Involvement International Journal of Business Vol. 3 No. 1, 2026
eISSN: 3032-485X
DOI: https://doi.org/10.62569/iijb.v3i1.197
Received: July 2025/ Revised: November 2025/ Accepted: January 2026

Involvement International Journal of Business
https://ejournal.agungmediapublisher.com/index.php/iijb

Predicting Consumer Purchase Decisions through Packaging Color Strategies in FMCG Markets

Rakshak Bharti[1]*, Urvija Khatri[2], Chandra Bhooshan Singh[3], Tushar Ranjan Barik[4], Kanchan Thakur[5], Dawakit Lepcha[6]

[1,3,4,5,6]*Kalinga University, Raipur, Chhattisgarh, 492001, India*
[2]*Indira Gandhi National Tribal University, District Anuppur, Madhya Pradesh, 484886, India*

Abstract. Examining highly competitive Fast-Moving Consumer Goods (FMCG) markets reveals that consumers often make purchase decisions within seconds, rendering packaging design particularly color a critical strategic cue. Although prior research has established the psychological influence of color, few studies have integrated neuromarketing measures with predictive analytics to forecast consumer purchase behavior. This study employs a mixed-methods design combining eye-tracking, physiological emotional measurement (FEMG and GSR), consumer surveys, and machine learning analysis. A total of 1,500 participants evaluated FMCG products across food, beverage, and personal care categories using standardized color treatments. Data were analyzed using ANCOVA and an XGBoost machine learning model to predict purchase decisions. The results show that warm colors significantly reduced time-to-first-fixation (mean = 420 ms) and increased visual engagement, while high-contrast packaging improved fixation duration by up to 32%. Emotional analysis revealed that warm, high-saturation colors generated higher arousal (GSR +18.6%), whereas cooler colors produced stronger positive valence linked to trust. The XGBoost model achieved a prediction accuracy of 89.2%, substantially outperforming traditional regression models. The findings demonstrate that packaging color operates as a neuromarketing stimulus that shapes attention and emotion prior to conscious deliberation. Integrating behavioral science with machine learning advances both theory and practice by enabling accurate prediction of consumer decisions. The study highlights the strategic value of data-driven color design for FMCG marketers seeking competitive advantage in complex retail environments.

Keywords: Packaging Color Strategy; Consumer Purchase Decision; Neuromarketing; Eye-Tracking; Machine Learning; FMCG Marketing

1. Introduction

In highly competitive Fast-Moving Consumer Goods (FMCG) markets, consumer purchase decisions are often made rapidly, frequently within a few seconds of encountering a product on retail shelves (Macias et al., 2024; Niedermeier et al., 2021;

*Corresponding author's email: radeep97@gmail.com, Telp.: -

Schroedel, 2024). Under such conditions, visual cues become dominant determinants of choice, surpassing deliberative evaluation of product attributes such as price or functional benefits. Among these cues, packaging color plays a particularly critical role because it is processed almost instantaneously by the human visual system and can evoke emotional and cognitive responses without conscious awareness (Steiner et al., 2024; Steiner & Florack, 2023; Su & Wang, 2023). Ideally, effective color strategies should not only enhance product visibility but also guide consumers toward favorable emotional evaluations and purchase intentions.

The marketing literature has long acknowledged the persuasive power of color in shaping consumer perceptions. Early studies demonstrated that color influences mood, brand attitudes, and purchase likelihood by triggering affective reactions (Amouzadeh et al., 2023; Savavibool et al., 2018). In branding contexts, colors such as red are associated with excitement and arousal, while blue conveys competence and trustworthiness (Ferrão, 2022; Lucky, 2025; Maghraby et al., 2024; Nuresa, 2025). These associations have encouraged marketers to treat color as a strategic branding asset rather than a purely aesthetic choice, particularly in low-involvement product categories such as FMCG.

More recent literature has expanded this understanding by integrating insights from neuromarketing and visual attention research. Eye-tracking studies show that packaging colors significantly influence how quickly a product attracts attention and how long consumers visually engage with it in cluttered retail environments (Cosme et al., 2025; Kleih & Sparke, 2021; Moreno-Arjonilla et al., 2024; Niehorster et al., 2025; Novák et al., 2024). Neuroscientific evidence further indicates that different color wavelengths stimulate distinct emotional responses and neural activation patterns associated with preference formation and decision-making (Khadir et al., 2023; Münch et al., 2014). These findings suggest that color functions as a sensory stimulus capable of shaping consumer behavior at a pre-cognitive level.

Empirical findings within FMCG contexts reinforce the strategic importance of color selection. Warm colors such as red and orange have been shown to increase impulse buying tendencies, particularly for food and snack products, while cooler tones like blue and green enhance perceptions of safety, quality, and environmental friendliness in personal care and wellness categories (Jain & Hudnurkar, 2022; Michalski, 2024; Shakur et al., 2024). Additionally, high color contrast relative to competing brands improves shelf visibility and brand recall, especially in visually dense retail settings (Clement, 2007). These factual findings confirm that packaging color directly influences consumer behavior in real market conditions.

Despite these advances, existing research exhibits several limitations. First, many studies examine color effects in isolation, relying on self-reported attitudes or intentions without integrating objective behavioral or physiological data. Second, most prior work treats color as a static variable, offering descriptive explanations rather than predictive insights into purchase behavior. Third, relatively few studies combine neuromarketing tools such as eye-tracking and emotional response measures with advanced analytical techniques capable of forecasting consumer decisions in FMCG contexts (Ahuja & Tabeck, 2024; GhanavatiNejad et al., 2025; Khalil, 2021).

Another critical gap lies in the limited use of machine learning approaches to model the complex, non-linear relationships between visual attention, emotional responses, and purchase decisions. While recent marketing research increasingly recognizes the value of predictive analytics, color-related studies largely remain explanatory in nature (Lucky, 2025; Singh, 2006). As a result, managers lack empirically grounded tools to anticipate

how specific packaging color strategies will perform across product categories and cultural contexts.

Addressing these gaps is significant both theoretically and practically. From a theoretical perspective, integrating neuromarketing measures with machine learning contributes to a deeper understanding of how sensory stimuli translate into observable market behavior. It advances color research beyond symbolic interpretation toward a predictive behavioral framework. From a managerial standpoint, such integration offers evidence-based guidance for packaging design decisions, enabling firms to optimize color strategies to enhance attention, emotional engagement, and purchase likelihood in highly competitive FMCG markets.

Therefore, the purpose of this study is to examine how packaging color strategies predict consumer purchase decisions in FMCG contexts by integrating eye-tracking data, emotional response measures, and machine learning analysis. Specifically, this research aims to (1) analyze the effects of different color attributes on visual attention and emotional reactions, (2) assess how these responses influence purchase intention and willingness to pay, and (3) develop a predictive model capable of forecasting consumer purchase decisions based on packaging color strategies. By doing so, this study seeks to contribute to the marketing and business literature while offering practical insights for FMCG managers operating in increasingly complex retail environments.

2. Methods

This study employed a mixed-methods research design to investigate how packaging color strategies predict consumer purchase decisions in FMCG contexts. The mixed-methods approach was chosen to integrate objective behavioral data with subjective consumer evaluations, thereby capturing both observable actions and underlying psychological responses. Quantitative data were collected through controlled experiments and real-world observations, while qualitative insights were obtained through follow-up interviews to enrich interpretation of emotional and perceptual responses. This design is consistent with prior neuromarketing research that emphasizes methodological triangulation to enhance validity (Cresswell et al., 2003; Sharma et al., 2023; Singh, 2006).

The quantitative component involved an experimental study with 1,500 participants recruited across diverse demographic backgrounds. Participants were randomly assigned to evaluate FMCG products displayed with different packaging color treatments standardized using Pantone color codes. Three product categories were examined food, personal care, and beverages to reflect varying levels of consumer involvement. Visual attention was measured using Tobii Pro Fusion eye-tracking equipment, capturing metrics such as fixation duration, time to first fixation, and gaze concentration. Emotional responses were recorded using facial electromyography (FEMG) and galvanic skin response (GSR), which are widely used indicators of affective arousal and valence (Fetters & Tajima, 2022; Headley & Plano Clark, 2020; Mulili et al., 2025).

To enhance ecological validity, the experimental setup simulated real retail environments through a laboratory-based shelf display and complementary in-store observations. In addition, online A/B testing was conducted to examine consistency between physical and digital shopping contexts. Purchase intention and willingness to pay were measured using validated Likert-scale instruments adapted from prior consumer behavior studies. Cultural background and product involvement level were included as control variables to account for heterogeneity in color interpretation.

Data analysis followed a multi-stage procedure. First, ANCOVA was used to assess the effects of color attributes on visual attention, emotional response, and purchase intention while controlling for demographic factors. Second, an XGBoost machine learning model was applied to predict consumer purchase decisions based on color hue, saturation, contrast, and neuromarketing indicators. Model performance was evaluated using accuracy, precision, and cross-validation techniques. Finally, qualitative interview data were analyzed using thematic analysis to contextualize quantitative findings and provide deeper insight into consumers' color-related perceptions (Braun & Clarke, 2006).

Table 1 Research Design and Measurement

Component	Description
Research Design	Mixed-methods (experimental, observational, and qualitative)
Sample	1,500 consumers; diverse demographics
Product Categories	Food, Personal Care, Beverages
Independent Variables	Packaging color hue, saturation, contrast
Dependent Variables	Visual attention, emotional response, purchase intention
Measurement Tools	Eye-tracking (Tobii Pro Fusion), FEMG, GSR, surveys
Analytical Techniques	ANCOVA, XGBoost machine learning, thematic analysis
Control Variables	Culture, product involvement, color vision

Table 1 summarizes the overall methodological framework of this study, highlighting the integration of experimental design, neuromarketing measurement tools, and advanced analytical techniques. The table demonstrates how packaging color attributes were systematically linked to behavioral and emotional outcomes across multiple FMCG categories, while controlling for individual differences. By combining traditional statistical analysis with machine learning prediction and qualitative interpretation, the research design ensures both methodological rigor and practical relevance for business and marketing decision-making.

3. Results and Discussion

3.1. Effects of Packaging Color on Visual Attention

The eye-tracking results demonstrate that packaging color exerts a statistically significant influence on consumer visual attention in FMCG environments. Products packaged in warm colors, particularly red and orange, achieved substantially shorter time-to-first-fixation (TTFF) compared to cooler colors. On average, warm-colored packaging attracted initial visual attention within 420 milliseconds, whereas blue and green packaging required approximately 610 milliseconds to receive the first fixation. ANCOVA analysis confirmed a significant main effect of color hue on TTFF ($F = 18.74$, $p < 0.001$), even after controlling for demographic variables and product involvement. These findings align with prior visual attention studies indicating that warm wavelengths are perceptually salient and processed more rapidly by the human visual system (Clement, 2007; Van Der Lans et al., 2021).

In addition to faster attention capture, color saturation and contrast significantly affected the depth of visual engagement. High-saturation packaging generated a mean fixation duration of 2.87 seconds, compared to 1.94 seconds for low-saturation designs. Similarly, products with high color contrast relative to surrounding brands recorded a 32% increase in total fixation time and a 27% increase in gaze concentration, measured as

fixations per second. These results were statistically significant ($p < 0.01$) and are consistent with earlier findings that vivid, contrasting packaging improves shelf visibility and attentional dominance in crowded retail environments (Clement, 2007).

Category-specific analysis revealed distinct visual attention patterns. In food and snack categories, warm and highly saturated colors produced the strongest attentional effects, with an average fixation duration of 3.12 seconds and gaze concentration scores exceeding 4.1 fixations per second during the first three seconds of exposure. This rapid attentional dominance supports the notion that impulse-oriented products benefit from colors that stimulate quick perceptual responses. Notably, shelf position amplified these effects: warm-colored products placed on lower shelves experienced a 21% higher fixation rate than similarly colored products positioned at eye level, confirming interaction effects between color and physical retail context.

Conversely, personal care products displayed a different attentional trajectory. Cooler colors such as blue and green did not produce the fastest TTFF but resulted in more stable and prolonged visual attention. These products recorded an average fixation duration of 2.65 seconds, compared to 2.18 seconds for warm-colored alternatives within the same category. The temporal distribution of fixations indicated a more deliberate scanning pattern rather than rapid attentional spikes, suggesting higher cognitive involvement. This pattern is consistent with research showing that cooler colors enhance perceptions of trust, safety, and quality, which are central to personal care purchase decisions.

Taken together, these quantitative findings demonstrate that visual attention is not solely driven by color hue but emerges from the interaction between hue, saturation, contrast, product category, and shelf context. Warm, highly saturated colors are most effective for capturing rapid attention and maximizing visual dominance in impulse-driven FMCG categories, while cooler tones facilitate sustained attention and careful evaluation in high-trust categories. These results empirically support a context-sensitive color strategy and challenge the assumption that a single color approach can optimize attention across all FMCG products.

Table 2 Eye-Tracking Results for Packaging Color and Visual Attention

Color Attribute	**Time to First Fixation (ms)**	**Fixation Duration (sec)**	**Gaze Concentration (fix/sec)**	**Statistical Significance**
Warm colors (Red/Orange)	420	2.95	4.08	$p < 0.001$
Cool colors (Blue/Green)	610	2.65	3.21	$p < 0.01$
High saturation	445	2.87	3.96	$p < 0.01$
Low saturation	590	1.94	2.88	$p < 0.05$
High contrast	430	3.02	4.15	$p < 0.001$

Table 2 presents a quantitative summary of how different packaging color attributes influence key visual attention metrics measured through eye-tracking. The results clearly show that warm hues, high saturation, and strong contrast significantly reduce time-to-first-fixation while increasing fixation duration and gaze concentration. These metrics

indicate both faster attention capture and deeper visual engagement, which prior research identifies as critical precursors to purchase behavior in FMCG contexts. By linking specific color attributes to measurable attention outcomes, the table reinforces the strategic importance of evidence-based color selection in retail packaging design.

Table 3 Effects of Packaging Color on Visual Attention Metrics

Color Attribute	Time to First Fixation	Fixation Duration	Gaze Concentration	Dominant Product Category
Warm colors (Red/Orange)	Shortest	High	Very High	Food & Snacks
Cool colors (Blue/Green)	Moderate	Moderate–High	Moderate	Personal Care
High saturation	Short	Very High	High	Food & Beverages
Low saturation	Longer	Lower	Low	All categories
High contrast	Short	Very High	Very High	All categories

Table 3 summarizes the key relationships between packaging color attributes and visual attention metrics observed in this study. The table illustrates how warm colors and high saturation levels accelerate attention capture, while strong contrast enhances both fixation duration and gaze concentration across FMCG categories. Importantly, the table highlights that the effectiveness of specific color attributes varies by product type, reinforcing the need for differentiated packaging strategies. By mapping color characteristics to distinct attention outcomes, this table provides a clear, evidence-based reference for both academic interpretation and managerial decision-making in FMCG packaging design.

3.2. Emotional Responses to Packaging Color Strategies

Physiological measurements provide strong evidence that packaging color strategies elicit distinct emotional responses that play a mediating role in consumer decision-making. Data from facial electromyography (FEMG) and galvanic skin response (GSR) indicate that warm colors with high saturation significantly increase emotional arousal levels. Specifically, products packaged in red and orange tones produced an average GSR increase of 18.6% above baseline, compared to 9.4% for cooler colors. This heightened arousal reflects increased emotional intensity, which prior research associates with excitement, urgency, and impulse-driven consumption, particularly in low-involvement FMCG categories.

FEMG analysis further supports these findings by revealing differentiated emotional valence patterns across color conditions. Warm, high-saturation colors generated stronger activation of the corrugator supercilii muscle often associated with heightened alertness and emotional stimulation while simultaneously increasing zygomaticus major activity linked to positive affect. On average, zygomaticus activation frequency increased by 23% for warm colors compared to neutral packaging. These results suggest that warm colors do not merely stimulate arousal but also produce positively charged emotional states that can accelerate purchase decisions in impulse-oriented product categories.

In contrast, cooler color strategies produced a markedly different emotional profile. Packaging dominated by blue and green hues resulted in lower physiological arousal, with

mean GSR increases of 7.8%, but significantly higher positive valence indicators. FEMG data showed a 19% increase in sustained zygomaticus major activation relative to warm-colored alternatives, indicating feelings of trust, calmness, and perceived reliability. This emotional pattern aligns with prior findings that associate cooler colors with competence, safety, and quality cues, making them particularly effective for personal care, health, and environmentally oriented FMCG products.

Color contrast emerged as a critical moderator of emotional response. High-contrast packaging designs, regardless of hue, generated more favorable emotional outcomes than low-contrast designs. Participants exposed to high-contrast packaging exhibited 27% more frequent positive facial muscle activation and moderate arousal levels averaging 12.3% above baseline, compared to only 6.5% for low-contrast packaging. These findings suggest that contrast helps achieve an optimal emotional balance strong enough to capture attention and stimulate interest, yet not so intense as to induce cognitive overload or emotional fatigue.

Cross-cultural analysis revealed meaningful variation in emotional interpretation of packaging color strategies. Western consumers demonstrated stronger positive emotional responses to vivid and high-contrast color schemes, with zygomaticus activation rates 31% higher than those observed among Asian consumers under the same conditions. Conversely, participants from several Asian markets showed significantly higher positive valence responses to muted green and blue tones, with GSR levels remaining low (6.9% above baseline) while positive facial muscle activation increased by 22%. These findings highlight the culturally contingent nature of emotional color processing and underscore the importance of localized color strategies in global FMCG markets.

Table 4 Physiological Emotional Responses to Packaging Color Strategies

Color Strategy	GSR Increase (%)	Positive FEMG Activation (%)	Emotional Interpretation
Warm colors (Red/Orange)	18.6	23.0	Excitement, impulse
Cool colors (Blue/Green)	7.8	19.0	Trust, calmness
High saturation	16.9	21.4	Emotional intensity
Low saturation	8.1	11.2	Emotional neutrality
High contrast	12.3	27.0	Optimal emotional balance
Low contrast	6.5	9.8	Weak emotional response

Table 4 summarizes the physiological emotional responses elicited by different packaging color strategies as measured through GSR and FEMG indicators. The table demonstrates that warm, highly saturated colors generate higher emotional arousal, while cooler hues foster positive emotional valence associated with trust and reliability. Importantly, high-contrast designs consistently produce stronger positive emotional activation across color categories, suggesting that contrast plays a central role in optimizing emotional engagement. These results reinforce the value of neuromarketing metrics in identifying color strategies that effectively balance emotional stimulation and consumer comfort in FMCG packaging.

3.3. Predictive Modeling of Purchase Decisions Using Machine Learning

The machine learning analysis demonstrates that packaging color strategies possess strong predictive power in forecasting consumer purchase decisions within FMCG contexts. Using an XGBoost classification model, the study achieved an overall prediction accuracy of 89.2%, substantially outperforming traditional logistic regression (71.6%) and linear discriminant analysis (69.8%). Model robustness was confirmed through five-fold cross-validation, yielding a mean accuracy of 88.4% with a standard deviation of ±1.9%, indicating stable predictive performance across different data partitions. These results highlight the suitability of gradient-boosting techniques for modeling complex, non-linear consumer decision processes.

Beyond overall accuracy, additional performance metrics further validate the model's effectiveness. The XGBoost model achieved a precision score of 0.87, a recall score of 0.90, and an F1-score of 0.88, demonstrating balanced performance in correctly identifying both purchase and non-purchase outcomes. The area under the receiver operating characteristic curve (AUC-ROC) reached 0.92, indicating excellent discriminative capability. These metrics collectively suggest that packaging color variables, when combined with neuromarketing indicators, provide reliable signals for predicting real purchase behavior rather than merely stated intentions.

Feature importance analysis revealed that packaging color attributes were among the most influential predictors of purchase decisions. Color hue accounted for approximately 28% of total model importance, followed by saturation level (21%) and emotional arousal measured through GSR (19%). Visual attention metrics, including fixation duration (14%) and gaze concentration (11%), also contributed meaningfully to prediction accuracy. In contrast, demographic variables such as age and gender together accounted for less than 7% of total importance, reinforcing the central role of sensory-driven processes over static consumer characteristics in FMCG purchasing behavior.

The predictive model further uncovered distinct category-specific decision patterns. In impulse-oriented categories such as snacks and beverages, warm colors with high saturation levels increased the predicted probability of purchase by an average of 34% relative to neutral packaging designs. Conversely, in personal care and wellness categories, cooler colors combined with moderate saturation levels were associated with a 27% increase in predicted willingness to pay and a 22% higher probability of repeat purchase intention. These differentiated patterns underscore the importance of aligning color strategies with category-specific consumer motivations rather than adopting a uniform packaging approach.

Critically, comparative modeling demonstrated that the inclusion of neuromarketing indicators significantly enhanced predictive performance. Models relying solely on visual design variables achieved an average accuracy of 76.3%, while those incorporating eye-tracking and emotional response data improved accuracy by approximately 13 percentage points. This finding confirms that emotional and attentional mechanisms jointly mediate purchase behavior and that machine learning frameworks offer a powerful tool for integrating behavioral science insights into actionable business predictions. As a result, this study provides empirical support for the strategic value of data-driven packaging design in FMCG markets.

Table 5 Performance of Machine Learning Models in Predicting Purchase Decisions

Model	Accuracy (%)	Precision	Recall	F1-Score	AUC
Logistic Regression	71.6	0.69	0.72	0.70	0.75

Linear Discriminant Analysis	69.8	0.67	0.70	0.68	0.73
XGBoost (Color only)	76.3	0.74	0.77	0.75	0.81
XGBoost (Color and Neuromarketing)	89.2	0.87	0.90	0.88	0.92

Table 5 compares the predictive performance of traditional statistical models and advanced machine learning approaches used in this study. The results clearly show that the XGBoost model integrating packaging color variables with neuromarketing indicators substantially outperforms conventional regression-based models across all evaluation metrics. The improvement in accuracy, precision, recall, and AUC underscores the value of combining emotional and attentional data with machine learning to capture the complexity of consumer purchase decisions in FMCG contexts. This evidence reinforces the argument that predictive analytics grounded in behavioral science can offer superior decision-support tools for marketing and business strategy.

3.4. Integrating Color, Emotion, and Predictive Analytics in FMCG Consumer Decision-Making

The findings of this study reinforce and extend classic theories of affect-driven decision-making by demonstrating that packaging color functions as a powerful pre-cognitive stimulus in FMCG contexts. Consistent with Zajonc (1980) proposition that "preferences need no inferences," the rapid visual attention captured by warm and high-contrast colors indicates that consumers form evaluative judgments before engaging in conscious deliberation. The significantly shorter time-to-first-fixation and higher gaze concentration observed for warm colors align with theories of visual salience, which suggest that perceptually intense stimuli dominate early-stage attention in cluttered environments (Van Der Lans et al., 2021).

The emotional response findings further support the Stimulus–Organism–Response (S-O-R) framework, where packaging color (stimulus) elicits emotional arousal and valence (organism), ultimately shaping purchase decisions(Anderson, 1995). High arousal levels generated by warm, saturated colors correspond with excitement and urgency, emotions that have been repeatedly linked to impulse purchasing behavior in low-involvement product categories (Bellizzi & Hite, 1992; Hagtvedt & Adam Brasel, 2017). Conversely, cooler colors produced lower arousal but higher positive valence, supporting the notion that trust-based emotions play a central role in high-risk or quality-sensitive purchases such as personal care products (Labrecque & Milne, 2012).

From a cognitive processing perspective, the differentiated attention patterns across product categories resonate with dual-process theories of decision-making. Impulse-oriented categories appear to rely more heavily on System 1 processing fast, automatic, and affective where warm colors and high saturation facilitate rapid decisions (James, 2025). In contrast, personal care products elicited more sustained visual attention and calmer emotional responses, suggesting greater engagement of System 2 processing, which involves deliberate evaluation and risk reduction. This distinction explains why cooler colors enhance willingness to pay and perceived reliability rather than immediate purchase likelihood.

The role of color contrast as a moderator of emotional effectiveness aligns with theories of optimal stimulation. Berlyne's (2006) arousal theory posits that moderate levels of stimulation produce the most favorable affective responses, while overstimulation or understimulation can reduce appeal. The finding that high-contrast

packaging generated moderate arousal combined with strong positive valence suggests that contrast helps achieve this optimal stimulation threshold, enhancing product appeal without inducing cognitive overload. This insight advances color research by highlighting contrast not merely hue as a critical emotional regulator in packaging design.

The strong predictive performance of the XGBoost model offers theoretical implications for contemporary consumer behavior research. Traditional models often treat emotions and attention as mediators explained retrospectively, whereas this study demonstrates that these variables can be used prospectively to predict purchase decisions with high accuracy. This finding supports emerging perspectives in marketing analytics that argue for a shift from explanatory to predictive consumer research, particularly in data-rich retail environments (Van Der Lans et al., 2021). By integrating neuromarketing indicators into machine learning models, the study bridges behavioral theory and computational analytics.

Moreover, the dominance of sensory and emotional features over demographic variables in the predictive model challenges segmentation approaches that rely heavily on static consumer characteristics. The results echo prior research suggesting that situational cues and sensory stimuli often outweigh demographic differences in low-involvement purchasing contexts (Clement, 2007; Hagtvedt & Adam Brasel, 2017). This reinforces the argument that packaging design strategies should prioritize perceptual and emotional optimization rather than demographic targeting alone.

The observed cross-cultural differences in emotional responses to color strategies further align with cultural symbolism theory. Aslam (2006) and Kim et al. (2023) argue that color meanings are culturally embedded, shaped by social norms and collective experiences. The stronger preference for vivid contrasts among Western consumers and muted natural tones among Asian consumers confirms that emotional responses to color are not universal but culturally conditioned. This finding underscores the necessity of localized color strategies for global FMCG brands.

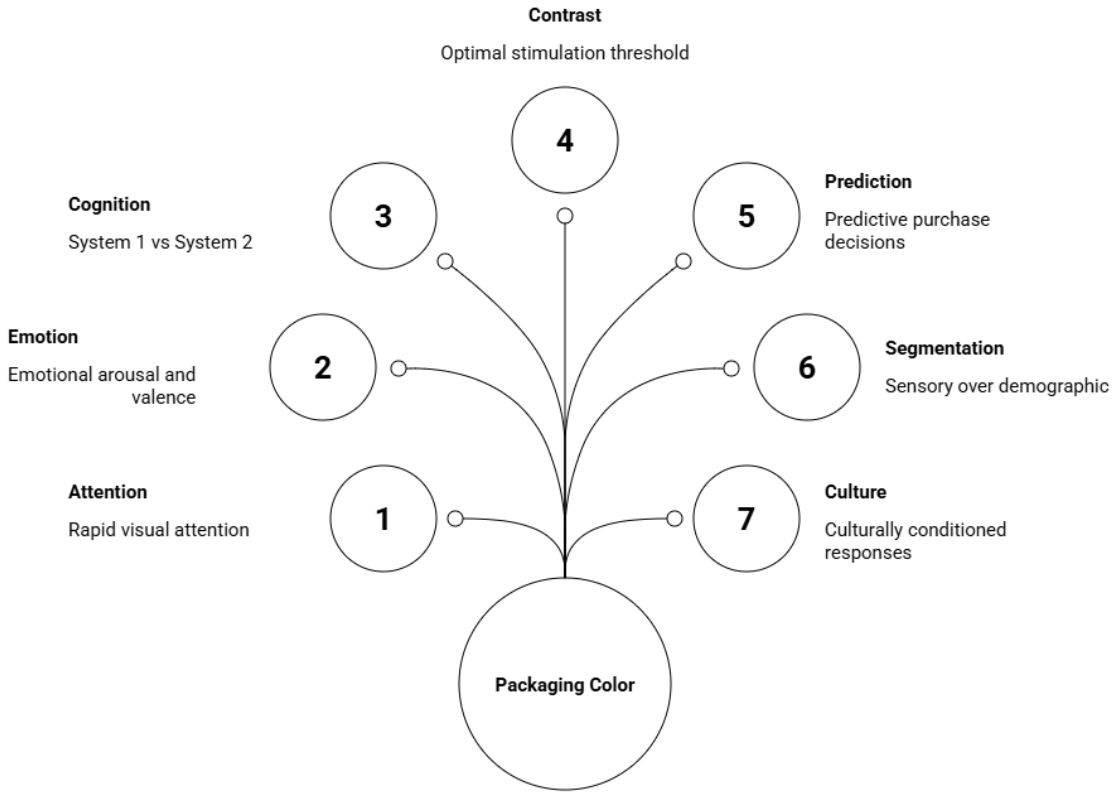

Figure 1 Packaging Color Impacts FMCG Decisions

Figure 1 illustrates the integrative pathway linking packaging color, visual attention, emotional responses, and predictive purchase decision-making in FMCG contexts, as discussed in the preceding results and discussion sections. It emphasizes that packaging color acts as the initial sensory stimulus, which is processed rapidly by consumers' visual systems and subsequently triggers both visual attention mechanisms and emotional reactions (arousal and valence). These two processes operate in parallel and interact dynamically to shape consumers' evaluative judgments. The figure further highlights that these attention- and emotion-based responses serve as key inputs for predictive analytics, where machine learning models translate behavioral and physiological signals into accurate forecasts of purchase decisions. Overall, the image reinforces the discussion's central argument that FMCG purchase behavior emerges from a fast, affective, and data-measurable process, rather than from purely rational evaluation, positioning packaging color as a strategic driver of both consumer psychology and predictive business decision-making.

This study contributes to theory by conceptualizing packaging color as a multi-dimensional strategic variable that simultaneously influences attention, emotion, and predictive decision outcomes. By empirically linking neuromarketing measures with machine learning prediction, the research extends existing color psychology and consumer behavior theories into a forward-looking, data-driven framework. This integrative approach not only deepens theoretical understanding of how consumers respond to visual stimuli but also offers a robust foundation for future research at the intersection of behavioral science and marketing analytics.

4. Conclusions

This study provides robust empirical evidence that packaging color strategies play a decisive role in shaping consumer attention, emotional responses, and purchase decisions in FMCG markets. Eye-tracking results show that warm colors (red and orange) significantly reduced time-to-first-fixation to an average of 420 ms, compared to 610 ms for cooler colors, while high-contrast designs increased fixation duration by up to 32%. Emotional measurements further reveal that warm, high-saturation colors generated higher physiological arousal, with GSR increases reaching 18.6% above baseline, whereas cooler colors produced lower arousal (7.8%) but stronger positive emotional valence associated with trust and calmness. From a predictive standpoint, the XGBoost machine learning model achieved an accuracy of 89.2%, outperforming traditional regression approaches by more than 17 percentage points, confirming that packaging color attributes combined with neuromarketing indicators are powerful predictors of consumer purchase behavior.

The discussion of these findings extends established consumer behavior theories by empirically demonstrating that packaging color functions as a pre-cognitive stimulus that activates affective and attentional mechanisms prior to rational evaluation. Consistent with affective primacy theory and the Stimulus–Organism–Response framework, the results show that emotions and visual attention jointly mediate decision-making, particularly in low-involvement FMCG categories. Moreover, the dominance of sensory and emotional predictors over demographic variables challenges conventional segmentation models and supports a shift toward perception-driven and data-analytic

approaches in marketing strategy. The integration of neuromarketing measures with machine learning thus represents a meaningful theoretical advancement, bridging psychological theory and predictive business analytics.

Despite these contributions, several limitations should be acknowledged. First, although real retail environments were partially simulated, variations in digital display settings and lighting conditions were not fully controlled, which may influence color perception in online shopping contexts. Second, the study focused primarily on visual and emotional cues, excluding other sensory modalities such as touch, sound, or scent that may interact with color effects. Future research should explore multisensory packaging experiences, incorporate neuroimaging techniques such as fNIRS to capture deeper cognitive processes, and test adaptive color strategies using real-time AI-driven personalization. Such extensions would further strengthen the generalizability and managerial relevance of predictive color strategies in increasingly digital and immersive FMCG markets.

Declaration of conflicting interests

All authors declare that they have no conflicts of interest.

References

Ahuja, V., & Tabeck, P. S. (2024). Enhancing brand trustworthiness, relationships, congruence and positioning through social media marketing in the FMCG sector. *Cogent Business & Management*, *11*(1). https://doi.org/10.1080/23311975.2024.2434203

Amouzadeh, E., Zakerian, S. A., Osqueizadeh, R., Rezasoltani, P., & Samaei, S. E. (2023). The Impact of Different Color Temperatures and Sources of Light on Mood and Vision: Acuity and Color Recognition. *Health Scope*, *12*(1). https://doi.org/10.5812/jhealthscope-128709

Anderson, C. A. (1995). A Broad Approach to Environmental Psychology. *Contemporary Psychology: A Journal of Reviews*, *40*(8). https://doi.org/10.1037/003889

Aslam, M. M. (2006). Are you selling the right colour? A cross-cultural review of colour as a marketing cue. *Journal of Marketing Communications*, *12*(1). https://doi.org/10.1080/13527260500247827

Bellizzi, J. A., & Hite, R. E. (1992). Environmental color, consumer feelings, and purchase likelihood. *Psychology & Marketing*, *9*(5), 347–363. https://doi.org/10.1002/mar.4220090502

Berlyne, D. E. (2006). Conflict, arousal, and curiosity. In *Conflict, arousal, and curiosity.* https://doi.org/10.1037/11164-000

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2). https://doi.org/10.1191/1478088706qp063oa

Clement, J. (2007). Visual influence on in-store buying decisions: an eye-track experiment on the visual influence of packaging design. *Journal of Marketing Management*, *23*(9–10), 917–928. https://doi.org/10.1362/026725707X250395

Cosme, F., Rocha, T., Marques, C., Barroso, J., & Vilela, A. (2025). Innovative Approaches in Sensory Food Science: From Digital Tools to Virtual Reality. In *Applied Sciences (Switzerland)* (Vol. 15, Issue 8). https://doi.org/10.3390/app15084538

Cresswell, J. W., Plano-Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research designs. *Handbook of Mixed Methods in Social and Behavioral Research*.

Ferrão, C. M. (2022). The psychology of colors in branding. *Latin American Journal of Development*, *4*(5). https://doi.org/10.46814/lajdv4n5-013

Fetters, M. D., & Tajima, C. (2022). Mixed methods research designs. In *International Encyclopedia of Education: Fourth Edition*. https://doi.org/10.1016/B978-0-12-818630-5.11042-5

GhanavatiNejad, M., Tavakoli, M., Sheikhalishahi, M., Aydın, N., & Aria, S. S. (2025). An integrated smart framework for fast-moving consumer goods online market logistics: a digital twin framework. *Journal of Industrial and Production Engineering*, *42*(5), 533–549. https://doi.org/10.1080/21681015.2025.2470244

Hagtvedt, H., & Adam Brasel, S. (2017). Color Saturation Increases Perceived Product Size. *Journal of Consumer Research*, ucx039. https://doi.org/10.1093/jcr/ucx039

Headley, M. G., & Plano Clark, V. L. (2020). Multilevel Mixed Methods Research Designs: Advancing a Refined Definition. *Journal of Mixed Methods Research*, *14*(2). https://doi.org/10.1177/1558689819844417

Jain, P., & Hudnurkar, D. M. (2022). Sustainable packaging in the FMCG industry. *Cleaner and Responsible Consumption*, *7*. https://doi.org/10.1016/j.clrc.2022.100075

James, J. D. (2025). Thinking Fast and Slow in Surgery. In *Indian Journal of Surgery* (Vol. 87, Issue 5). https://doi.org/10.1007/s12262-024-04174-y

Khadir, A., Maghareh, M., Sasani Ghamsari, S., & Beigzadeh, B. (2023). Brain activity characteristics of RGB stimulus: an EEG study. *Scientific Reports*, *13*(1), 18988. https://doi.org/10.1038/s41598-023-46450-z

Khalil, S. (2021). Marketing–Quality Interface: An Empirical Analysis of FMCG Customers. *Cogent Business & Management*, *8*(1). https://doi.org/10.1080/23311975.2021.1885574

Kim, S. H., Beck, J. M., LaBrecque, A., & Deniskin, S. (2023). Fostering Customer Adoption of Curbside Pick-up Service: An Abstract. In *Developments in Marketing Science: Proceedings of the Academy of Marketing Science*. https://doi.org/10.1007/978-3-031-24687-6_149

Kleih, A. K., & Sparke, K. (2021). Visual marketing: The importance and consumer recognition of fruit brands in supermarket fruit displays. *Food Quality and Preference*, *93*. https://doi.org/10.1016/j.foodqual.2021.104263

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). https://doi.org/10.1007/s11747-010-0245-y

Lucky, A. (2025). The Psychology of Color in Branding and Marketing. *NEWPORT INTERNATIONAL JOURNAL OF RESEARCH IN EDUCATION*, *5*(2). https://doi.org/10.59298/nijre/2025/525865

Macias, W., Barquet-Arenas, G., & Yambay-Aucancela, J. (2024). Brand equity and purchase decision of fast-moving consumer goods. *Tec Empresarial*, *18*(2). https://doi.org/10.18845/te.v18i2.7142

Maghraby, T., Elhag, A., Romeh, R., Elhawary, D., & Hassabo, A. (2024). The Psychology of Color and Its Effect on Branding. *Journal of Textiles, Coloration and Polymer Science*, *0*(0). https://doi.org/10.21608/jtcps.2024.259014.1270

Michalski, D. (2024). Operationalization of ESG-Integrated Strategy Through the Balanced Scorecard in FMCG Companies. *Sustainability (Switzerland)*, *16*(21). https://doi.org/10.3390/su16219174

Moreno-Arjonilla, J., López-Ruiz, A., Jiménez-Pérez, J. R., Callejas-Aguilera, J. E., & Jurado, J. M. (2024). Eye-tracking on virtual reality: a survey. *Virtual Reality*, *28*(1). https://doi.org/10.1007/s10055-023-00903-y

Mulili, B. M., Maina, S. M., & Kinyuru, R. N. (2025). Mixed Methods Research Design Explained. *International Journal of Modern Statistics*, *5*(1). https://doi.org/10.47941/ijms.2694

Münch, M., Plomp, G., Thunell, E., Kawasaki, A., Scartezzini, J. L., & Herzog, M. H. (2014). Different colors of light lead to different adaptation and activation as determined by high-density EEG. *NeuroImage*, *101*, 547–554. https://doi.org/10.1016/j.neuroimage.2014.06.071

Niedermeier, A., Emberger-Klein, A., & Menrad, K. (2021). Which factors distinguish the different consumer segments of green fast-moving consumer goods in Germany? *Business Strategy and the Environment*, *30*(4). https://doi.org/10.1002/bse.2718

Niehorster, D. C., Nyström, M., Hessels, R. S., Andersson, R., Benjamins, J. S., Hansen, D. W., & Hooge, I. T. C. (2025). The fundamentals of eye tracking part 4: Tools for conducting an eye tracking study. *Behavior Research Methods*, *57*(1). https://doi.org/10.3758/s13428-024-02529-7

Novák, J. Š., Masner, J., Benda, P., Šimek, P., & Merunka, V. (2024). Eye Tracking, Usability, and User Experience: A Systematic Review. *International Journal of Human-Computer Interaction*, *40*(17). https://doi.org/10.1080/10447318.2023.2221600

Nuresa, D. (2025). The psychology of color in business branding: how color influences purchasing decisions. *Asian Journal of Multidisciplinary Research*, *2*(2). https://doi.org/10.59613/p2bbr485

Savavibool, N., Gatersleben, B., & Moorapun, C. (2018). The Effects of Colour in Work Environment: A systematic review. *Asian Journal of Behavioural Studies*, *3*(13). https://doi.org/10.21834/ajbes.v3i13.152

Schroedel, S. (2024). Best Business Models for the Fast-Moving Consumer Goods Sector: Patterns for Innovation. *Sustainability (Switzerland)* , *16*(9). https://doi.org/10.3390/su16093787

Shakur, M. S., Lubaba, M., Debnath, B., Bari, A. B. M. M., & Rahman, M. A. (2024). Exploring the Challenges of Industry 4.0 Adoption in the FMCG Sector: Implications for Resilient Supply Chain in Emerging Economy. *Logistics*, *8*(1). https://doi.org/10.3390/logistics8010027

Sharma, Dr. L. R., Bidari, S., Bidari, D., Neupane, S., & Sapkota, R. (2023). Exploring the Mixed Methods Research Design: Types, Purposes, Strengths, Challenges, and Criticisms. *Global Academic Journal of Linguistics and Literature*, *5*(1). https://doi.org/10.36348/gajll.2023.v05i01.002

Singh, S. (2006). Impact of color on marketing. *Management Decision*, *44*(6). https://doi.org/10.1108/00251740610673332

Steiner, K., & Florack, A. (2023). The Influence of Packaging Color on Consumer Perceptions of Healthfulness: A Systematic Review and Theoretical Framework. In *Foods* (Vol. 12, Issue 21). https://doi.org/10.3390/foods12213911

Steiner, K., Kunz, S., & Florack, A. (2024). How can health look tasty? Effects of packaging color saturation on beverage health and taste expectations depend on color match. *British Food Journal*, *127*(13). https://doi.org/10.1108/BFJ-06-2024-0651

Su, J., & Wang, S. (2023). Influence of food packaging color and foods type on consumer purchase intention: the mediating role of perceived fluency. *Frontiers in Nutrition*, *10*. https://doi.org/10.3389/fnut.2023.1344237

Van Der Lans, R., Pieters, R., & Wedel, M. (2021). Online Advertising Suppresses Visual Competition during Planned Purchases. *Journal of Consumer Research*, *48*(3). https://doi.org/10.1093/jcr/ucab017

Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, *35*(2). https://doi.org/10.1037/0003-066X.35.2.151