Assessing the Impact of Point-of-Sale Beer Brand Ads Through Consumer Neuroscience Research

Darko Lukić*, Slađana Starčević, Goran Pitić

Metropolitan University, FEFA Faculty, Belgrade, Serbia
dlukic@fefa.edu.rs, sstarcevic@fefa.edu.rs, gpitic@fefa.edu.rs

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Abstract

This study employs EEG and eye-tracking to assess how brand equity, creative complexity, and spatial layout influence implicit consumer responses to point-of-sale (POS) beer advertisements. Through the theoretical lens of predictive coding and processing fluency, laboratory testing with Serbian beer consumers (N = 20) revealed that simpler designs yielded superior attention performance across TFD and TTFF (*d* up to 2.62), independent of brand strength. Spatial repositioning reduced packshot detection time by 0.89s (p<0.001, d=1.78) in horizontal versus vertical layouts. EEG showed no significant brand differences (valence d=0.07, p=0.765), offering a theoretical interpretation consistent with predictive coding, wherein expected stimuli elicit reduced neural activation, with brand strength operating solely through attentional pathways. Eye-tracking revealed strong brands' automatic attentional capture of iconic elements (e.g., letter 'J'; TTFF=0.47s), theoretically reconciled via processing fluency as effortless decoding. We derive actionable POS benchmarks: packshot detection < 0.5s, slogan engagement > 1.0s, emotional valence > 5.0, cognitive load < 5.0. This advances GDPR/NDA-compliant methodology while offering practical guidelines grounded in neurocognitive theory.

Introduction

For much of the 20th century, the prevailing view in economics was that consumer decision-making was driven by rational calculations (Thaler & Sunstein, 2021). This view, grounded in classical utility theory, holds that individuals act as rational agents in the marketplace, evaluating goods and services based on objective cost-benefit analyses to maximise utility (Genco et al., 2013). Accordingly, marketers should focus on rational and logical arguments to influence consumer behaviour (Bale-Tourtoulou et al., 2020).

*Corresponding author

Empirical research in consumer behaviour has challenged this paradigm, as it fails to capture the complexity of human decision-making (Plassmann et al., 2012). Neuroscientific studies have revealed that consumer behaviour is driven by a wide range of unconscious and emotional factors beyond purely rational considerations (Cherubino et al., 2019). This shift has led to the development of consumer neuroscience, which uses insights from brain research to understand the role of unconscious processes in consumer behaviour (Bell et al., 2018).

Consumer neuroscience has shown promise in assessing POS advertising, as it can influence consumer decision-making at a crucial stage in purchasing (Chandon et al., 2009; Oliveira & Giraldi, 2019; Moriuchi, 2021). Several studies have examined the effectiveness of marketing stimuli using neuromarketing research techniques. However, they have primarily focused on television communications (Ćirović et al., 2022; Harris et al., 2019; Janić et al., 2022; Krampe et al., 2018; Ohme et al., 2010; Oliveira & Giraldi, 2019). Few studies have examined the effectiveness of marketing stimuli such as products, packaging, and price (Husić-Mehmedović et al., 2017; Garczarek-Bąk et al., 2021; Khushaba, 2012), digital and print ads or brand logos (Bruce et al., 2014; Ciceri et al., 2019). Most studies relied on a single neuroscience technique, such as electroencephalography (EEG), eye tracking (ET), or functional magnetic resonance imaging (fMRI). Only a few studies combined multiple techniques (Ćirović, 2022; Garczarek-Bąk et al., 2021; Krampe et al., 2018; Ohme et al., 2011). Studies that have measured the effectiveness of POS marketing stimuli are rare (Chandon et al., 2009; Oliveira & Giraldi, 2019) and usually limited to only one neuro technique.

This study examines how neuromarketing, in laboratory settings, can be used to gain insights into consumer responses to POS advertising for beer brands. In contrast to prior studies that mainly examined attention, this research explores attention, emotions and cognition. The primary objectives of this research are:

1. To assess the impact of POS beer brand advertisements on consumer attention, emotions, and cognition using a combination of EEG and ET.
2. To examine the relationship between consumer neuroscientific responses and real-world brand performance metrics, such as market share.

This study will examine the following research questions:
RQ1: Do beer ads evoke emotional responses?
RQ2: Do they interest consumers?
RQ3: Are they complex to process?
RQ4: Do reactions differ between strong/weak brands?
RQ5: Do layouts affect visual attention?
To contextualise the study within existing research, we now review the foundational and contemporary literature on consumer neuroscience.

Literature Review

The Rise of Consumer Neuroscience in Marketing Research

Consumer neuroscience is an interdisciplinary field that combines neuroscience, psychology, and marketing to understand consumers' unconscious responses to different marketing stimuli (Lee et al., 2017). The emergence of consumer neuroscience as a distinct field can be traced back to the 1970s (Casado-Aranda, 2021). Pioneering researchers used pupil dilation measurements to examine the cognitive activity of people watching TV commercials. Later, EEG and galvanic skin response studies were conducted (Ford, 2019). The first scientific studies were conducted at the University of Wisconsin-Madison and Harvard in the 1980s and 1990s (Plassmann et al., 2012). To this day, numerous authors have claimed the vast potential of neuromarketing (Ariely & Berns, 2010; Levallois et al., 2019).

Overview of Techniques Used in Exploring the Implicit Attitudes of Consumers

Neuromarketing techniques can be classified into three categories based on the type of brain activity they measure - biometric, electrical, or metabolic (Ramsøy, 2015). In the following lines, we elaborate on the three most important and academically accepted neuromarketing techniques (two of which were employed in this study).

Biometric Neuromarketing Research: ET

The ET technique uses infrared technology to monitor eye movements, fixations, and the duration of a person's gaze on specific Areas of Interest (AOI) (Oliveira & Giraldi, 2019; Ramsøy, 2015). The respondent's gaze creates a "heat map" that visualises the areas of the stimulus that attracted the most attention. As the number of views focused on a particular area increases, the colour gradually changes from green to yellow, orange, and finally red (Garczarek-Bąk et al., 2021; Khushaba, 2012; Šola et al., 2022). Eye movements can be tracked in laboratory conditions using a device placed in front of the screen, or in real-world settings through specialised glasses (Bayle-Tourtoulou & Badoc, 2020).

The AOIs represent predefined regions of interest in the stimulus (e.g., logo, packaging, or slogan). ET can provide metrics on visual attention, including *Frequency or Eyeball Count* (EC), *Time to First Fixation* (TTFF), *Total Fixation Duration* (TFD), etc (Karmakar et al., 2019; Ramsøy, 2015). A significant limitation of eye tracking is capturing the emotional valence, or reactions associated with the areas that received the most visual attention. Consequently, it is often combined with other neuromarketing techniques, like EEG, to fill the gap (Oliveira & Giraldi, 2019; Ramsøy, 2015).

Electrical Brain Activity Neuromarketing Research: EEG

Exposure to marketing stimuli prompts neurons to transmit electrochemical signals, generating weak electrical currents. EEG monitors electrical activities in the brain, which occur as neurons "fire" and transmit information to one another (Bazzani et al., 2020). EEG is performed by placing electrodes that measure brain waves on the individual's head. The EEG measures several types of brain waves, each associated with different cognitive and emotional states (Aldayel et al., 2021). Key performance indicators (KPIs) measured by EEG include (Ćirović et al., 2022; Janić et al., 2022; Hakim et al., 2020):

- Emotional valence (0-10; >5 optimal)
- Brain engagement (0-10; >5 optimal)
- Cognitive load (0-10; <5 optimal).

EEG has a high temporal resolution, capturing brain activity in milliseconds. However, the spatial resolution is weak compared to fMRI (Bayle-Tourtoulou & Badoc, 2020). Besides laboratory research, EEG can be used in real-world environments (Harris et al, 2019).

Neuromarketing Research of Brain Metabolic Activity: fMRI

The fMRI technique can measure the activity of deeper brain structures (Morin, 2019). Exposure to a stimulus prompts increased blood flow to specific brain regions, raising the levels of oxygenated haemoglobin in the blood (Ariely & Berns, 2010). The fMRI scanner measures changes in the BOLD (Blood Oxygen Level Dependent) signal, indicating neural activity in specific brain regions (Bayle-Tourtoulou & Badoc, 2020). Stimulation of specific brain regions is associated with experiences of pleasure, stress, attention, or fear (Bell et al., 2018). Although fMRI has limited temporal resolution, it offers the highest spatial resolution among neuromarketing techniques (Ciceri, 2019).

The substantial costs associated with fMRI implementation (Ariely & Berns, 2010) led to our selection of more economically feasible EEG and eye-tracking methodologies.

Overview of Preceding Research

Previous research in consumer neuroscience has established that brand equity, spatial positioning, and creative complexity each substantially influence consumer implicit behaviour. Strong brands have been shown to evoke higher engagement and more favourable affective responses, as evidenced by increased neural activation in reward-related areas (Stoll, Baecke, & Kenning, 2008; Oliveira & Giraldi, 2019) and faster orientation of visual attention (Khushaba et al., 2013; Wedel & Pieters, 2008). Previous research also detected that brand strength enhances both valuation processes and memory encoding, underlining the importance of established brand associations in shaping implicit reactions (Plassmann et al., 2012). In addition, the design and layout of marketing stimuli have been demonstrated to impact visual attention distribution and processing fluency. The research found that higher visual complexity increases TTFF and reduces TFD to core brand elements (Pieters, Wedel & Batra, 2010). Another study showed that cluttered designs diminish both engagement and processing fluency (Ramsøy et al., 2020). Also, spatial positioning of identical visual content can create attentional priority effects that systematically guide gaze sequences and dwell time (Wedel & Pieters, 2008; Reimann et al., 2010). We combined ET and EEG to measure attentional patterns and subconscious cognitive responses to quantify these interactions. This aligns with established neuromarketing research demonstrating that multi-modal measurements can provide comprehensive insights into consumer responses (Venkatraman et al., 2021).

Research Methodology

Research Methodology, Techniques, Sample and Stimuli

EEG and eye-tracking were employed to measure consumer responses to beer brand posters in the Serbian market, focusing on Jelen, a strong brand with a 17.8% market share, and Nikšićko, a weaker brand with a 6.3% share. The sample consisted of 20 beer consumers, evenly divided by gender (10 men and 10 women), aged 25 to 45.

The sample size of $N = 20$ provided 80% statistical power to detect large effects ($d \geqslant 0.90$), although it was underpowered for medium effects (d=0.50; power=33%). Bootstrap resampling was conducted to assess robustness and confirm the stability of the ET metrics.

Data was collected using a Tobii Pro Nano eye tracker (60 Hz) and an Emotiv Insight EEG device (five channels). A within-subjects design was used, in which all participants were exposed to each stimulus for 5s in a randomised order.

Due to GDPR and NDA restrictions, raw data could not be shared. Instead, proxy standard deviations were drawn from previous studies (Balconi & Sansone, 2021; Ramsøy et al., 2020) to simulate distributions (Table 1). Bootstrap resampling applied to the aggregated EEG and ET metrics further confirmed consistency with established neuromarketing benchmarks.

Table 1
Proxy Standard Deviations

Metric	Proxy SD	Prior Studies Ranges	95% CI
EEG Emotional Valence	1.2	1.0 – 1.4	[0.95 – 1.45]
Eye-tracking TTFF	0.5	0.4 – 0.6	[0.42 – 0.58]
Eye-Tracking TFD	0.5	0.4 – 0.6	[0.42 – 0.58]

Source: Authors.

Statistical analyses included paired t-tests with 19 degrees of freedom, Bayesian t-tests, Cohen's d, and TOST equivalence testing with a ±0.5 margin. Bayesian analyses were conducted using a default Cauchy prior with a scale of 0.707.

Three stimuli were tested (Figures 1-3): Jelen Horizontal (the primary campaign visual with a complex design), Jelen Vertical (the same brand elements presented in an alternative layout), and Nikšićko Horizontal (the primary campaign visual with a simpler design). The inclusion of two Jelen variants with identical branding but differing layouts allowed for the isolation of Hypotheses 2 and 3, by addressing the confound between brand equity and complexity. Comparisons with Nikšićko provided evidence for attentional capture, as specified in Hypothesis 1b.

Figure 1
Jelen Horizontal poster

Source: Commercial client (identity withheld under NDA)

Figure 2
Jelen Vertical poster

Source: Commercial client (identity withheld under NDA)

Figure 3
Nikšićko Horizontal poster

Source: Commercial client (identity withheld under NDA)

Hypothesis

The study proposes the following hypotheses:

H1a: Stronger brands elicit more positive neural responses consistent with valuation framework concepts (Plassmann et al., 2012).
H1b: Stronger brands command greater attentional prioritisation of distinctive assets (Milosavljevic & Cerf, 2008).
H2: Spatial repositioning alters attention patterns (Wedel & Pieters, 2008).
H3: Higher complexity impedes processing fluency and visual engagement (Pieters et al., 2010; Reber et al., 2004).

These hypotheses derive predictive power from predictive coding theory (reduced neural resource allocation for expected stimuli such as strong brands) and processing fluency (effortless decoding of visually simple designs).

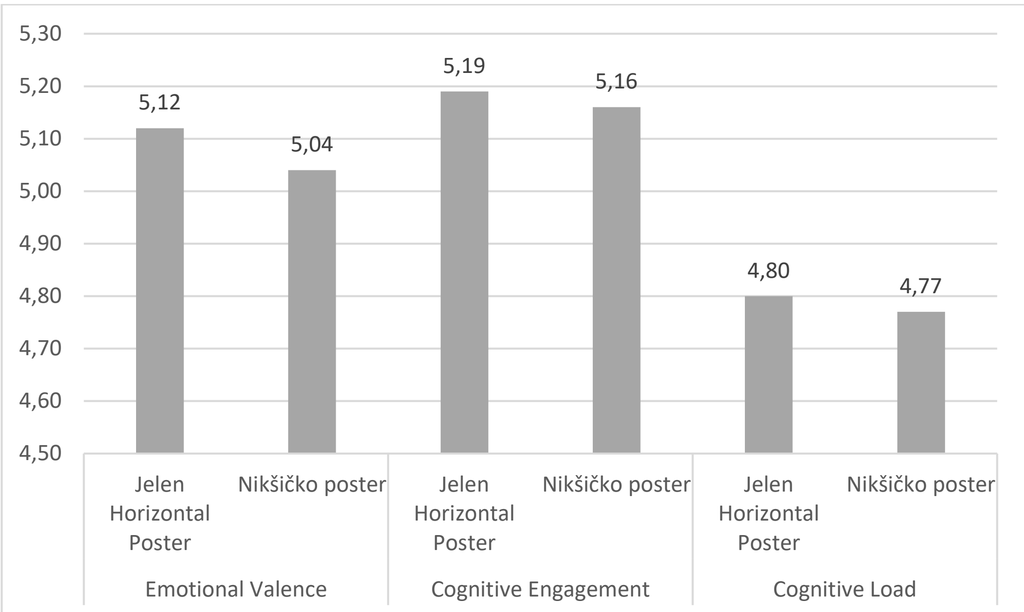
We now examine the neurophysiological and attentional patterns elicited by the tested stimuli with these methodological foundations.

Research Results and Discussion

EEG Results

Values above 5 in emotional valence and engagement suggest positive emotions and motivational relevance, while values below 5 in cognitive load indicate fluent stimulus processing. This thresholding aligns with established neuromarketing practice (Brockbank & Feldon, 2024; Lingelbach et al., 2023; Janić et al., 2022), reflects device-specific FMCG norms (Emotiv EPOC; Genco et al., 2013) and Serbian campaign databases (Brainpropaganda, unpublished database). These values represent benchmarks.

Figure 4
EEG Metrics by Stimulus



Note: This chart presents group-level means with 95% confidence intervals.
Source: Authors

As presented in Figure 4, Jelen Horizontal elicited slightly higher valence (*M*=5.12 vs 5.04) and engagement (5.19 vs 5.16) than Nikšićko. Cognitive load was low for both (Jelen: 4.80; Nikšićko: 4.77). Differences were non-significant:

- *Valence*: $t(19) = 0.30$, $p = 0.765$, $d = 0.07$, $BF_{01} = 3.1$
- *Engagement*: $t(19) = 0.11$, $p = .912$, $d = 0.02$, $BF_{01} = 3.1$
- *Load*: $t(19) = 0.11$, $p = 0.912$, $d = 0.02$, $BF_{01} = 3.1$

TOST procedure (equivalence margin: ±0.5; Lakens, 2017) confirmed emotional valence difference equivalent to zero (p=0.032).

While H1a found no support in EEG (valence d=0.07, p=0.765, H1a null), theoretically resolved through predictive coding, H1b emerged decisively in the ET part: strong brands commanded automatic attentional capture of iconic elements (e.g., letter 'J'; H1b supported). Absent valence differences ($d = 0.07$, $BF_{01} = 3.1$) may reflect reduced neural resource allocation for familiar brand stimuli, consistent with predictive coding theory (Kok et al., 2012). While not directly measured, this interpretation aligns with theoretical expectations and warrants validation in future multimodal research.
The detailed analysis of AOIs regarding the visual attention patterns for two poster variants of Jelen beer reveals the following insights.

ET Results - Heatmaps and Comparative Analysis

ET results and heatmap analysis confirmed all AOIs were salient (Figure 5).

For the Jelen Horizontal poster, the visual pattern of TTFF was the fastest for the letter "J" (0.25s), followed by the product packaging, slogan and logo. TFD was the longest for the letter "J" (1.43s), followed by the packaging (0.97s) and the slogan (0.93). For the Jelen Vertical poster, the visual pattern of TTFF was quite different. The central positioning of the letter "J" made it the fastest element to capture attention (0.47s), followed by the slogan (1.14s), logo (1.37s), and packaging (1.66s).

Despite the same visual and creative elements on the two Jelen beer posters, the implicit visual patterns, heatmaps, TTFF, and TFD for the different AOIs were markedly different. For the horizontal poster, participants focused most on the letter J, the packaging, and the slogan. In contrast, the prominent positioning of the letter J in the Vertical poster diverted attention away from the packaging. TFD on the packaging was 0.65 seconds for the Vertical poster, compared to 0.97 seconds for the Horizontal poster, and 1.73 seconds vs 1.43 seconds for the letter “J”. These implicit visual pattern differences likely affect advertising effectiveness.

Consequently, H1b found support in Jelen's automatic attentional capture of its iconic 'J'. Jelen's 'J' commanded automatic attentional capture (TTFF=0.25s/0.47s, TFD=1.43/1.73s), which reflects effortless decoding (Reber et al., 2004), overriding design complexity (H1b supported).

The comparison between the Jelen Horizontal and Vertical posters validated H2. Key attention metrics confirmed significant effects of spatial positioning:

- *Packshot* TTFF: 0.77 s (horizontal) vs. 1.66 s (vertical), $t(19) = -7.96$, $p < 0.001$, $d = -1.78$, $BF_{01} = 0.001$
- *Packshot* TFD: 0.97 s vs. 0.65 s, $t(19) = 2.86$, $p = 0.010$, $d = 0.64$, $BF_{01} = 0.12$
- *Slogan* TTFF: 1.04 s vs. 1.14 s, $t(19) = -0.89$, $p = 0.382$, $d = -0.20$, $BF_{01} = 2.2$
- *Slogan* TFD: 0.93 s vs. 0.88 s, $t(19) = 0.45$, $p = 0.660$, $d = 0.10$, $BF_{01} = 3.0$

Horizontal layouts cut packshot detection time by 0.89s ($p < 0.001$, d= 1.78), directly influencing POS ad placement. These differences, especially in TTFF, confirm that even subtle shifts in layout can drastically alter gaze patterns, thus confirming H2.

The Nikšićko Horizontal poster outperformed the Jelen posters for the packaging and slogan AOIs (Figure 5).

Figure 5
Comparative analysis of heatmaps for Jelen and Nikšićko

Source: Commercial client (identity withheld under NDA) and authors' compilation

The Jelen (4.80) and Nikšićko (4.77) posters yielded cognitive load values below the threshold of 5.0, indicating fluent processing. The marginal difference (0.03) falls within confidence intervals and should not be interpreted as superiority. Though non-significant, the *directionally* lower cognitive load for simpler designs (Nikšićko) aligns with processing fluency principles (Reber et al., 2004).

The observed visual attention differences between Jelen and Nikšićko were statistically tested to assess the impact of creative complexity. Key brand AOIs demonstrated large and significant differences in both TTFF and TFD.

Packshot AOI:

- TTFF was significantly longer for *Jelen Vertical* (M = 1.66 s) than for *Nikšićko* (M = 0.35 s), $t(19) = -11.72$, $p < 0.001$, $d = -2.62$, $BF_{01} < 0.0001$
- TFD was significantly shorter for *Jelen Vertical* (M = 0.65 s) than for *Nikšićko* (M = 1.50 s), $t(19) = 7.60$, $p < 0.001$, $d = 1.70$, $BF_{01} = 0.003$

Slogan AOI:

- TTFF increased from 0.78 s (*Nikšićko*) to 1.14 s (*Jelen Vertical*), $t(19) = 3.22$, $p = 0.004$, $d = 0.72$, $BF_{01} = 0.08$
- TFD declined from 1.08 s (*Nikšićko*) to 0.88 s (*Jelen Vertical*), $t(19) = 1.79$, $p = 0.196$, $d = 0.40$, $BF_{01} = 1.8$

The comparison of Nikšićko with Jelen Horizontal further reinforces this trend, despite both being horizontal layouts:

- Faster packshot detection (*TTFF*: 0.35 s vs. 0.77 s), $t(19) = -3.76$, $p = 0.001$, $d = -0.84$, $BF_{01} = 2.1$
- Longer total fixation on key elements like the slogan and packshot (e.g., *slogan TFD*: 1.08 s vs. 0.93 s), $t(19) = 1.34$, $p = 0.196$, $d = 0.30$, $BF_{01} = 2.1$

This indicates that creative simplicity alone - regardless of layout orientation - drives deeper visual processing and more efficient cognitive engagement, confirming H3 with strong, converging evidence.

Combined EEG and eye-tracking results reveal that enhanced visual processing (faster detection, deeper engagement) primarily stems from design simplicity and layout optimisation, not brand strength alone**.** While H3 (complexity→attention) received strong support from eye-tracking (d up to 2.62), H1b (brand salience→automatic attention capture) was confirmed through iconic elements like 'J' (TTFF=0.47s, TFD=1.73s). EEG showed only directional trends for H1a (valence) and H3 (load), lacking statistical significance. Thus, brand equity influences consumer responses dominantly through attentional pathways (H1b/H2), not neural valence**,** while layout/complexity effects (H2/H3) are decisive.

Considering the evidence presented, the following section outlines the study's conclusions, managerial implications and limitations.

Conclusion

This study investigated how brand equity, spatial positioning, and creative complexity influence unconscious consumer responses to POS beer advertisements. Crucially, we derive and empirically validate a neurocognitive model: predictive coding explains brand equity's "neural invisibility" (H1a null), while processing fluency accounts for brand salience effects (H1b) and layout/complexity optimisation (H2/H3 supported).

Three mechanisms emerged: 1) Predictive coding minimises neural effort for expected brands (H1a null→RQ1/RQ4), 2) Processing fluency enables automatic brand capture (H1b→RQ2/RQ4), 3) Layout/complexity directs attention (H2/H3→RQ3/RQ5). This tripartite mechanism resolves RQ1-RQ5: predictive coding explains emotional neutrality (RQ1/RQ4), processing fluency enables brand capture (RQ2/RQ4), and layout/complexity directs attention (RQ3/RQ5).

H1a: While EEG results did not reach statistical significance, they were directionally aligned.

H1b: Processing fluency in action (*validating our neurocognitive model*): strong brands automatically captured attention through iconic assets ('J' TTFF=0.47s), overriding complexity barriers. This combination of results demonstrates that brand equity can influence implicit consumer responses, particularly through iconic brand cues that automatically attract attention and activate associative memory networks (Henderson et al., 2003; Genco et al., 2013).

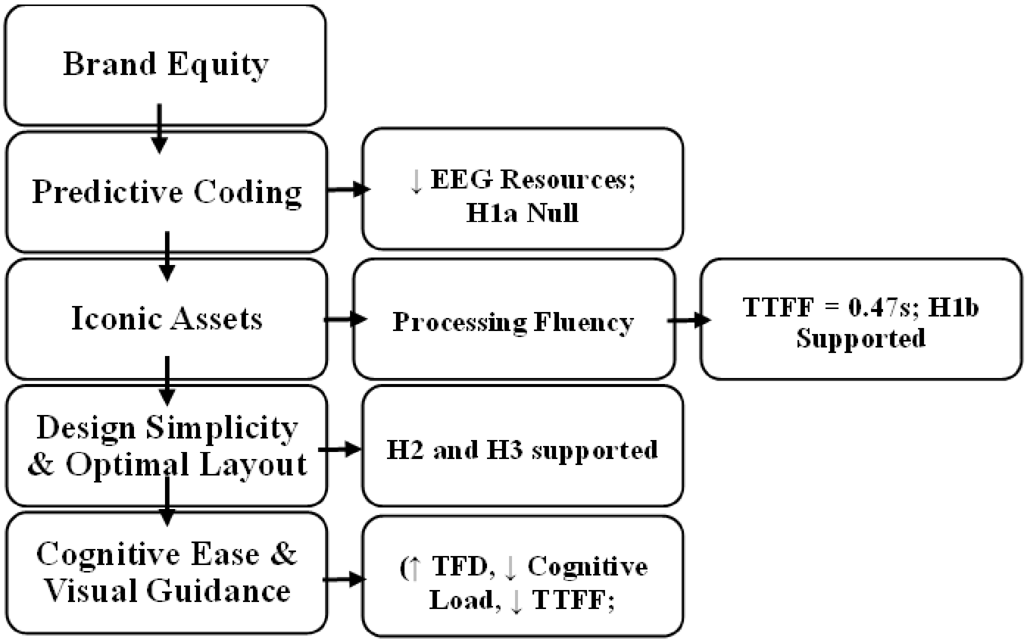
H2 was supported by statistically significant differences between the Jelen Horizontal and Vertical posters. These results clearly indicate that even minor changes in spatial arrangement can disrupt attention to core brand assets, confirming the hypothesis that layout strongly influences implicit gaze behaviour (Wedel & Pieters, 2008).

H3 was strongly supported by both statistical data and inter-brand comparisons. Nikšićko's simpler layout outperformed Jelen's more complex vertical and horizontal design across all attention metrics. EEG cognitive load scores were directionally consistent with this finding, but with a non-significant difference. The convergence of these results suggests that creative simplicity facilitates more fluent cognitive processing, while visual clutter - regardless of brand strength - can dilute attention and elevate mental effort. Thus, H3 is supported by statistically significant ET effects and reinforced by EEG-based cognitive load directional trend (no statistical significance), in line with theories of processing fluency and attentional economy (Reber, Schwarz, & Winkielman, 2004; Pieters & Wedel, 2012).

A conceptual path model is presented in Figure 6 to synthesise these findings visually. It illustrates the hypothesised sequence. This layered model helps interpret how layout and brand familiarity drive downstream neurocognitive engagement (Hubert & Kenning, 2008; Plassmann et al., 2015).

Figure 6

Neurocognitive model - brand equity triggers predictive coding (H1a null), enabling fluency-driven attentional capture (H1b), design/layout optimization (H2/H3) drives cognitive-visual efficiency



Source: Authors

Comparison of the Findings to Previous Research Results

The results and conclusions align with past research, emphasising that neuromarketing methods can offer valuable insights for operational decision-making. All connections between the present findings and prior research, including specific comparisons of key effects and methodological alignment, are comprehensively detailed in Table 2.

Table 2
Prior research comparisons ordered by hypothesis validation sequence (H1a-H1b-H2-H3-Methodology)

Study	Domain	Key Findings	Relevance to Current Study
Khushaba et al. (2013)	EEG – Brand Engagement	Familiar brands evoke higher engagement (small effect size)	Supports directional EEG trends (H1a); small *d*=0.07 aligns with modest expected effects
Balconi & Sansone (2021).	EEG – Brand Differentiation	Neural differences require large samples to detect strong brand effects	Explains EEG non-significance in H1a due to limited power (*N*=20)
Milosavljević & Cerf (2008)	Attention – Brand Bias	Visual attention is biased toward familiar brands	Confirms H1b: 'J' logo dominated gaze (TTFF= 0.47s; TFD=1.73s)
Wedel & Pieters (2008)	Eye-Tracking – Layout	Spatial layout influences scan paths and TFD	Confirms H2: Horizontal layout improved TTFF by 0.89s (*d*=1.78)
Reimann et al. (2010)	Spatial Fluency	Proximity and symmetry facilitate processing	Supports H2: Less fluent layouts reduced TFD
Pieters et al. (2010)	Visual Complexity	Complexity increases TTFF and decreases TFD	Confirms H3: Simpler Nikšićko ad showed ↓TTFF (*d*=2.62), ↑TFD (*d*=1.70)
Ramsøy et al. (2020)	Processing Fluency	Cluttered design impairs attention and encoding	Supports H3: Clutter dilutes visual focus and processing
Venkatraman et al. (2021)	Multimodal Prediction	EEG + Eye-tracking improves predictive accuracy	Validates our combined-method approach across H1a–H3

Note: Effect sizes exceed Pieters et al. (2010) benchmarks (d > 0.8 = large).
Source: Authors

To conclude, POS effectiveness hinges not on brand equity *per se*, but on its interaction with design fluency: iconic assets exploit attentional automaticity (H1b), while simplicity neutralises complexity penalties (H3).

Managerial Implications

This study provides initial insights into revealing attention patterns distribution and cognitive processing that can inform strategies for optimising POS beer advertising (Table 3).

The derived POS neuromarketing design guidelines (Table 3) suggest placing the packshot and slogan either in the upper-left area or at the visual centre of the stimulus. Horizontal layouts are preferable, as they support more efficient fixation paths. To avoid visual overload, the number of elements within each stimulus should be limited to three or four. Incorporating distinctive brand assets, such as iconic letters, helps trigger faster brand recall. Finally, the design should aim for a TTFF of less than 0.5 seconds and a TFD of more than one second for the core elements.

Table 3
Preliminary POS Neuromarketing Benchmarks from Eye-Tracking and EEG Results

KPI	Recommended Threshold	Interpretation
Packshot TTFF	< 0.5 seconds	Rapid detection of key product elements
Slogan TFD	> 1.0 seconds	Sustained engagement with the message
EEG Emotional Valence	> 5.0	Positive affective resonance
EEG Cognitive Load	< 5.0	Fluent, low-effort processing

Note: Benchmarks derived from: Brockbank & Feldon, 2024; Lingelbach et al., 2023; Janić et al., 2022; Ćirović et al., 2022; study averages and neuromarketing norms in the FMCG context of Serbia; validation advised due to context dependency.
Source: Authors

Although conducted in a controlled lab environment, this study delivers neuroscience-backed benchmarks that enable managers to design POS ads with proven impact on consumer attention, emotion, and cognitive ease.

Limitations

Despite the presented findings and their implications, several limitations should be acknowledged. First, respondent-level data could not be shared because of GDPR and NDA restrictions, which constrained transparency and secondary analysis. Second, the relatively small sample size (*N*=20) limited the statistical power of the EEG measures, particularly for medium effects. Third, the research was conducted in a laboratory rather than a real-world retail environment, which may affect ecological validity. A further methodological limitation concerns the use of the Emotiv system, which is restricted to five channels and therefore provides less spatial resolution than medical-grade EEG equipment. In addition, brand strength and design complexity were not entirely orthogonal across the stimuli - for example, in the comparison between Jelen and Nikšićko - thereby limiting direct causal inference. Nevertheless, within-brand layout comparisons between Jelen Horizontal and Jelen Vertical offered partial isolation of the effects related to Hypotheses 2 and 3. Finally, the findings should be interpreted within the specific context of the beer industry in the Serbian market, which may restrict the generalizability of results to other categories or cultural settings.

Despite these, the study offers a rigorous and replicable framework for conducting neuromarketing research under strict data-sharing constraints.

While this study's multimodal approach (EEG + eye-tracking) advances POS research, future work should: (1) expand sample size to detect medium effects, (2) validate findings in real-world retail settings, and (3) integrate fMRI for deeper neural insights.

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Ocena vpliva oglasov za blagovne znamke piva na prodajnih mestih s pomočjo nevroznanstvenih raziskav potrošnikov

Izvleček

Ta študija uporablja EEG in sledenje očesu, da oceni, kako blagovna znamka, kreativna kompleksnost in prostorska razporeditev vplivajo na implicitne odzive potrošnikov na oglase za pivo na prodajnih mestih (POS). Skozi teoretsko prizmo napovednega kodiranja in procesne sposobnosti je laboratorijsko testiranje s srbskimi potrošniki piva (N = 20) pokazalo, da so enostavnejše zasnove dosegle boljšo pozornost pri kazalnikih TFD in TTFF (d do 2,62) neodvisno od moči blagovne znamke. Prostorska prestavitev je zmanjšala čas zaznave izdelka za 0,89 s ($p < 0{,}001$, $d = 1{,}78$) pri vodoravni v primerjavi z navpično postavitvijo. EEG ni pokazal pomembnih razlik med blagovnimi znamkami glede na valenco ($d = 0{,}07$, $p = 0.765$), kar je teoretsko skladno z napovednim kodiranjem, kjer pričakovani dražljaji povzročajo manjšo nevronsko aktivacijo, moč blagovne znamke pa deluje zgolj prek mehanizmov pozornosti. Sledenje očem je pokazalo, da močne blagovne znamke samodejno pritegnejo pozornost na ikonične elemente (npr. črka »J«; TTFF = 0,47 s), kar je teoretično usklajeno s procesno sposobnostjo kot dekodiranjem brez napora. Iz raziskave izpeljemo uporabne merilnike za POS: zaznava izdelka < 0,5 s, vključenost s sloganom > 1,0 s, čustvena valenca > 5,0, kognitivna obremenitev < 5,0. To prispeva k razvoju metodologije, skladne z GDPR/NDA, in hkrati ponuja praktične smernice, utemeljene na nevrokognitivni teoriji.

Ključne besede: nevroznanost potrošnikov, vrednost blagovne znamke, EEG (elektroencefalografija), sledenje očem, vizualna pozornost