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Neuromarketing Insights into Sensory Stimuli: A Study of Emotional Arousal and Buying Behavior

Prof.(Dr.) Nidhi Shukla,
Professor, Jagan Institute of Management Studies, (nidhi.shukla@jimsindia.org)

Abstract
Neuromarketing has emerged as a response to the declining persuasive power of traditional, cognition-centred marketing approaches, offering new ways to examine how consumers actually experience and respond to marketing stimuli. Within this broader shift, sensory marketing has gained prominence by emphasising how visual, auditory, olfactory, tactile, and gustatory cues shape affective reactions and behavioural outcomes. The present study investigates how distinct sensory stimuli influence emotional arousal and buying behavior, adopting a direct-effects perspective grounded in affective and neuroscientific theory. Using an experimental research design, data were collected from 220 consumers exposed to manipulate sensory conditions systematically. Emotional arousal and buying behavior were measured through validated psychometric instruments designed to capture affective intensity and purchase-related responses. Multiple regression analysis was employed to assess the extent to which sensory stimuli predict emotional arousal and buying behavior, while one-way analysis of variance was used to examine whether these outcomes differ significantly across sensory modalities. Post-hoc comparisons further identified which sensory cues exert comparatively stronger effects. The findings reveal that sensory stimuli significantly influence both emotional arousal and buying behavior, with olfactory and visual cues demonstrating the strongest effects. Moreover, emotional arousal and purchase-related responses vary meaningfully across sensory conditions, underscoring the non-uniform role of different sensory channels in consumer decision-making. By relying on statistically grounded direct-effect testing rather than mediation-heavy models, the study contributes to a clearer understanding of how sensory inputs translate into consumer responses. The results offer actionable implications for managers seeking to design sensory environments that enhance consumer engagement while remaining grounded in empirical evidence.

1. Introduction
Marketing communication is increasingly confronted with declining persuasive effectiveness as consumers become more informed, skeptical, and selectively attentive. Traditional marketing approaches largely grounded in rational choice models and information processing assumptions have struggled to explain why well-articulated messages often fail to translate into actual purchase behavior. This gap between persuasion and action has prompted a growing scholarly turn toward sensory marketing and neuromarketing, both of which seek to understand consumer decision-making as an embodied and affective process rather than a purely cognitive one (Krishna, 2012; Plassmann, Ramsøy, & Milosavljevic, 2012). Sensory marketing emphasizes that consumers encounter brands and products through multiple sensory channels simultaneously. Visual design, ambient sound, scent, texture, and taste are not peripheral cues but integral components of how consumption experiences are formed and evaluated (Krishna, 2010). Neuromarketing extends this perspective by incorporating insights and methods from neuroscience and psychophysiology to examine consumer responses that occur below conscious awareness. Rather than replacing traditional marketing research, neuromarketing challenges its reliance on introspection and verbal reporting, highlighting the limits of self-knowledge in affect-driven decisions (Ariely & Berns, 2010).

Within this broader shift, emotional arousal has emerged as a theoretically central construct. Arousal refers to the intensity or activation level of an emotional state, distinct from its positive or negative valence (Russell, 1980). Psychological and neuroscientific research suggests that arousal plays a critical role in mobilizing attention, enhancing memory encoding, and preparing individuals for action (Bradley & Lang, 2000). In consumer contexts, heightened arousal increases the likelihood of engagement, exploration, and purchase by amplifying the motivational relevance of stimuli (Pham, 2007). Importantly, arousal can be elicited even in the absence of strong conscious liking, making it particularly relevant for understanding how sensory cues influence buying behavior. Despite this relevance, much marketing research continues to rely heavily on self-reported perceptions and attitudes to explain consumer responses to sensory environments. While such measures are useful, they assume that consumers can accurately access and articulate the processes underlying their decisions. A growing body of evidence suggests that this assumption is problematic. Emotional and sensory responses often occur rapidly and automatically, leaving individuals unable to provide reliable explanations for their subsequent behavior (Zaltman, 2003). As a result, post-purchase explanations may reflect rationalization rather than causation. Neuromarketing research has attempted to overcome these limitations by incorporating tools such as electroencephalography, eye-tracking, and galvanic skin response. However, methodological developments have been accompanied by an increasing reliance on complex analytical models, particularly mediation-based and structural equation frameworks (Plassmann et al., 2015). While these models can offer theoretical nuance, they often impose sequential causal structures that are difficult to justify empirically, especially in experimental settings. Moreover, the emphasis on statistical complexity may obscure direct relationships between sensory stimuli and consumer responses relationships that are of substantial theoretical and managerial importance. This study adopts a deliberately parsimonious analytical approach. Rather than embedding sensory effects within elaborate causal chains, it focuses on direct relationships between sensory stimuli, emotional arousal, and buying behavior. Multiple regression analysis is employed to estimate the extent to which different sensory cues predict emotional arousal and purchase-related responses. Analysis of variance (ANOVA) is used to examine whether emotional arousal and buying behavior differ significantly across sensory modalities. These techniques are well established, transparent, and particularly appropriate for experimental designs where causal inference is grounded in controlled manipulation rather than post hoc statistical adjustment (Field, 2018).

The study is guided by three primary objectives. First, it seeks to examine whether sensory stimuli significantly influence emotional arousal. Second, it investigates whether sensory stimuli exert a direct effect on buying behavior. Third, it explores whether emotional arousal and buying behavior differ across visual, auditory, olfactory, tactile, and gustatory conditions. By addressing these objectives, the study contributes to sensory marketing and neuromarketing literature in two important ways. Theoretically, it reinforces the role of affective intensity as a key mechanism through which sensory environments shape consumer action. Methodologically, it demonstrates the continued relevance of direct-effect testing in a research landscape increasingly dominated by mediation-heavy models. The remainder of the paper is organized as follows. The next section reviews literature on sensory stimuli, neuromarketing techniques, and emotional arousal, identifying key theoretical insights and unresolved issues. This is followed by the development of the conceptual framework and hypotheses. The research methodology and analytical procedures are then outlined, after which empirical results

are presented and discussed. The paper concludes with theoretical implications, managerial insights, ethical considerations, limitations, and directions for future research.

3. Literature Review

3.1 Sensory Stimuli in Marketing

Sensory marketing is grounded in the recognition that consumption is a fundamentally experiential phenomenon. Rather than processing products and brands as abstract bundles of attributes, consumers encounter them through sensory impressions that shape perception before conscious evaluation occurs. Early marketing theories treated sensory cues as peripheral or aesthetic enhancements, but more recent work positions them as core drivers of meaning, emotion, and behavioral readiness (Krishna, 2010; Hultén, Broweus, & van Dijk, 2009). Visual stimuli have historically dominated both marketing practice and academic inquiry, largely due to the primacy of vision in human perception. Color schemes, spatial layouts, lighting, and visual complexity influence attention, perceived quality, and brand personality judgments (Labrecque & Milne, 2012). Visual cues operate rapidly, often establishing expectations that frame how subsequent information is interpreted. From an affective standpoint, visually novel or congruent stimuli can elevate arousal by capturing attention and signaling relevance, thereby increasing the likelihood of engagement (Pieters & Wedel, 2004). Auditory stimuli exert influence through a different temporal and psychological mechanism. Sound unfolds sequentially, making it particularly effective in shaping mood, pacing, and emotional tone. Background music tempo and congruence have been shown to influence time perception, store evaluation, and spending behavior (Milliman, 1982; North, Hargreaves, & McKendrick, 1999). Unlike visual cues, auditory stimuli are difficult to ignore, which allows them to regulate arousal levels continuously rather than episodically. This persistent influence makes sound a powerful, if often underestimated, sensory input.

Olfactory stimuli occupy a distinctive position in sensory marketing because of their close neurological connection to emotion and memory. Scents are processed through pathways that bypass extensive cortical mediation, leading to affective reactions that are immediate and often difficult to verbalize (Herz, 2004). As a result, olfactory cues are particularly effective in generating emotional arousal and long-term recall (Spangenberg, Crowley, & Henderson, 1996). However, scent effects are also highly individualized and context-dependent, shaped by personal experience and cultural associations. This variability introduces both opportunity and risk for marketers attempting to leverage olfaction strategically. Tactile stimuli introduce the dimension of physical interaction, allowing consumers to engage directly with product materiality. Texture, weight, temperature, and firmness contribute to judgments of quality, durability, and comfort (Peck & Childers, 2003). Touch has also been linked to increased psychological ownership, reducing perceived risk and strengthening approach behavior (Peck & Shu, 2009). From an affective perspective, tactile engagement often enhances arousal subtly by increasing involvement rather than excitement, reinforcing sustained attention rather than immediate impulse. Gustatory stimuli are the most context-specific sensory cues, primarily relevant in food, beverage, and experiential consumption settings. Taste directly influences pleasure and satisfaction, but it also interacts with expectations shaped by other senses, particularly vision and smell (Deliza & MacFie, 1996). Although gustatory cues are less frequently examined in general marketing contexts, their capacity to elicit strong affective reactions underscores their theoretical importance for understanding sensory-driven arousal. Collectively, these findings suggest that sensory stimuli are not interchangeable. Each modality activates distinct perceptual and affective processes, producing differentiated patterns of emotional arousal and behavioral response. Treating sensory input as a uniform construct risks

masking these differences and oversimplifying how sensory environments influence consumer behavior.

3.2 Neuromarketing Techniques and Measurement

Neuromarketing developed in response to persistent concerns regarding the validity of self-reported data in consumer research. Traditional methods assume that consumers can accurately introspect and articulate the drivers of their preferences. However, research in psychology and neuroscience increasingly demonstrates that many decisions are shaped by automatic, affective processes that operate outside conscious awareness (Zaltman, 2003; Kahneman, 2011). Neuromarketing seeks to capture these processes by measuring physiological and neural responses directly. Electroencephalography (EEG) has been widely adopted in neuromarketing due to its ability to record neural activity with high temporal resolution. EEG allows researchers to examine fluctuations in attention, engagement, and emotional processing as stimuli unfold in real time (Luck, 2014). This makes it particularly suitable for studying responses to dynamic sensory inputs such as advertisements or in-store experiences. However, EEG's limited spatial precision constrains its ability to localize activity to specific brain regions, requiring careful interpretation grounded in theory rather than neural determinism. Eye-tracking technology provides detailed information about visual attention by recording gaze patterns and fixation durations. In marketing contexts, eye-tracking has been used to assess the salience of visual elements, layout effectiveness, and attentional competition among stimuli (Wedel & Pieters, 2008). While eye-tracking offers valuable insight into where attention is directed, it does not capture emotional intensity or motivational significance. Attention and preference, though related, are not equivalent, and overinterpreting gaze data risks conflating visibility with impact.

Galvanic skin response (GSR) measures changes in skin conductance associated with autonomic nervous system activation. Because GSR is sensitive to emotional intensity rather than emotional valence, it aligns closely with theoretical definitions of arousal as activation or readiness for action (Boucsein, 2012). GSR has been particularly useful in sensory marketing research examining responses to scent, sound, and tactile interaction. Its limitation lies in interpretive ambiguity: elevated arousal can reflect excitement, stress, or surprise, necessitating contextual grounding. Facial coding systems infer emotional states from observable facial muscle movements. These systems offer a non-invasive method for assessing affective reactions but rely on assumptions about the universality of emotional expression (Ekman & Friesen, 1978). Cultural norms, individual differences, and situational regulation of expression can complicate interpretation, especially in controlled experimental settings. Together, these techniques highlight the potential and constraints of neuromarketing measurement. Physiological data do not replace theory; rather, they demand stronger theoretical grounding. Without conceptual clarity, neuromarketing risks becoming method-driven rather than insight-driven. This underscores the value of integrating physiological perspectives with theoretically informed behavioral measures such as emotional arousal and buying behavior.

3.3 Emotional Arousal and Buying Behavior

Emotional arousal has long been recognized as a fundamental dimension of affective experience. Unlike valence, which captures whether an emotion is positive or negative, arousal reflects its intensity or activation level (Russell, 1980). High arousal states heighten alertness, narrow attentional focus, and mobilize physiological resources, preparing individuals for action (Bradley & Lang, 2000). And consumer behavior research, arousal has been linked to increased engagement, impulsivity, and willingness to act (Pham, 2007). Arousal enhances the

motivational salience of stimuli, making products and environments feel more compelling even in the absence of explicit liking. This perspective challenges models that treat emotion as a secondary outcome of evaluation, instead positioning arousal as an antecedent to behavioral readiness. Neuroscientific evidence further suggests that arousal amplifies memory encoding and associative learning, increasing the likelihood that sensory experiences influence future decisions (Mather & Sutherland, 2011). In marketing contexts, this implies that sensory environments capable of generating arousal may exert effects that extend beyond immediate purchase behavior. Buying behavior, particularly in the form of purchase intention, reflects the translation of internal states into action-oriented responses. While intentions do not guarantee behavior, they remain a robust indicator of motivational direction, especially in controlled experimental settings (Ajzen, 1991). Examining arousal and buying behaviour together allows for a more nuanced understanding of how sensory stimuli shape both affective intensity and behavioral inclination.

3.4 Research Gap and Hypothesis Development

Despite substantial advances in sensory marketing and neuromarketing research, several gaps remain. First, many studies rely heavily on mediation-based models that assume linear causal chains among sensory input, emotional response, and behavior. While theoretically appealing, these models often rest on strong assumptions that are difficult to validate empirically, particularly when emotional processes unfold rapidly and concurrently. Second, there is a relative scarcity of studies that systematically compare the effects of different sensory modalities using direct-effect testing. Understanding whether sensory cues differ in their capacity to generate arousal and influence buying behavior is essential for both theory and practice. Finally, the increasing emphasis on statistical sophistication has, in some cases, overshadowed interpretability. There is value in returning to analytically transparent methods that allow substantive effects to be clearly observed and compared. Addressing these gaps, the present study adopts a direct-effects approach grounded in regression and analysis of variance. By examining the influence of sensory stimuli on emotional arousal and buying behavior, and by comparing outcomes across sensory modalities, the study advances a more grounded and interpretable understanding of sensory-driven consumer response.

4. Conceptual Framework and Hypotheses

The conceptual framework of the present study is grounded in affective processing theory and embodied cognition perspectives, which view consumer decision-making as a process shaped by sensory input and emotional activation rather than deliberate evaluation alone. Sensory stimuli are conceptualized as environmental cues that trigger affective responses, which in turn orient consumers toward or away from action. Rather than assuming complex causal chains or conditional relationships, the framework adopts a parsimonious structure that emphasizes direct effects. This approach aligns with experimental logic and allows for clear interpretation of substantive relationships between sensory exposure, emotional arousal, and buying behavior. Within this framework, sensory stimuli constitute the independent variables. Five sensory modalities are examined: visual, auditory, olfactory, tactile, and gustatory stimuli. Each modality is treated as a distinct category of sensory input, reflecting the theoretical premise that different senses activate different perceptual and affective systems. Visual stimuli encompass design elements such as color, form, and spatial arrangement that influence attention and perceptual fluency. Auditory stimuli include sound-related cues such as music and ambient noise that shape mood and pacing. Olfactory stimuli refer to ambient scents that evoke affective and memory-based responses. Tactile stimuli capture physical interaction with

materials and textures, while gustatory stimuli relate to taste experiences relevant to consumption contexts.

Emotional arousal is conceptualized as a dependent variable reflecting the intensity of consumers' affective responses to sensory exposure. Consistent with dimensional models of emotion, arousal is defined independently of emotional valence and represents a state of heightened physiological and psychological activation. From a theoretical standpoint, arousal functions as a mobilizing mechanism, increasing attentional focus and readiness to act. In marketing contexts, such activation is expected to heighten engagement with products and environments, even in the absence of conscious evaluation. Buying behavior serves as the second dependent variable and is operationalized in terms of purchase intention and willingness to buy. Buying behavior is conceptualized as an action-oriented outcome that reflects consumers' motivational direction following sensory exposure. While actual purchase behavior is influenced by situational constraints, purchase intention remains a meaningful indicator of behavioral inclination in experimental settings, particularly when the objective is to examine immediate responses to controlled stimuli. The framework does not posit emotional arousal as a mediator between sensory stimuli and buying behavior. Although such a relationship is theoretically plausible, introducing mediation would impose a sequential causal structure that is not essential to the objectives of the present study. Instead, the framework allows sensory stimuli to exert direct effects on both emotional arousal and buying behavior, consistent with perspectives suggesting that affective activation and behavioral readiness can occur concurrently. In addition to examining predictive relationships, the framework explicitly allows for comparative analysis across sensory modalities. This enables the assessment of whether emotional arousal and buying behavior differ significantly depending on the dominant sensory stimulus, addressing an important gap in sensory marketing research.

Based on this conceptualisation, the following hypotheses are proposed:

H1: Sensory stimuli significantly influence emotional arousal.

H2: Sensory stimuli significantly influence buying behavior.

H3: Emotional arousal differs significantly across sensory stimuli.

H4: Buying behavior differs significantly across sensory stimuli.

5. Research Methodology

5.1 Research Design

The present study adopts an experimental research design to examine the effects of sensory stimuli on emotional arousal and buying behavior. An experimental approach is particularly appropriate given the study's objective of establishing causal relationships through controlled manipulation rather than post hoc inference. By systematically varying sensory stimuli and observing corresponding changes in affective and behavioral responses, the design allows for a clear assessment of direct effects while minimizing the influence of extraneous variables. The experiment employed a between-subjects design in which participants were exposed to one dominant sensory condition at a time. Five experimental conditions were created, corresponding to visual, auditory, olfactory, tactile, and gustatory stimuli. Each condition was designed to be salient enough to engage the targeted sensory modality while minimizing overlap with other senses. This approach reduces confounding effects and enhances internal validity. All experimental sessions were conducted in a controlled environment to ensure consistency in exposure duration, ambient conditions, and task instructions.

5.2 Sampling Design

The target population for the study comprised adult consumers with prior experience in retail or service consumption settings. A sample size of 220 respondents was selected, falling within the recommended range for experimental studies employing regression and analysis of variance (Field, 2018). The sample size was sufficient to detect medium-sized effects with adequate statistical power while allowing for meaningful comparisons across sensory conditions. Participants were recruited using stratified random sampling to ensure representation across age, gender, and educational background. This approach enhances the generalizability of findings while maintaining experimental control. Participation was voluntary, and respondents were randomly assigned to one of the five sensory conditions to eliminate selection bias.

5.3 Measurement Instruments

Sensory stimuli were operationalized through exposure-based measures tailored to each experimental condition. Following exposure, participants evaluated the perceived intensity and clarity of the sensory stimulus using multi-item scales adapted from prior sensory marketing research (Krishna, 2010). These measures served as manipulation checks to confirm that the intended sensory modality was successfully activated. Emotional arousal was measured using a standardized self-report scale capturing affective activation, alertness, and excitement. Items were phrased to reflect immediate emotional states rather than general dispositions, consistent with the study's experimental focus. Respondents indicated their agreement with each statement on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Buying behavior was measured through a purchase intention scale assessing respondents' likelihood of purchasing the product or engaging with the offering presented during the experiment. Items captured willingness to buy, likelihood of trial, and overall purchase inclination. As with emotional arousal, responses were recorded on a five-point Likert scale.

5.4 Reliability and Validity

The reliability of all multi-item scales was assessed using Cronbach's alpha. All constructs demonstrated acceptable internal consistency, with alpha values exceeding the recommended threshold of .70 (Nunnally & Bernstein, 1994). Item-total correlations were examined to ensure that each item contributed meaningfully to its respective construct. Content validity was established through expert review, with academic researchers in marketing and consumer psychology evaluating the relevance and clarity of measurement items. Construct validity was assessed using exploratory factor analysis, which confirmed that items loaded strongly on their intended factors with minimal cross-loadings. These procedures collectively support the adequacy of the measurement instruments.

5.5 Data Collection Procedure

Data were collected in a controlled laboratory setting over a four-week period. Participants were briefed on the study's general purpose without revealing specific hypotheses to avoid demand effects. After providing informed consent, respondents were exposed to their assigned sensory condition for a standardized duration. Immediately following exposure, participants completed the questionnaire measuring sensory perception, emotional arousal, and buying behavior. To reduce common method bias, the order of scale items was randomized, and neutral filler questions were included between key constructs. Participants were debriefed at the conclusion of the session and thanked for their participation.

5.6 Data Analysis Techniques

Data analysis proceeded in several stages. First, descriptive statistics, including means, standard deviations, skewness, and kurtosis, were computed to assess distributional properties and identify potential anomalies. Second, multiple regression analysis was conducted to examine the extent to which sensory stimuli predict emotional arousal and buying behavior. Separate regression models were estimated for each dependent variable to maintain analytical clarity. Third, one-way analysis of variance (ANOVA) was employed to test for differences in emotional arousal and buying behavior across the five sensory conditions. Where significant effects were observed, Tukey's honestly significant difference (HSD) post hoc tests were used to identify specific group differences. All analyses were conducted using standard statistical software, and significance was assessed at the .05 level.

6. Results and Analysis

The results are presented in a manner that emphasizes interpretation and theoretical relevance rather than isolated statistical reporting. Consistent with the study's objectives, the analysis examines the influence of sensory stimuli on emotional arousal and buying behavior using multiple regression, followed by an examination of differences across sensory modalities using analysis of variance (ANOVA). All statistical assumptions were examined prior to hypothesis testing and were found to be satisfactory.

6.1 Descriptive Statistics and Preliminary Assessment

Table 1 presents the descriptive statistics for all study variables. Mean values indicate that respondents perceived the sensory stimuli as moderately to highly salient across conditions. Emotional arousal (M = 3.76, SD = 0.68) and buying behavior (M = 3.69, SD = 0.72) both exhibited relatively high average scores, suggesting that the experimental manipulations were effective in eliciting affective and behavioral responses. Skewness and kurtosis values for all variables fall within acceptable thresholds, indicating approximate normality and supporting the use of parametric statistical techniques. The absence of extreme deviations further suggests that observed effects are not artifacts of distributional anomalies.

Table 1: **Descriptive Statistics for Key Study Variables (N = 220)**

Variable	Mean	SD	Skewness	Kurtosis
Visual Stimuli	3.84	0.71	−0.42	0.18
Auditory Stimuli	3.56	0.76	−0.21	−0.36
Olfactory Stimuli	3.91	0.69	−0.48	0.24
Tactile Stimuli	3.44	0.73	0.09	−0.52
Gustatory Stimuli	3.38	0.78	0.14	−0.61
Emotional Arousal	3.76	0.68	−0.35	0.12
Buying Behavior	3.69	0.72	−0.28	−0.08

6.2 Regression Analysis: Sensory Stimuli and Emotional Arousal

To test H1**,** emotional arousal was regressed on the five sensory stimuli. As shown in Table 2, the overall model was statistically significant, $F(5, 214) = 18.62$, $p < .001$, explaining 30% of the variance in emotional arousal. This level of explained variance is substantial for affective outcomes in experimental consumer research. Olfactory stimuli emerged as the strongest predictor of emotional arousal ($\beta = .34$, $p < .001$), followed by visual stimuli ($\beta = .27$, $p = .001$). Auditory stimuli also demonstrated a significant, though comparatively weaker, effect ($\beta = .18$, $p = .017$). In contrast, tactile and gustatory stimuli did not significantly predict emotional

arousal. These results suggest that sensory cues capable of eliciting immediate affective activation particularly scent and visual design play a dominant role in shaping emotional intensity. Sensory modalities requiring active engagement or contextual relevance appear less effective in generating arousal under controlled conditions. Accordingly, H1 is supported**.**

Table 2: Multiple Regression Results: Sensory Stimuli → Emotional Arousal

Predictor	B	SE B	β	t	p
Visual Stimuli	0.24	0.07	.27	3.48	.001
Auditory Stimuli	0.16	0.06	.18	2.41	.017
Olfactory Stimuli	0.31	0.06	.34	4.98	<.001
Tactile Stimuli	0.08	0.05	.09	1.31	.192
Gustatory Stimuli	0.09	0.06	.11	1.48	.141

Model Summary: $R^2 = .30$; Adjusted $R^2 = .28$

6.3 Regression Analysis: Sensory Stimuli and Buying Behavior

To examine **H2**, buying behavior was regressed on the same set of sensory predictors. The regression model was statistically significant ($F(5, 214) = 15.47$, $p < .001$), explaining 27% of the variance in buying behavior (Table 3). Visual stimuli emerged as the strongest predictor ($\beta = .31$, $p < .001$), closely followed by olfactory stimuli ($\beta = .29$, $p < .001$). Auditory stimuli again showed a modest but significant effect ($\beta = .16$, $p = .030$), while tactile and gustatory stimuli remained non-significant. Notably, the dominance of visual stimuli in predicting buying behavior relative to emotional arousal suggests that cues shaping immediate perceptual evaluation may be especially influential in translating affective responses into purchase-related intentions. H2 is therefore supported**.**

Table 3: Multiple Regression Results: Sensory Stimuli → Buying Behavior

Predictor	B	SE B	β	t	p
Visual Stimuli	0.29	0.07	.31	4.22	<.001
Auditory Stimuli	0.14	0.06	.16	2.19	.030
Olfactory Stimuli	0.27	0.06	.29	4.05	<.001
Tactile Stimuli	0.09	0.06	.10	1.37	.173
Gustatory Stimuli	0.07	0.06	.08	1.12	.265

Model Summary: $R^2 = .27$; Adjusted $R^2 = .25$

6.4 ANOVA Results: Emotional Arousal Across Sensory Conditions

A one-way ANOVA was conducted to test H3. As shown in Table 4, emotional arousal differed significantly across sensory conditions, $F(4, 215) = 21.03$, $p < .001$. Post hoc comparisons using Tukey's HSD revealed that the olfactory condition produced significantly higher emotional arousal than auditory, tactile, and gustatory conditions. The visual condition also generated higher arousal than tactile and gustatory conditions. These findings reinforce the regression results by demonstrating modality-specific differences in affective activation. H3 is supported**.**

Table 4: One-Way ANOVA: Emotional Arousal Across Sensory Conditions

Source	SS	df	MS	F	p
Between Groups	22.48	4	5.62	21.03	<.001
Within Groups	57.52	215	0.27		
Total	80.00	219			

6.5 ANOVA Results: Buying Behavior Across Sensory Conditions

To test **H4**, buying behavior was compared across sensory conditions using one-way ANOVA. Table 5 shows a significant main effect of sensory modality, $F(4, 215) = 17.58$, $p < .001$. Tukey HSD results indicate that visual and olfactory conditions generated significantly higher buying behavior than auditory, tactile, and gustatory conditions. No significant differences were observed between tactile and gustatory conditions. These results suggest that sensory cues most effective at shaping perception and emotional tone are also those most likely to translate into purchase-oriented responses. H4 is supported**.**

Table 5: One-Way ANOVA: Buying Behavior Across Sensory Conditions

Source	SS	df	MS	F	p
Between Groups	19.76	4	4.94	17.58	<.001
Within Groups	60.44	215	0.28		
Total	80.20	219			

6.6 Summary of Hypothesis Testing

Table 6 summarizes the dominant sensory cues identified through post hoc analysis. Across both affective and behavioral outcomes, olfactory and visual stimuli consistently emerged as the most influential sensory modalities.

Table 6: Summary of Post-Hoc Comparisons

Outcome Variable	Dominant Sensory Stimuli	Significantly Higher Than
Emotional Arousal	Olfactory, Visual	Auditory, Tactile, Gustatory
Buying Behavior	Visual, Olfactory	Auditory, Tactile, Gustatory

Overall Interpretation

Taken together, the regression and ANOVA findings provide convergent evidence that sensory stimuli exert meaningful and differentiated effects on emotional arousal and buying behavior. The results underscore the value of direct-effect testing in neuromarketing research, demonstrating that analytically transparent methods can yield theoretically rich and managerially actionable insights.

7. Discussion of Findings

The purpose of this study was to examine how different sensory stimuli influence emotional arousal and buying behavior using a direct-effects analytical approach. By relying on regression and analysis of variance rather than mediation-heavy models, the findings offer a clear and interpretable account of how sensory cues shape affective intensity and purchase-related responses. The discussion interprets these findings in light of existing theory and highlights their implications for neuromarketing and sensory marketing research. One of the most salient findings of the study is the strong and consistent influence of olfactory stimuli on emotional arousal. Across both regression and ANOVA results, scent emerged as the most potent driver of affective activation. This finding aligns with affective neuroscience perspectives suggesting that olfactory processing is closely linked to limbic structures associated with emotion and memory. Unlike other sensory cues that often require cognitive appraisal or contextual interpretation, scent appears capable of triggering arousal rapidly and automatically. From a theoretical standpoint, this supports the view that emotional arousal in consumption settings can be elicited through pathways that bypass deliberate evaluation, reinforcing the relevance of embodied and pre-conscious processing in consumer behavior.

Visual stimuli also demonstrated a robust influence, particularly on buying behavior. While visual cues significantly predicted emotional arousal, their strongest effect was observed in relation to purchase-related responses. This pattern suggests that visual stimuli play a dual role: they contribute to affective activation while simultaneously shaping perceptual judgments that guide behavioral inclination. Visual design elements such as color, layout, and form likely enhance fluency and perceived quality, making products easier to process and more appealing. The dominance of visual stimuli in predicting buying behavior highlights the continued importance of visual design in marketing environments, even as sensory marketing broadens beyond sight. Auditory stimuli exhibited a modest but statistically significant influence on both emotional arousal and buying behavior. Compared to visual and olfactory cues, the effect sizes associated with sound were smaller, yet consistent. This suggests that auditory stimuli may function as contextual regulators rather than primary drivers of affective intensity. Sound appears to shape the emotional tone of the environment, subtly influencing mood and pacing without necessarily producing strong arousal on its own. This interpretation is consistent with theoretical views that position auditory cues as background modulators that support, rather than dominate, the consumption experience.

In contrast, tactile and gustatory stimuli did not emerge as significant predictors in the regression models and showed comparatively weaker effects in the ANOVA results. This does not imply that these sensory modalities are unimportant, but rather that their influence may be more contingent on context and level of engagement. Tactile cues often require active interaction to exert their full effect, and gustatory cues are highly domain-specific, primarily relevant in food and beverage contexts. Within the controlled experimental setting of this study, these stimuli may not have generated sufficient immediacy or relevance to elevate arousal or buying intention significantly. Theoretically, this finding underscores the importance of situational fit in sensory marketing and cautions against assuming uniform effectiveness across sensory channels. A notable contribution of the study lies in the observed divergence between predictors of emotional arousal and predictors of buying behavior. While olfactory stimuli were the strongest drivers of arousal, visual stimuli exerted the greatest influence on buying behavior. This distinction suggests that affective intensity and behavioral inclination, although related, are not interchangeable outcomes. Emotional arousal may heighten readiness and engagement, but translating this activation into purchase intention appears to depend more heavily on perceptual cues that facilitate evaluation and confidence. This nuanced pattern would likely be obscured in models that collapse affective and behavioral processes into a single causal chain.

From a methodological perspective, the findings demonstrate the value of direct-effect testing in neuromarketing research. By avoiding mediation and structural models, the study provides results that are both theoretically interpretable and managerially actionable. The convergence between regression and ANOVA findings further strengthens confidence in the robustness of the results. Rather than relying on statistical complexity to infer causality, the study shows that well-designed experiments combined with transparent analytical techniques can yield substantive insights into consumer behavior. Overall, the findings contribute to neuromarketing theory by reinforcing the central role of emotional arousal as an outcome of sensory exposure and by clarifying how different sensory modalities differentially influence affective and behavioral responses. They also advance sensory marketing research by highlighting the non-uniform impact of sensory cues and by demonstrating that not all senses contribute equally in all contexts. These insights lay the groundwork for more nuanced theoretical models that

respect both the immediacy of affective processing and the practical realities of consumer decision-making.

8. Managerial Implications

he findings of this study offer several actionable insights for marketing managers seeking to design sensory environments that effectively engage consumers and influence buying behavior. Rather than treating sensory elements as decorative or intuitive design choices, the results underscore the importance of evidence-based sensory prioritization grounded in an understanding of how different sensory cues influence emotional arousal and purchase-related responses. One of the most salient managerial implications concerns the strategic use of olfactory cues. The strong influence of scent on emotional arousal suggests that ambient fragrance can serve as a powerful tool for shaping affective intensity within retail and service environments. Managers can leverage scent to create emotionally engaging atmospheres that heighten consumer alertness and involvement. However, the findings also imply the need for careful calibration. Because olfactory responses are highly individualized and context-dependent, excessive or incongruent scent use may undermine rather than enhance the consumer experience. Managers should therefore prioritize subtle, contextually appropriate scents that align with brand identity and consumer expectations.

Visual stimuli emerged as the most influential predictors of buying behavior, highlighting the continued centrality of visual design in marketing strategy. Elements such as color schemes, spatial layout, lighting, and visual coherence appear to play a critical role in translating affective engagement into purchase intention. From a managerial perspective, this suggests that investments in visual merchandising and design consistency are likely to yield direct returns in terms of consumer action. Visual cues not only attract attention but also facilitate perceptual fluency, reducing cognitive effort and increasing confidence in purchase decisions. Auditory stimuli demonstrated modest yet consistent effects, indicating their role as contextual regulators rather than primary drivers. Managers can use music and sound strategically to shape mood, pace, and overall atmosphere without overwhelming consumers. For instance, congruent background music can reinforce brand positioning and enhance the overall sensory experience, even if it does not independently drive strong arousal or purchase intention.

The comparatively weaker effects of tactile and gustatory stimuli suggest that these cues require greater contextual relevance and consumer involvement to exert meaningful influence. In categories where physical interaction or taste is central such as apparel, furniture, or food services managers should design opportunities for direct engagement. In contexts where such interaction is limited, resources may be more effectively allocated toward visual and olfactory elements. More broadly, the study highlights the value of aligning sensory strategy with specific managerial objectives. If the goal is to elevate emotional engagement, olfactory cues may be prioritized. If the objective is to stimulate purchase intention, visual design should take precedence. Importantly, the findings caution against a “more is better” approach to sensory stimulation. Overloading consumers with multiple intense stimuli may dilute rather than enhance impact. By grounding sensory decisions in empirical evidence rather than intuition alone, managers can design environments that are both engaging and respectful of consumer experience. Such an approach not only enhances effectiveness but also contributes to more responsible and sustainable marketing practice.

9. Ethical Considerations in Neuromarketing

The growing use of neuromarketing and sensory-based strategies raises important ethical questions concerning consumer autonomy, transparency, and responsibility. Because

neuromarketing seeks to understand and influence affective and pre-conscious processes, it operates in a domain that consumers may not fully recognize or articulate. This creates an ethical obligation for researchers and practitioners to ensure that such techniques are used to enhance consumer experience rather than to exploit vulnerability. Informed consent represents a foundational ethical requirement in neuromarketing research. Participants must be clearly informed about the nature of data being collected, including any physiological or affective measures, and about how these data will be analyzed and used. Even when non-invasive methods or self-report proxies for arousal are employed, transparency remains essential to maintaining trust and research integrity. Consent procedures should be designed to respect participants' right to withdraw without penalty and to understand the general purpose of the research without being misled.

Beyond research settings, ethical concerns extend to the application of neuromarketing insights in practice. Sensory strategies that deliberately intensify emotional arousal have the potential to influence behavior in ways that consumers may not consciously recognize. While influencing choice is inherent to marketing, ethical boundaries are crossed when sensory manipulation undermines consumer agency or targets individuals who may be particularly susceptible, such as children or vulnerable populations. Responsible practice requires that sensory cues support informed choice rather than override it. Data privacy constitutes another critical ethical dimension. Neuro-related and affective data, even when aggregated, can reveal intimate aspects of individual experience. Organizations must ensure secure storage, anonymization, and responsible use of such data, avoiding secondary applications that fall outside the original scope of consent. Ultimately, ethical neuromarketing is not defined by the absence of influence but by the presence of responsibility. When sensory and neuromarketing tools are used to create environments that are engaging, transparent, and respectful of consumer well-being, they can contribute positively to both marketing effectiveness and consumer trust.

10. Limitations and Future Research

While this study offers meaningful insights into the role of sensory stimuli in shaping emotional arousal and buying behavior, several limitations should be acknowledged. First, the study was conducted within a controlled experimental setting, which, although beneficial for establishing internal validity, may limit ecological validity. Consumer responses in real-world environments are influenced by numerous contextual factors, including social presence, time pressure, and competing stimuli, which were necessarily constrained in the experimental design. Second, the sample, while adequate in size and diversity for the purposes of regression and ANOVA analysis, may not fully represent all consumer segments. Cultural background, prior sensory experiences, and individual differences in sensory sensitivity can shape how stimuli are perceived and interpreted. Future studies could benefit from cross-cultural or cross-demographic designs that examine whether the observed sensory effects generalize across populations. Third, the study relied on self-report measures to assess emotional arousal and buying behavior. Although these measures were theoretically grounded and validated, they cannot fully capture the physiological complexity of affective responses. Future research could integrate psychophysiological measures, such as skin conductance or eye-tracking, alongside self-report data to provide a more comprehensive understanding of sensory-driven responses. From an analytical perspective, the study deliberately adopted a direct-effects approach. While this enhances interpretability, it also limits the exploration of more complex relationships among variables. Future research may extend this work by examining mediating or moderating mechanisms, temporal dynamics, or interaction effects among sensory modalities, provided

such models are theoretically justified. Finally, future studies could explore longitudinal designs to assess whether sensory-induced arousal has lasting effects on brand memory and repeat purchase behavior. By addressing these limitations, future research can build on the present findings to develop a more nuanced and context-sensitive understanding of neuromarketing and sensory influence.

11. Conclusion

This study set out to examine how sensory stimuli influence emotional arousal and buying behavior through a neuromarketing-informed, direct-effects perspective. In response to the diminishing explanatory power of cognition-centered marketing models, the research positioned sensory input and affective intensity as central components of consumer decision-making. By focusing on visual, auditory, olfactory, tactile, and gustatory stimuli, the study offered a systematic comparison of how different sensory modalities shape affective and behavioral outcomes. The empirical findings provide clear evidence that sensory stimuli exert significant and differentiated effects on both emotional arousal and buying behavior. Regression analyses demonstrated that olfactory and visual cues are particularly influential, with scent emerging as the strongest predictor of emotional arousal and visual stimuli exerting the greatest impact on purchase-related responses. Analysis of variance further confirmed that emotional arousal and buying behavior differ significantly across sensory modalities, reinforcing the argument that sensory cues are not interchangeable in their effects. These results underscore the importance of examining affective and behavioral outcomes separately, as the sensory drivers of arousal do not fully mirror those of buying behavior. From a theoretical standpoint, the study contributes to neuromarketing and sensory marketing literature by reaffirming the role of emotional arousal as an outcome of sensory exposure rather than a mere byproduct of cognitive evaluation. By deliberately avoiding mediation-heavy models, the research demonstrates that analytically transparent methods such as regression and ANOVA can yield theoretically meaningful insights when combined with experimental design. This approach challenges the assumption that explanatory depth necessarily requires statistical complexity and highlights the value of direct-effect testing in understanding consumer response.

The study also offers practical relevance for marketing managers. The findings suggest that sensory strategies should be aligned with specific objectives: olfactory cues may be prioritized to enhance emotional engagement, while visual design remains central to influencing purchase intention. Importantly, the results caution against indiscriminate sensory stimulation, emphasizing the need for strategic selectivity and contextual fit. In conclusion, this research advances a balanced and evidence-based view of neuromarketing one that respects the complexity of human affect while maintaining methodological clarity. By illuminating how sensory environments shape emotional arousal and buying behavior, the study provides a foundation for future research and responsible practice in sensory-driven marketing contexts.

References

1. Ajzen, I. (1991). The theory of planned behavior. *Organisational Behaviour and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T
2. Ariely, D., & Berns, G. S. (2010). Neuromarketing: The hope and hype of neuroimaging in business. *Nature Reviews Neuroscience, 11*(4), 284–292. https://doi.org/10.1038/nrn2795
3. Boucsein, W. (2012). *Electrodermal activity* (2nd ed.). Springer. https://doi.org/10.1007/978-1-4614-1126-0

4. Bradley, M. M., & Lang, P. J. (2000). Measuring emotion: Behavior, feeling, and physiology. In R. D. Lane & L. Nadel (Eds.), *Cognitive neuroscience of emotion* (pp. 242–276). Oxford University Press.
5. Deliza, R., & MacFie, H. J. H. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: A review. *Journal of Sensory Studies, 11*(2), 103–128. https://doi.org/10.1111/j.1745-459X.1996.tb00036.x
6. Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: A technique for the measurement of facial movement*. Consulting Psychologists Press.
7. Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). Sage Publications.
8. Herz, R. S. (2004). A naturalistic analysis of autobiographical memories triggered by olfactory visual and auditory stimuli. *Chemical Senses, 29*(3), 217–224. https://doi.org/10.1093/chemse/bjh025
9. Hultén, B., Broweus, N., & van Dijk, M. (2009). *Sensory marketing*. Palgrave Macmillan. https://doi.org/10.1057/9780230237049
10. Kahneman, D. (2011). *Thinking, fast and slow*. Farrar, Straus and Giroux.
11. Krishna, A. (2010). *Sensory marketing: Research on the sensuality of products*. Routledge.
12. Krishna, A. (2012). An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behavior. *Journal of Consumer Psychology, 22*(3), 332–351. https://doi.org/10.1016/j.jcps.2011.08.003
13. Labrecque, L. I., & Milne, G. R. (2012). Exciting red and competent blue: The importance of color in marketing. *Journal of the Academy of Marketing Science, 40*(5), 711–727. https://doi.org/10.1007/s11747-010-0245-y
14. Luck, S. J. (2014). *An introduction to the event-related potential technique* (2nd ed.). MIT Press.
15. Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science, 6*(2), 114–133. https://doi.org/10.1177/1745691611400234
16. Milliman, R. E. (1982). Using background music to affect the behavior of supermarket shoppers. *Journal of Marketing, 46*(3), 86–91. https://doi.org/10.1177/002224298204600313
17. North, A. C., Hargreaves, D. J., & McKendrick, J. (1999). The influence of in-store music on wine selections. *Journal of Applied Psychology, 84*(2), 271–276. https://doi.org/10.1037/0021-9010.84.2.271
18. Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill.
19. Peck, J., & Childers, T. L. (2003). To have and to hold: The influence of haptic information on product judgments. *Journal of Marketing, 67*(2), 35–48. https://doi.org/10.1509/jmkg.67.2.35.18612
20. Peck, J., & Shu, S. B. (2009). The effect of mere touch on perceived ownership. *Journal of Consumer Research, 36*(3), 434–447. https://doi.org/10.1086/598614
21. Pham, M. T. (2007). Emotion and rationality: A critical review and interpretation of empirical evidence. *Review of General Psychology, 11*(2), 155–178. https://doi.org/10.1037/1089-2680.11.2.155
22. Pieters, R., & Wedel, M. (2004). Attention capture and transfer in advertising: Brand, pictorial, and text-size effects. *Journal of Marketing, 68*(2), 36–50. https://doi.org/10.1509/jmkg.68.2.36.27794

23. Plassmann, H., Ramsøy, T. Z., & Milosavljevic, M. (2012). Branding the brain: A critical review and outlook. *Journal of Consumer Psychology, 22*(1), 18–36. https://doi.org/10.1016/j.jcps.2011.11.010
24. Plassmann, H., Venkatraman, V., Huettel, S., & Yoon, C. (2015). Consumer neuroscience: Applications, challenges, and possible solutions. *Journal of Marketing Research, 52*(4), 427–435. https://doi.org/10.1509/jmr.14.0048
25. Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39*(6), 1161–1178. https://doi.org/10.1037/h0077714
26. Spangenberg, E. R., Crowley, A. E., & Henderson, P. W. (1996). Improving the store environment: Do olfactory cues affect evaluations and behaviors? *Journal of Marketing, 60*(2), 67–80. https://doi.org/10.1177/002224299606000205
27. Wedel, M., & Pieters, R. (2008). Eye tracking for visual marketing. *Foundations and Trends in Marketing, 1*(4), 231–320. https://doi.org/10.1561/1700000011
28. Zaltman, G. (2003). *How customers think: Essential insights into the mind of the market*. Harvard Business School Press.