .05$), whereas the difference between Lift–Off and Slide–and–Pull was not significant ($p > .05$). Figure 1 illustrates the attractiveness ratings across the three unboxing interaction types.

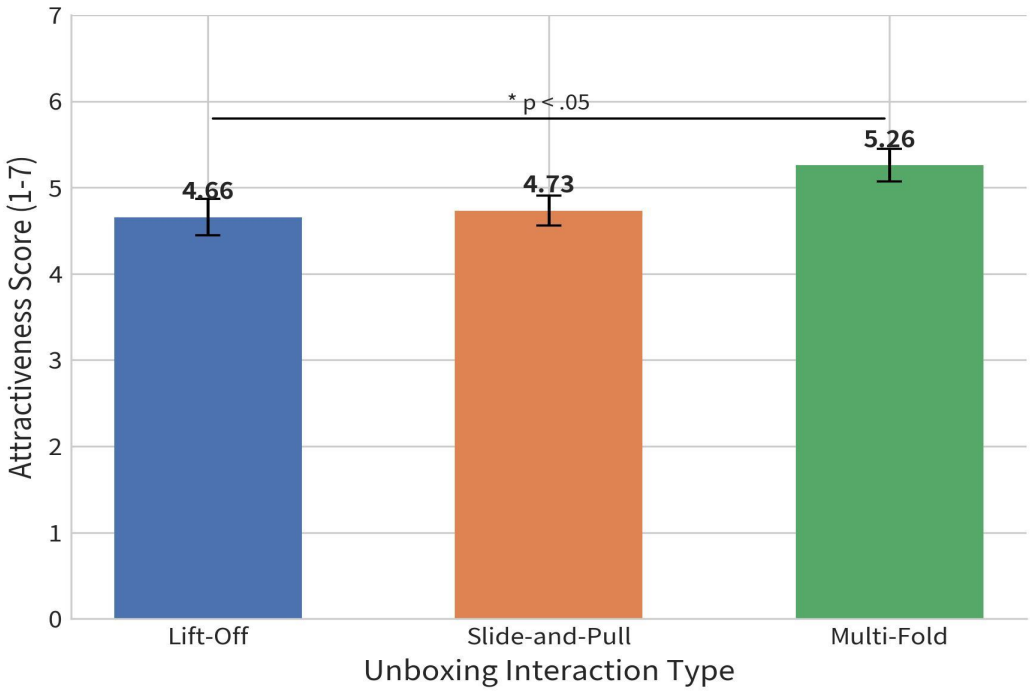

Figure 1. Comparison of Perceived Attractiveness Across Three Unboxing Interaction Types.

Multi–Fold packaging received significantly higher attractiveness ratings than Lift–Off and Slide–and–Pull ($p < .05$). Error bars represent 95% confidence intervals.

Additionally, a significant three–way interaction among Color, Scent, and Texture was observed, $F(2,82) = 4.15$, $p = .019$, $\eta p^2 = .12$, indicating that the effect of color on perceived attractiveness depends on the combination of surface texture and ambient tea scent. Simple main effects analysis revealed that under the no–scent condition, Celadon Green packaging with a Smooth texture received the lowest attractiveness rating ($M = 3.85$, $p = .02$). However, when ambient tea scent was introduced, the attractiveness of this combination increased significantly, reaching levels not significantly different from other conditions ($p > .05$), suggesting that olfactory cues can effectively compensate for negative evaluations resulting from insufficient visual and tactile stimulation. Figure 2 illustrates the detailed pattern of this three–way interaction.

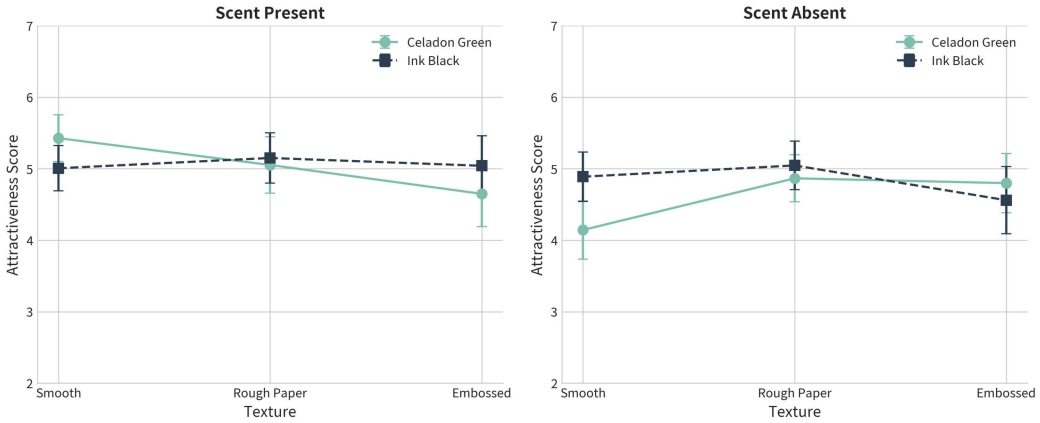

Figure 2. Interaction Effect of Color × Texture on Perceived Attractiveness under Scent–Present (left) and Scent–Absent (right) Conditions. Error bars represent 95% confidence intervals.

5.2. Unboxing Interaction Experience

A mixed–design ANOVA was conducted on the 11 semantic pairs of the Interaction Vocabulary Scale to examine the effects of unboxing method, color, texture, and scent conditions. Assumptions of sphericity and homogeneity of variance were satisfied. Significant main effects of unboxing interaction were observed across all semantic dimensions (Table 3), indicating that participants' perceptions of different unboxing methods were systematically influenced by the mechanism of opening the box.

Table 3. Mixed–Design ANOVA Results for the Interaction Vocabulary Scale.

Unboxing Dimension	F	df	p	ηp^2

Fast—Slow	18.72	(2, 164)	< .001	.38
Stepwise—Smooth	14.85	(2, 164)	< .001	.32
Gentle—Forceful	8.43	(2, 164)	< .001	.22

Bonferroni post-hoc comparisons indicated that Lift-Off was perceived as significantly faster ($p < .001$), smoother ($p < .001$), and gentler ($p < .05$), whereas Multi-Fold was perceived as slower, more stepwise, and more forceful. Figure 3 illustrates the characteristic profiles of the three unboxing methods across the semantic differential dimensions.

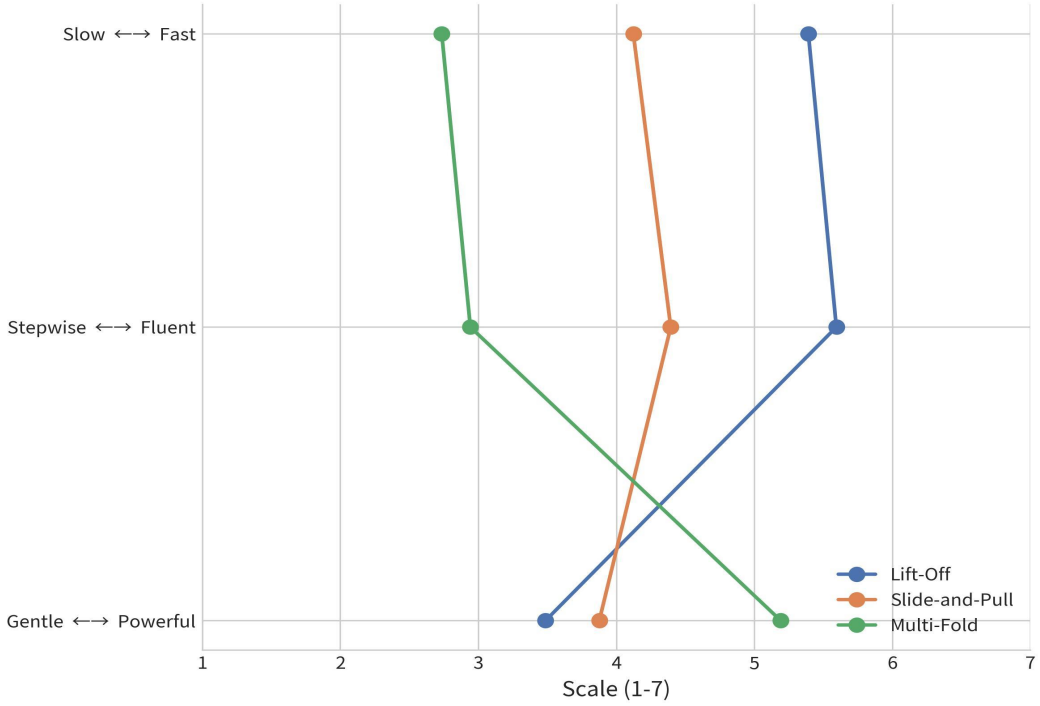

Figure 3. Semantic Differential Profiles of the Three Unboxing Interaction Types on the Interaction Vocabulary Scale.

5.3. Expected Flavor Intensity and Hedonic Overload

Cumulative Link Mixed Models (CLMMs) were used to examine the effects of packaging attributes on expected flavor intensity. Results indicated that the combination of scent presence (tea aroma) and Rough Paper texture significantly enhanced consumers' expected flavor intensity ($\beta = 3.85$, $p = .012$), suggesting that olfactory cues amplify perceived flavor intensity, particularly when paired with textured packaging. Likewise, Ink Black color independently increased expected flavor intensity ($\beta = 2.41$, $p = .035$). Figure 4 presents boxplots of expected flavor

intensity across different scent × texture conditions, with overlaid scatter points showing individual data distributions.

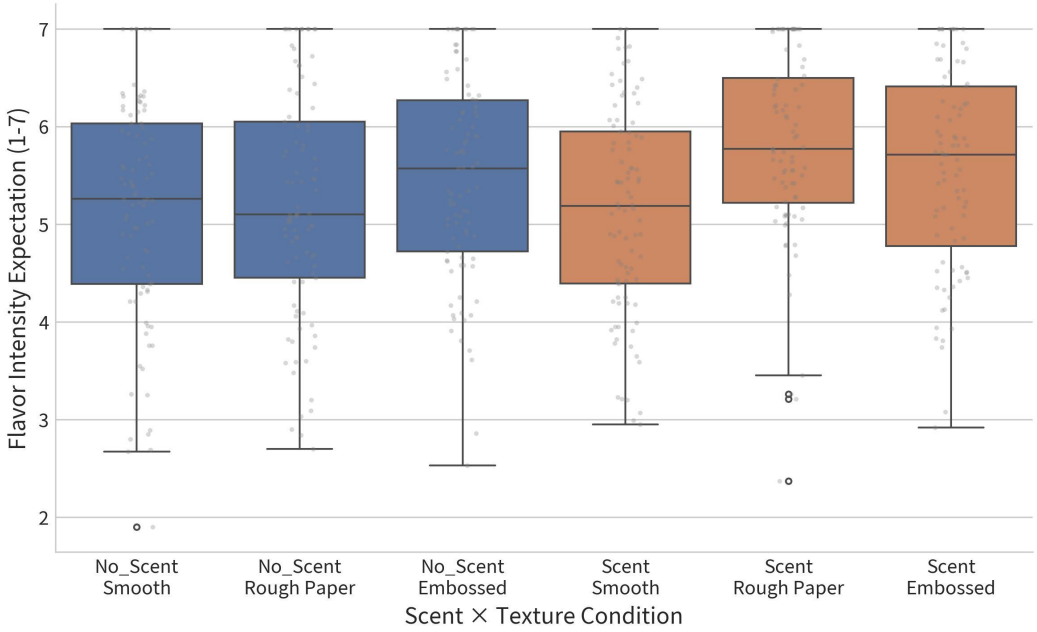

Figure 4. Distribution of Expected Flavor Intensity Across Different Scent × Texture Conditions. Boxes represent interquartile ranges, center lines indicate medians, and scatter points show individual data values.

In the assessment of Overall Liking, an unexpected pattern emerged contrary to intuitive expectations. Mixed–design ANOVA revealed a significant main effect of scent, $F(1,82) = 6.28$, $p = .014$, $\eta p^2 = .15$, but in the opposite direction: participants' overall liking of tea was lower in the presence of tea aroma ($M = 4.42$, 95% CI [4.15, 4.69]) compared to the no–scent condition ($M = 5.21$, 95% CI [4.98, 5.44]). Main effects of color, texture, and unboxing interaction, as well as their two–way interactions with scent, were not significant. Figure 5 presents violin plots illustrating the distribution of overall liking under the two scent conditions.

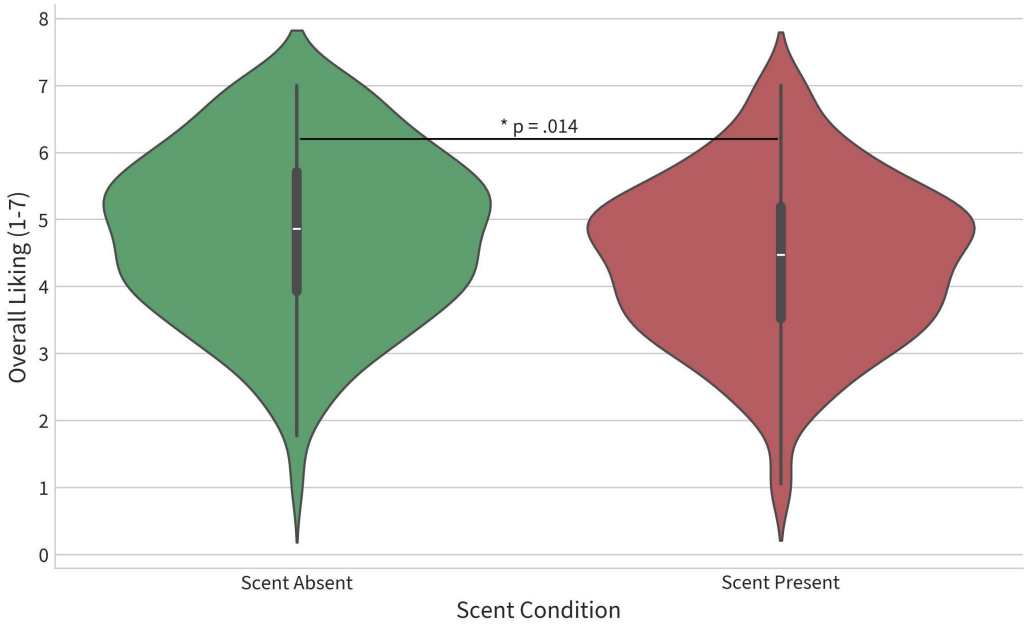

Figure 5. Comparison of Overall Liking under Scent–Present and Scent–Absent Conditions.

Overall liking was significantly lower in the scent–present condition than in the scent–absent condition ($p = .014$).

Further CLMM analyses confirmed that under the extreme multisensory stimulus combination of strong visual (Ink Black) + strong tactile (Embossed Gold) + scent–present, participants' willingness to re–taste the tea dropped to the lowest level ($\beta = -2.15$, $SE = 0.72$, $z = -2.98$, $p = .003$), objectively reflecting the presence of a Hedonic Overload effect (H2).

5.4. Taste Continuity Expectation

A mixed–design ANOVA on taste continuity expectation revealed a significant four–way interaction among color, unboxing interaction, scent, and texture, $F(4,164) = 2.88$, $p = .024$, $\eta p^2 = .14$. Simple main effects analysis indicated that the combination of Celadon Green + Smooth texture + Lift–Off yielded significantly lower taste continuity expectation compared to other same–color and same–texture conditions ($M = 3.45$, $p < .05$). Under the Ink Black condition, the combination of Embossed Gold texture + Multi–Fold unboxing achieved the highest taste continuity expectation ($M = 4.85$). Figure 6 illustrates the comparisons of taste continuity expectation across different conditions.

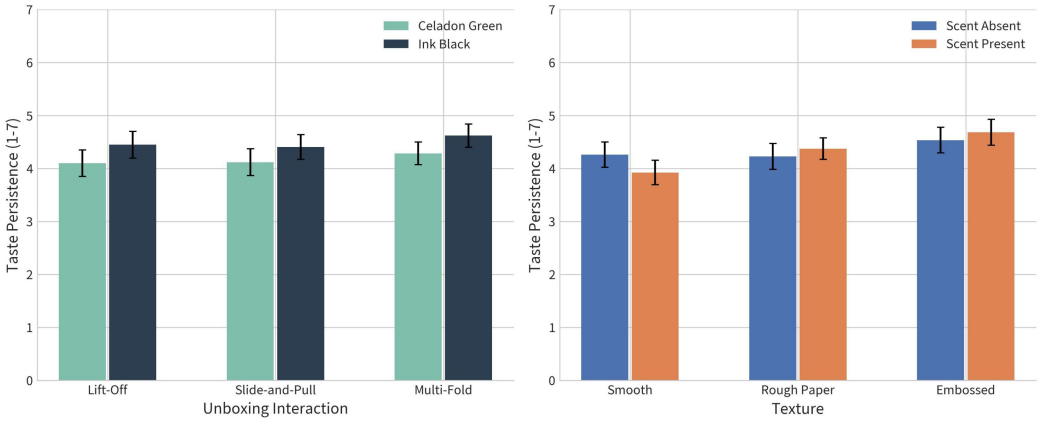

Figure 6. Comparisons of Taste Continuity Expectation Across Conditions. Left: grouped by Color × Unboxing Interaction; Right: grouped by Scent × Texture. Error bars represent 95% confidence intervals.

5.5. Product—Packaging Congruence

A mixed-design ANOVA was conducted on the composite product—packaging congruence score (including alignment, uniqueness, and perfection). A significant main effect of texture was observed, $F(2,82) = 5.12$, $p = .008$, $\eta p^2 = .21$. Post-hoc comparisons indicated that Rough Paper texture received the highest congruence rating ($M = 5.15$), significantly higher than Smooth texture ($M = 4.52$, $p < .01$) and Embossed Gold ($M = 4.68$, $p < .05$). Additionally, a significant three-way interaction among Color × Texture × Scent was observed, $F(2,82) = 3.88$, $p = .024$, $\eta p^2 = .17$. Under the no-scent condition, Ink Black combined with Rough Paper was rated as the most congruent with the positioning of a "premium boutique black tea" ($M = 5.70$, $p < .01$). Figure 7 presents a heatmap of congruence ratings for different Color × Texture combinations under the two scent conditions.

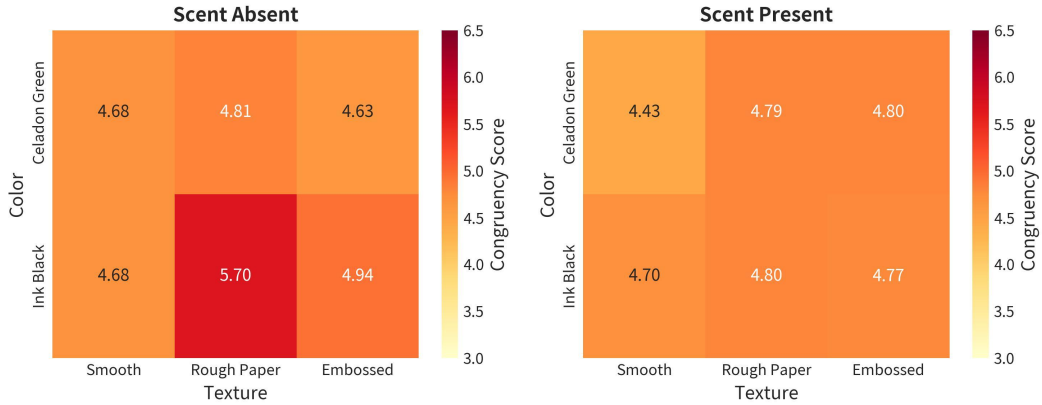

Figure 7. Heatmap of Product—Packaging Congruence Ratings. Left: Scent-Absent condition; Right: Scent-Present condition. Darker colors indicate higher congruence ratings.

5.6. Emotional Responses

Correspondence Analysis (CA) was conducted on the emotional data from the PrEmo scale. Different textures elicited markedly distinct distributions of emotional labels. Chi-square tests indicated a significant association between texture and

emotion words ($\chi^2(42) = 78.45$, $p = .001$), whereas neither color ($\chi^2(28) = 22.35$, $p = .892$) nor unboxing interaction ($\chi^2(56) = 41.20$, $p = .985$) showed significant associations with emotion word selection. Table 4 summarizes the chi–square results and the significant emotion word associations.

Table 4. Summary of Chi–Square Tests and Significant Associations with Emotional Words.

Factor	χ^2 (df)	p–value	Significant Word Associations (Standardized Residual |z| > 1.96)
Scent	48.72 (14)	.018	No single word exceeded the threshold (overall diffuse effect)
Texture	78.45 (42)	.001	Rough Paper: Pride (z = 2.35), Desire (z = 2.12); Embossed Gold: Boredom (z = 2.08); Smooth: Calm (z = 1.99)
Color	22.35 (28)	.892	No significant associations
Unboxing	41.20 (56)	.985	No significant associations

Figure 8 Biplot from Correspondence Analysis, illustrating the associations between texture conditions and emotional words in two–dimensional space.

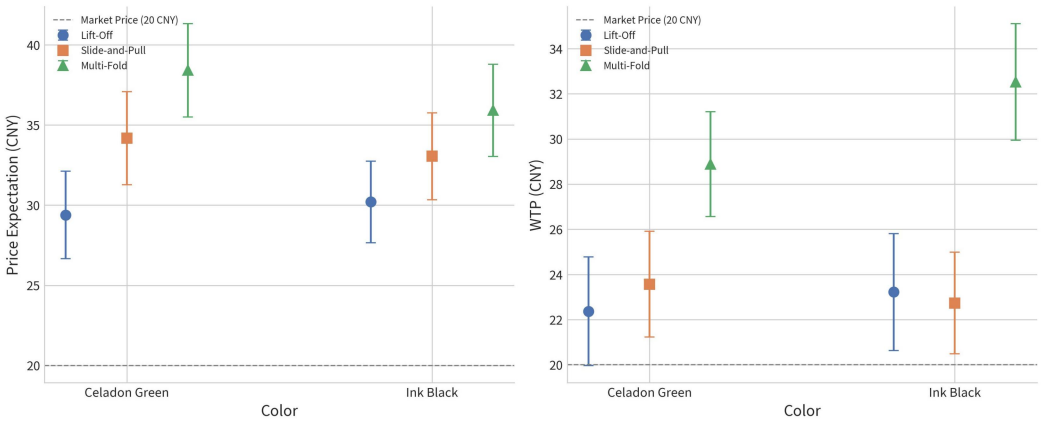

Figure 8. Correspondence analysis (CA) biplot of texture conditions and emotional vocabulary. Diamond markers represent texture conditions, while circular markers represent emotional words. Closer proximity indicates stronger associations.

A mixed–design ANOVA on the PrEmo composite scores of emotional valence revealed a significant main effect of emotion, $F(13, 390) = 24.15$, $p < .001$, $\eta p^2 = .45$, as well as a significant color × texture interaction, $F(2, 82) = 4.22$, $p = .018$, $\eta p^2 = .19$. Simple main effect analyses indicated that under the embossed foil texture condition, the effect of color reached statistical significance, $F(1, 82) = 5.35$, $p = .023$. Specifically, celadon green elicited higher ratings of admiration, joy, and desire in this texture condition, whereas ink black produced higher ratings of pride and fascination

under the coarse rice-paper texture. Figure 9 presents PrEmo spider plots for the three texture conditions.

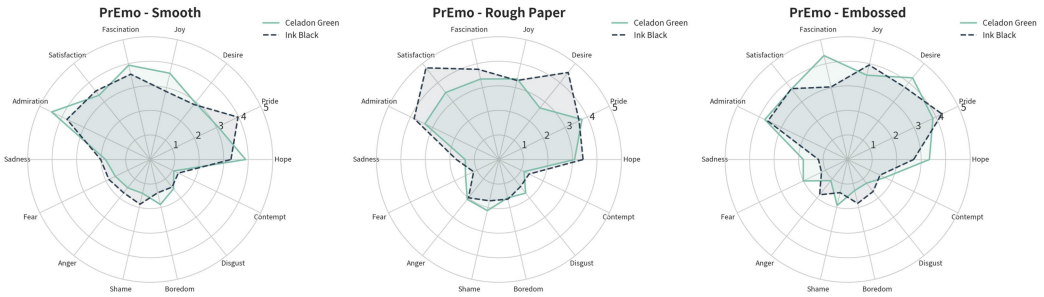

Figure 9. PrEmo emotional response spider plots under three texture conditions (smooth, coarse rice-paper, embossed foil), presented separately for each color (celadon green, ink black).

5.7. Price Expectation and Willingness to Pay (WTP)

Analyses of log-transformed price expectation and WTP data revealed highly consistent trends. A significant main effect of packaging opening interaction on WTP was observed, $F(2, 164) = 6.75$, $p=.001$, $\eta p^2=.24$. Post hoc comparisons indicated that the WTP for multilayer foldable packaging ($M=28.5$ CNY) was significantly higher than for the telescopic-lid packaging ($M=19.2$ CNY, $p<.001$) and pull-out packaging ($M=21.8$ CNY, $p < .01$).

A significant interaction between scent and texture was found on price expectation, $F(2, 82) =5.84$, $p=.004$, $\eta p^2=.26$. Under the no-scent condition, coarse rice-paper packaging elicited a substantially higher price premium compared to smooth texture ($p<.01$). However, when a subtle tea aroma was present, price expectations for smooth-texture packaging increased significantly, reducing the gap with coarse-texture packaging ($p>.05$). Figure 10 presents a comparison of price expectations and WTP across different conditions.

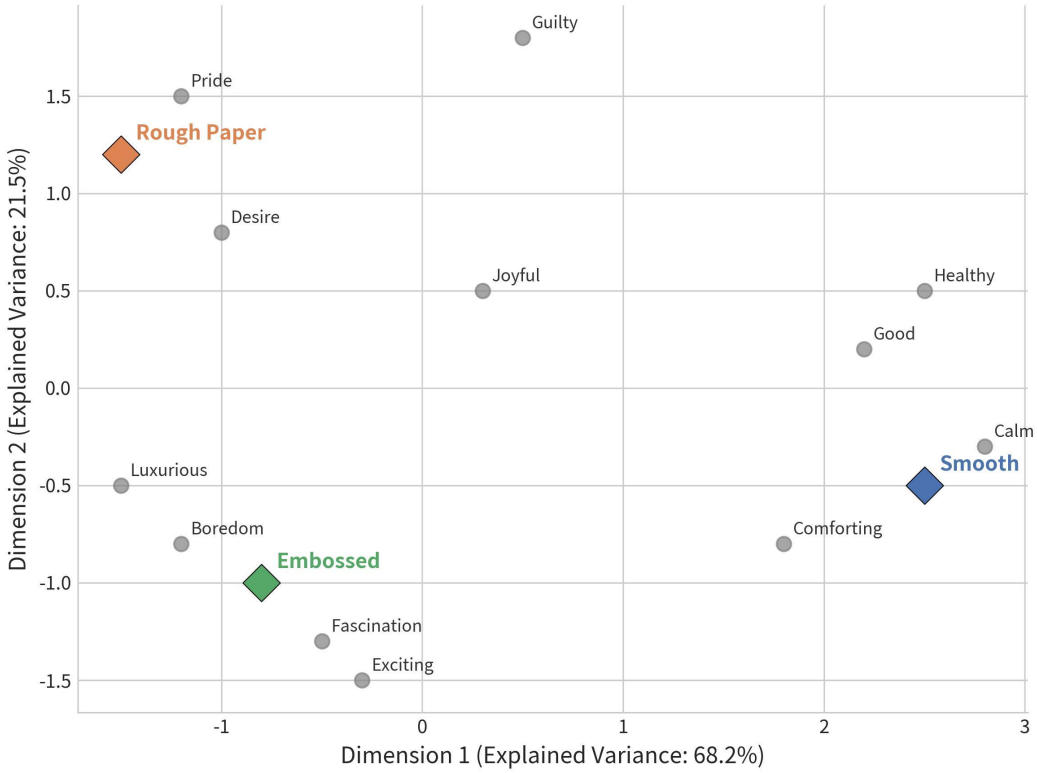

Figure 10. Price expectations (left) and willingness to pay (WTP, right) under different color × packaging opening interaction conditions.

Dashed lines indicate the market reference price (20 CNY). Solid markers indicate values significantly above the market price, while hollow markers indicate values significantly below it. Error bars represent 95% confidence intervals.

One-sample t-tests compared participants' price expectations and WTP with the actual market reference price of a single serving of tea (20 CNY). In the optimal combination of "Ink Black + Coarse Rice-paper + Multilayer Foldable + No Scent," participants' WTP (M = 35.6 CNY) was significantly higher than the market price, $t(14) = 4.25$, $p < .001$, representing a 78% premium. Conversely, under the "Celadon Green + Smooth + Telescopic Lid + Scent" condition, WTP (M = 16.8 CNY) was significantly lower than the market price, $t(14) = -2.18$, $p = .047$.

5.8. Perceived Luxury and Purchase Intention

Internal consistency analysis of the purchase intention scale indicated excellent reliability, Cronbach's $\alpha = .94$. A mixed-design ANOVA revealed a significant main effect of scent on purchase intention, $F(1, 82) = 9.85$, $p = .002$, $\eta p^2 = .24$, with higher scores under the tea-scent condition (M = 3.72) than under the no-scent condition (M = 3.28, $p < .05$).

Analysis of perceived luxury showed significant main effects of both scent, $F(1, 82) = 12.45$, $p < .001$, $\eta p^2 = .30$, and packaging opening interaction, $F(2, 164) = 8.92$, $p < .001$, $\eta p^2 = .22$. Luxury perception was higher under the tea-scent condition (M = 4.68) compared to no-scent (M = 3.95). Multilayer foldable packaging received the highest luxury perception rating (M = 4.85), significantly higher than telescopic-lid

packaging (M = 3.82, p < .001). Figure 11 illustrates perceived luxury across different scent × packaging opening interaction conditions.

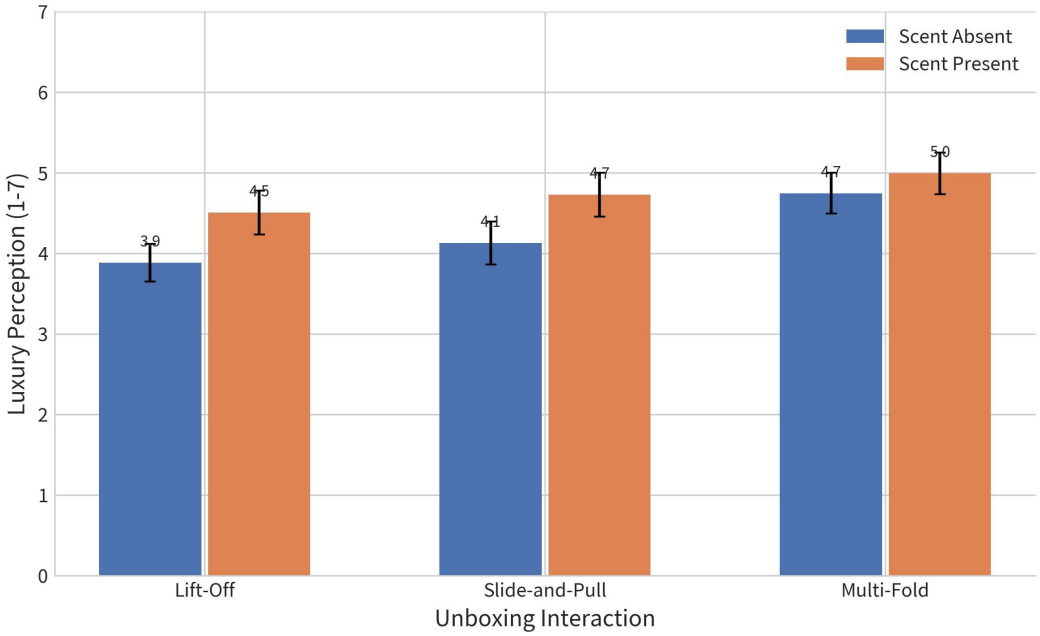

Figure 11. Perceived luxury scores under different scent × packaging opening interaction conditions. Error bars represent 95% confidence intervals.

5.9. Perceived Hardness and Smoothness

Cumulative link mixed model (CLMM) analyses indicated that the presence of scent significantly reduced perceived smoothness (β = −3.60, p = .046), suggesting that olfactory cues may lead to a perception of a rougher texture. Furthermore, embossed foil texture paired with multilayer foldable packaging significantly decreased perceived smoothness (β = −4.32, p = .043). Figure 12 presents perceived hardness and smoothness under different scent × texture conditions.

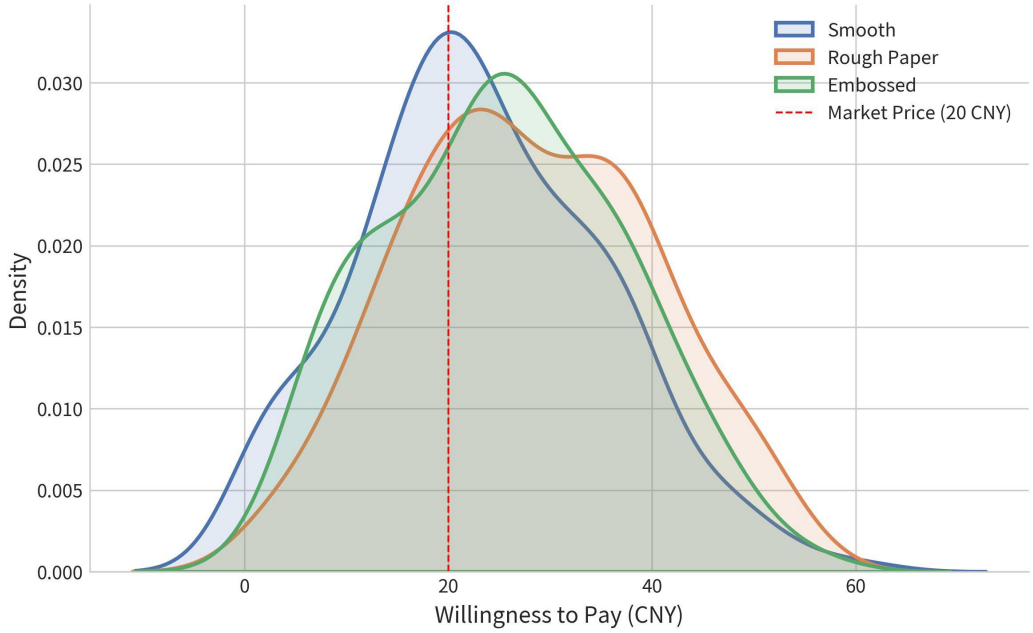

Figure 12. Perceived hardness (left) and smoothness (right) under different scent × texture conditions. Error bars represent 95% confidence intervals.

5.10. Distribution Characteristics of Willingness to Pay

Figure 13 presents kernel density distributions of WTP across the three texture conditions, visually illustrating the differentiated impact of texture on consumers' economic valuation.

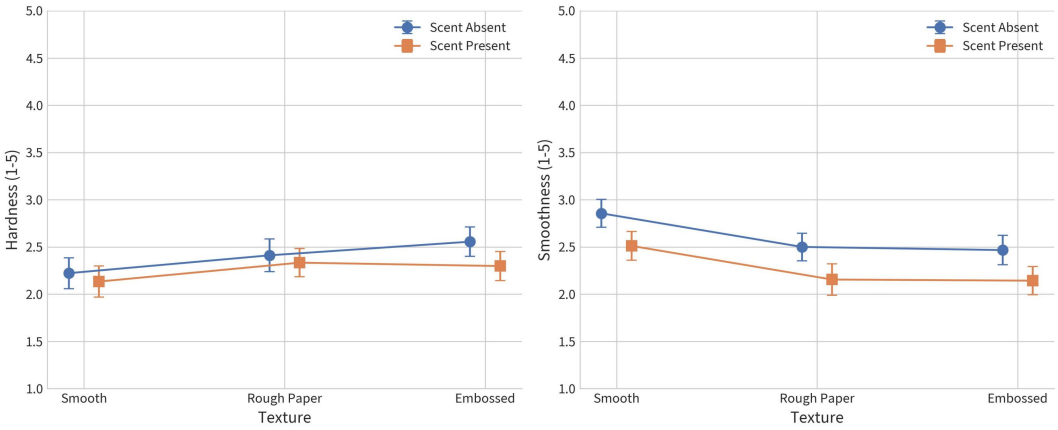

Figure 13. Kernel density distributions of willingness to pay (WTP) under the three texture conditions. The red dashed line indicates the market reference price (20 CNY). The WTP distribution for coarse rice–paper texture is noticeably shifted to the right.

5.11. Distribution of Emotional Valence Across Conditions

Figure 14 presents horizontal boxplots illustrating the distribution of emotional valence across all six scent × texture conditions. The red dashed line indicates the neutral emotional baseline.

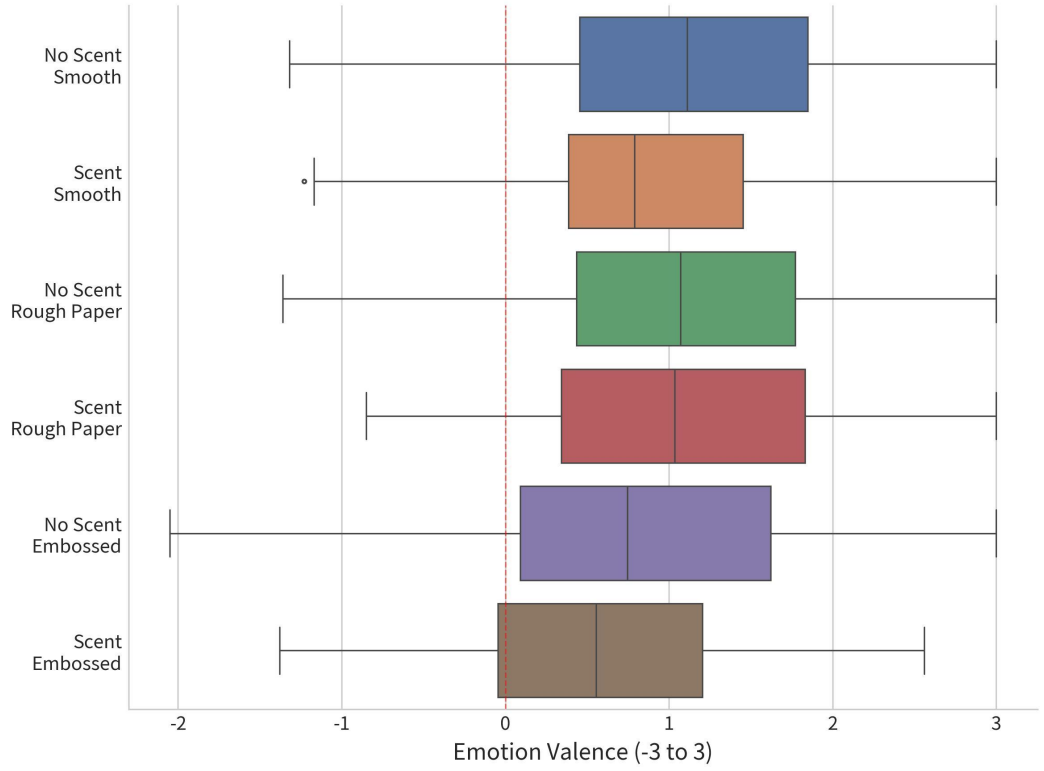

Figure 14. Horizontal boxplots of emotional valence under different scent × texture conditions. The red dashed line indicates the neutral emotional baseline (0).

5.12. Willingness to Re-taste

Figure 15 illustrates the distribution proportions of willingness to re-taste under scented and unscented conditions, visually reflecting the suppressive effect of scent on repeated consumption intention.

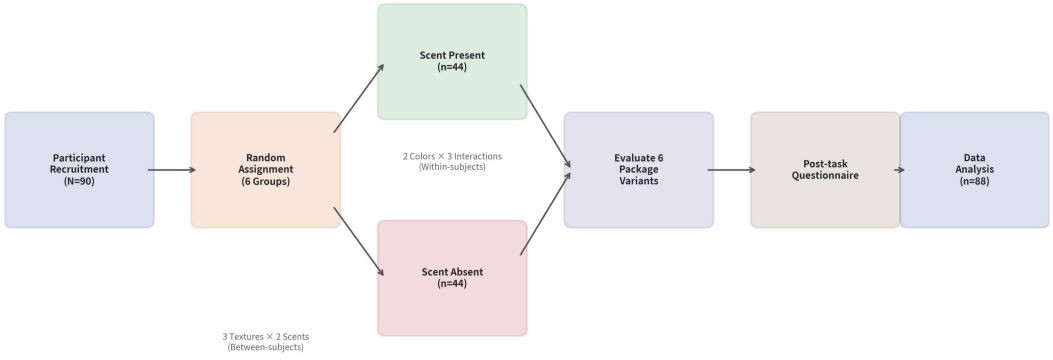

Figure 15. Distribution of willingness to re-taste scores under unscented (left) and scented (right) conditions. The proportion of high scores is noticeably reduced under the scented condition.

5.13. Overview of Experimental Procedure

Figure 16 presents an overview of the complete experimental procedure, illustrating all key stages from participant recruitment to data analysis.

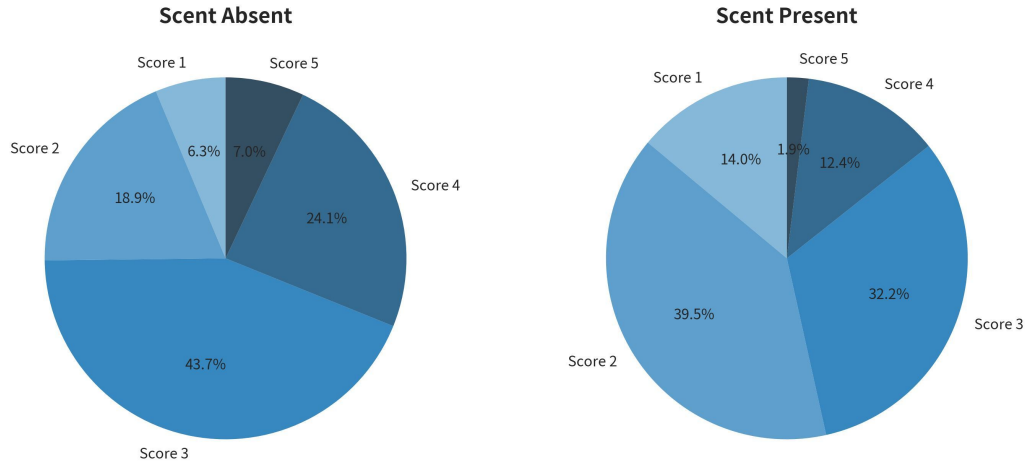

Figure 16. Experimental workflow. The figure illustrates the complete procedure from participant recruitment (N = 90), random assignment into six groups, evaluation of six packaging variants, to data analysis (n = 88).

6. Discussion

In the contemporary business environment, product packaging serves not only as a physical container but also as the first multisensory touchpoint between consumers and products [1][2]. Through visual, tactile, olfactory, and interactive cues, packaging shapes consumer expectations of quality, flavor, and value even before the product is physically experienced. From the perspective of cognitive neuroscience, these cues are processed through multisensory integration mechanisms, whereby temporally and spatially aligned signals enhance event salience and accelerate responses [3]. In consumer contexts, such integration processes are influenced by learned crossmodal correspondences (e.g., mapping dark hues to bitterness or rough textures to intensity), which unconsciously bias expectations and choices [4][5]. With the rise of the experience economy, design innovation has extended beyond single-dimensional visual aesthetics to the deep intersection of technology, commerce, and culture. Particularly in the premium tea market, packaging design plays a critical role in conveying brand heritage, highlighting cultural connotations, and enhancing product premiumization.

6.1. Lateral Comparison: Consistencies and Differences with Previous Research

The core findings of this study are both consistent with and extend prior research in the field of multisensory packaging.

- First, regarding the enhancing effect of packaging interaction on perceived attractiveness and WTP (H1), the results align closely with studies by Bae [15], Li

and Cho [36], and Berden [37], all of which found that more complex packaging structures elicit stronger positive emotions and higher perceived value. Importantly, this study identifies a nuanced difference: in the context of premium tea, the benefits of increasing packaging interaction complexity are not indefinitely linear. While multilayer foldable packaging significantly outperformed telescopic–lid packaging in terms of attractiveness and WTP, its advantage over pull–out packaging was not always significant under certain conditions (e.g., scented + embossed foil), suggesting a potential "complexity ceiling" effect. This finding extends Berden [37], indicating that the optimal level of interaction complexity may be moderated by product category and cultural context;

- Second, regarding the "hedonic overload" phenomenon (H2), the findings are consistent with Doty's [17] inverted–U relationship between scent intensity and hedonic pleasure but extend this principle from purely olfactory contexts to multisensory packaging experiences. Notably, in prior benchmark studies (e.g., Velasco et al.'s chocolate packaging research), the addition of scent enhanced overall liking, whereas in the present study, environmental tea aroma decreased overall liking [2]. This difference may stem from the intrinsic characteristics of the product category: chocolate scent aligns strongly with chocolate flavor (high prior congruence), whereas the relationship between tea aroma and flavor is more subtle and complex. Environmental tea scent may have overactivated flavor expectations before tasting, increasing prediction error and reducing overall liking, consistent with the "prediction error minimization" principle in predictive coding frameworks [6][7];
- Third, concerning product—packaging congruence, ink black paired with coarse rice–paper achieved the highest congruence ratings under no–scent conditions, consistent with crossmodal correspondence theory [4], where dark colors and rough textures activate associative chains such as "weighty—bitter—high–quality," aligning well with premium black tea characteristics. However, introducing tea aroma significantly reduced this congruence, suggesting that olfactory cues can disrupt established visual—tactile correspondences and introduce additional cognitive dimensions.

6.2. Longitudinal Mechanisms: From Perception to Behavior

The results reveal a clear pathway from multisensory packaging design to consumer economic decisions. Visual (color) and tactile (texture) cues first shaped baseline expectations of product quality (e.g., flavor intensity, taste persistence). Subsequently, the ritualistic experience of opening the package added emotional value (e.g., luxury perception, fascination). These cognitive and affective evaluations jointly translated into economic behavior, including price expectation and WTP.

This pathway can be interpreted through the EPIC model [8]: multisensory cues serve as exteroceptive input, forming prior beliefs about product quality, while body movements during the unboxing process (e.g., unfolding multiple panels) generate interoceptive predictions, adjusting expected physiological states such as arousal and anticipation. When exteroceptive and interoceptive predictions align, consumers experience greater emotional satisfaction and perceived value, leading to higher willingness to pay.

Luxury perception plays a key mediating role in this pathway. Although scent reduced overall liking (hedonic overload), it simultaneously enhanced perceived luxury and purchase intention. This apparent paradox suggests that consumer evaluations of "liking" and "willingness to purchase" may rely on distinct cognitive pathways—the former dependent on immediate hedonic experience, the latter influenced by social value judgments such as luxury perception and brand image.

6.3. Differential Attribution: Moderation by Cultural Context and Product Category

Several findings differ from Western FMCG packaging research, likely due to moderation by cultural context and product category.

Culturally, Chinese tea traditions emphasize natural aesthetics ("harmony of humans and nature") and material philosophy ("vessel as carrier of Dao"). Coarse rice–paper texture achieved the highest product—packaging congruence, likely because it activated cultural schemas associated with craftsmanship, traditional techniques, and simplicity. Such cultural moderation was not observed in Western chocolate packaging studies, where gloss and color saturation primarily convey quality signals [27].

Regarding product category, tea is a "slow–consumption" product with inherent ritualistic and meditative aspects. The gradual, stepwise nature of multilayer foldable unboxing aligns with tea ceremony principles, likely underlying its superior attractiveness and WTP compared with faster–opening formats. In contrast, complex unboxing in FMCG contexts may be perceived as inconvenient rather than ceremonial, leading to different effects.

6.4. Limitations and Future Research Directions

Limitations include: (1) a young, convenience sample drawn from university and surrounding communities, limiting generalizability; (2) a controlled sensory lab environment differing from real–world shopping contexts; (3) scent manipulation via ambient diffusion, preventing precise control of individual exposure; (4) focus on black tea only, leaving applicability to green or white tea uncertain.

Future research could explore: (1) eye–tracking or EEG to capture temporal dynamics of multisensory integration; (2) field experiments in real retail environments

to test ecological validity; (3) cross–cultural comparisons to systematically examine cultural moderation of multisensory packaging effects; (4) integration of digital packaging technologies (AR, NFC) with traditional sensory cues.

7. Discussion

From an innovative perspective integrating design and technology, business, and culture, this study systematically revealed the cross–modal mechanisms through which multisensory packaging design influences consumer perceptions of quality, emotional experiences, and willingness to pay (WTP) for premium tea. Based on 528 evaluations from 88 participants across 18 multisensory packaging variants, the key findings are as follows:

- First, packaging interaction complexity is the strongest driver of perceived value. Multilayer foldable unboxing, by prolonging anticipation and enhancing ritual, significantly increased perceived attractiveness ($\eta p^2 = .18$), luxury perception ($\eta p^2 = .22$), and WTP (with a 78% premium), supporting the hypothesis that interaction complexity enhances predictive fluency (H1);
- Second, the synergistic effects of multisensory cues follow a nonlinear pattern. Moderate combinations of sensory stimuli (e.g., coarse rice–paper + ink black + no scent) maximized product—packaging congruence and perceived quality, whereas excessive multisensory stimulation (e.g., embossed foil + ink black + scented + multilayer foldable) triggered a "hedonic overload" effect, reducing overall liking and willingness to re–taste, partially supporting the multisensory congruence and hedonic overload hypothesis (H2);
- Third, olfactory cues exhibit a double–edged effect. Environmental tea aroma enhanced perceived luxury and purchase intention while decreasing overall liking, revealing a cognitive dissociation between "liking" and "willingness to purchase." This finding carries practical implications for packaging design, indicating that scent must be carefully controlled in intensity and context.
- Fourth, cultural context significantly moderates the direction of cross–modal correspondence effects. Within the Chinese tea culture context, coarse rice–paper texture (rather than smooth or luxurious surfaces) achieved the highest product—packaging congruence, suggesting that packaging design should be deeply embedded within the cultural schemas of the target market.

The theoretical contributions of this study include: (1) integrating multisensory integration theory with predictive coding models in the context of tea packaging design, thereby extending the theoretical boundaries of sensory marketing; (2) simultaneously examining the independent and interactive effects of visual, tactile, olfactory, and dynamic interaction modalities within a unified experimental framework

for the first time; and (3) elucidating the manifestation of "hedonic overload" in complex multisensory packaging.

The practical implications provide empirically grounded strategies for premium tea brands: (1) prioritize innovative unboxing experiences rather than simply enhancing visual decoration; (2) employ culturally meaningful materials such as coarse rice-paper in high-end products instead of solely pursuing smooth luxury; (3) use scent marketing cautiously, avoiding the addition of olfactory stimuli to packaging already high in visual and tactile intensity; and (4) tailor cross-modal correspondence strategies to the cultural characteristics of the target market.

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