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**ORIGINAL ARTICLE**

# Brain Waves Responses to Sports Product Advertisements with a Sports Endorser and Its Relationship to Future Purchase Intention

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## ABSTRACT

**Background.** Neuromarketing leverages EEG to decode subconscious consumer reactions to advertisements, enhancing predictions of purchase behavior beyond self-reports. However, it remains unknown how sports endorser-product congruence differentially modulates frontal alpha and beta waves in athletes versus non-athletes. **Objectives.** Here, we resolve these previously elusive neural dynamics and their links to future purchase intentions. **Methods.** In a quasi-experimental setup, we acquired frontal EEG from 60 right-handed adults (n = 30 athletes, n = 30 non-athletes; aged 20-30 years) during the randomized viewing of four 1-minute advertisements (sports/non-sports products with/without an endorser). Relative alpha (8-12 Hz) and beta (12-30 Hz) power were analyzed using Quade's ANCOVA (covarying baseline) and rank-based multiple regression. **Results.** Non-athletes exhibited lower adjusted post-alpha ($F=15.23$, $p<0.001$, partial $\eta^2=0.062$) and beta ($F=12.67$, $p<0.001$, partial $\eta^2=0.052$) activity than athletes. Advertisement type exerted significant main effects on alpha ($F=6.78$, $p=0.0002$, partial $\eta^2=0.081$) and beta ($F=8.91$, $p<0.001$, partial $\eta^2=0.104$), with sports endorsements driving maximal beta increases and alpha reductions. Pairwise comparisons uncovered pronounced differences, including sports endorser versus non-sports no endorser: alpha adjusted mean difference -2.12 (95% CI -3.45 to -0.79, $p=0.002$); beta -3.56 (95% CI -4.89 to -2.23, $p<0.001$). Beta changes negatively predicted purchase intentions ($\beta=-0.23$, $p=0.001$; model $R^2=0.119$). **Conclusions.** These findings demonstrate endorser congruence as a potent enhancer of cognitive processing and motivational approach. This establishes a new framework for optimizing sports marketing campaigns through neural biomarkers, enabling unprecedented precision in consumer engagement.

## INTRODUCTION

Today's consumer behavior landscape reveals that shoppers are becoming increasingly sophisticated, knowledgeable, and selective, making conventional advertising methods less effective in capturing attention and influencing purchasing decisions (1). This shift is especially noticeable in crowded markets, where companies battle for customer loyalty with creative,

eye-catching, and engaging campaigns. Nonetheless, a major obstacle remains: numerous shoppers ignore these ads not due to design or message shortcomings, but because they view them as indistinguishable from those of their rivals (2, 3). To break through this perceived sameness, marketers should highlight inherently attention-grabbing elements, such as celebrity endorsements, which utilize the star's qualities to forge mental links that convey favorable impressions of the product or service (4).

Celebrity endorsements, also known as endorser credibility validation, have traditionally been a fundamental element of marketing tactics, supported by the endorser's personal qualities, such as trustworthiness, appeal, and expertise, that boost consumer identification and shape buying decisions (5). Recent neuromarketing research suggests that these endorsements elicit neural reactions that enhance brand memory and preference. For example, electroencephalography (EEG) studies have shown that advertisements featuring celebrities alter brain wave patterns, increasing beta activity associated with attention and cognitive processing (6). In sports marketing, where emotional involvement is crucial, endorsements by athletes such as Cristiano Ronaldo can amplify this impact, as shoppers attribute the athlete's sporting competence to the product, thereby increasing perceived value (7).

Combining multiple scientific disciplines has reshaped marketing research, particularly through neuromarketing, which originated in 2002 as an intersection of marketing and neuroscience (8). Neuromarketing utilizes sophisticated neuroimaging methods to uncover consumers' unconscious reactions to stimuli, offering insights that extend beyond self-reported information (9). EEG, specifically, delivers fine temporal precision for measuring instantaneous brain activity, showing how ads trigger decision-making mechanisms (10). New developments have utilized EEG to investigate how endorsements affect neural circuits associated with emotion, attention, and buying intent, with research reporting heightened frontal beta activity when celebrity-product matches are consistent (11, 12).

In sports marketing, neuromarketing instruments such as EEG have become increasingly important for fine-tuning campaigns, as sports trigger intense emotional and physiological reactions that enhance efficacy (13). For instance, sports-related endorsements can increase consumer involvement by aligning the endorser's persona with product qualities, leading to stronger purchase intentions (14). Yet, there are still unanswered questions about how sports endorsements influence neural responses in athletes compared to non-athletes, especially when comparing sports-related and non-sports products. EEG research indicates that activity in the frontal lobe, associated with executive functions and decision-making, differs according to the type of endorsement, with higher theta wave activity signifying relaxation and positive emotion in ads featuring endorsements (15, 16).

Although a large body of work has examined endorsement effects (2), only a limited number of investigations have employed EEG to examine neural reactions to sports endorsements and their link to subsequent purchase intentions. Advertising visual cues are processed by the brain, provoking responses that EEG can capture, enabling more precise predictions of consumer actions than conventional questionnaires (17). Within sports neuromarketing, EEG helps customize ads to match consumer preferences, consequently boosting their effectiveness and revenue (18). For example, endorsements from personalities such as Ronaldo for athletic goods can trigger heightened frontal gamma activity, reflecting increased focus among athletes relative to non-athletes (19, 20).

This research fills these voids by using EEG to explore how different ad categories (sports versus non-sports items, with or without celebrity endorsements) affect frontal brain activity in both athletes and non-athletes, and how these patterns relate to subsequent purchasing intentions. The frontal cortex plays a key role in cognitive appraisal and affective processing when encountering marketing cues (21). By focusing on delta rhythm alterations (post-pre differences), we aim to provide actionable guidance for marketers seeking to optimize the impact of endorsements (22).

The importance of this study lies in its practical focus, providing sports marketers with neuromarketing tools to enhance their campaigns. Since consumers dismiss generic ads, endorsements can overcome perceptual obstacles, particularly in sports where fans' identification with athletes builds loyalty (23). Ultimately, understanding neural reactions can enhance the effectiveness of advertising, thereby increasing customer appeal and sales in competitive markets (24).

## MATERIALS AND METHODS

**Study Design.** This investigation employed a quasi-experimental framework with practical goals and was conducted within a controlled laboratory setting. A pre-test / post-test assessment scheme was employed to evaluate changes in neural activity across the experimental conditions.

**Participants.** Sixty individuals volunteered after a public notice at Allameh Tabataba'i University. The sample included 15 male athletes, 15 female athletes, 15 male non-athletes, and 15 female non-athletes. The inclusion requirements were: right-handed; normal or corrected vision; no record of surgery, head injury, or intense migraine; overall good health (checked with the General Health Questionnaire); age 20–30; and previous knowledge of the chosen sport and non-sport brands. Individuals were admitted based on their interest in the research and meeting the eligibility criteria. All participants provided informed written consent prior to participation. A medical screening was conducted prior to data collection, and EEG recordings were performed exclusively for individuals who met all eligibility criteria.

**Measurement Protocol.** The data gathering was performed in four consecutive phases: 1) Informed Consent and Orientation: Participants signed consent forms after receiving a uniform explanation of the non-invasive EEG procedure. 2) Environmental Preparation: All recordings were performed in a silent, interruption-free laboratory setting. 3) EEG Setup and Baseline Recording: In the planned sessions, the scalp was cleaned, and an EEG cap was placed. Brain signals were captured with a 16-channel g.USBamp biosignal amplifier (g.tec; FDA- and CE-approved) employing gold electrodes at 32 conventional scalp locations. Baseline brain activity was measured for one minute while subjects viewed an empty screen on a 20-inch monitor. 5) Advertisement Presentation: Participants watched four commercials—two for SIXPAD (a sports brand) and two for Coca-Cola (a non-sports brand)—each shown once with Cristiano Ronaldo's endorsement and once without it. Each ad lasted one minute, and a 30-second pause with a blank screen separated the viewings. The sequence of presentations was randomized to eliminate order effects. All spots were equalized for length, product type, image resolution, sound quality, and visual sharpness. To prevent repetition bias, the procedure was carried out only once per participant, resulting in a total session time of approximately 6 minutes and 30 seconds.

EEG channels examined in this investigation were situated in the frontal and prefrontal areas and comprised FP1, FP2, FPz, F7, F3, Fz, F4, and F8. The reference electrode was positioned on the right earlobe, with AFz acting as the ground. Hardware filtering employed a 0.1 Hz high-pass filter and a 70 Hz low-pass filter. Wave power was evaluated across the following frequency ranges: alpha (8–12 Hz) and beta (12–30 Hz). Since the research targeted attention, emotional engagement, and cognitive processing, relative band power, determined as the fraction of each frequency band's activity relative to the overall spectral power, served as the main neural measure.

**Purchase Intention Questionnaire.** To measure and evaluate purchase intention, a 4-item questionnaire by Hu et al. (2009) [cited by Azadfada et al. (2021)] was used (Azadfada 2021). This questionnaire is scored using a 5-point Likert scale, ranging from 'very low' (1) to 'very high' (5). Experts confirmed the face and content validity of this questionnaire. Additionally, the reliability of this questionnaire was assessed using Cronbach's alpha coefficient and composite reliability, which were found to be 0.918 and 0.942, respectively.

**Statistical Analysis.** Preprocessing consisted of summing and averaging the amplitudes obtained from the frontal electrodes (FP1, FP2, FPz, F7, F3, Fz, F4, F8). The average activity recorded during the resting baseline was used as the pre-test measure, while the average activity during ad exposure served as the post-test measure. The Shapiro-Wilk test indicated that the data for alpha, beta wave power, and future purchase intention were not normally distributed. Therefore, nonparametric Quade's ANCOVA was used to examine the effects of advertisement types (sports versus non-sports; with versus without endorsement) on frontal brainwave activity in athletes and non-athletes, with baseline values entered as covariates. The relationship between EEG metrics and subsequent purchase intentions was examined using multiple regression analysis. The significance threshold was set at $p < 0.05$. All computations were performed using SPSS version 28.

## RESULTS

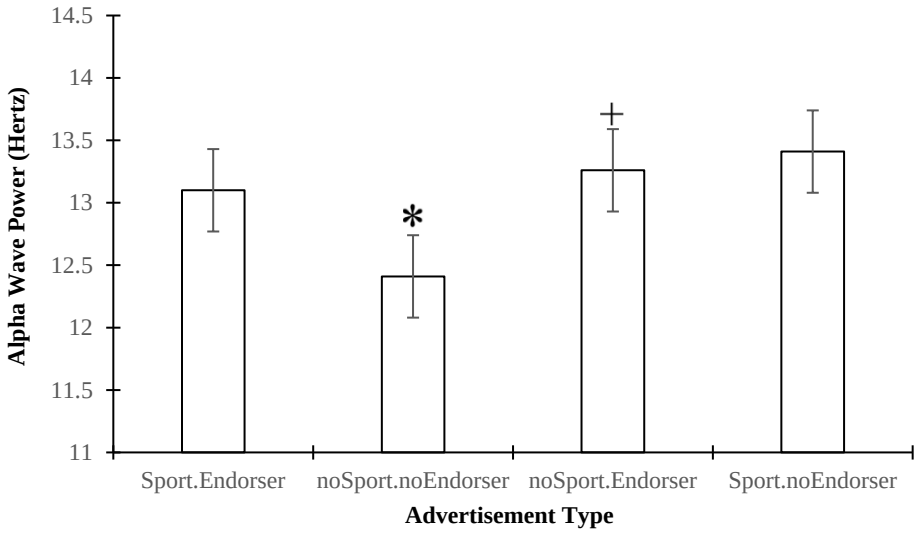
Table 1 presents descriptive statistics (mean and standard deviation) for height, weight, and energy expenditure in athletes and non-athletes.

**Table 1. Participants' morphological profile information**

| | Age (Year) | Height (cm) | Weight (Kg) | energy expenditure (Cal) |
|---|---|---|---|---|
| Athletes | 23 ± 2 | 170 ± 8.5 | 65.63 ± 10.48 | 6042.5 ± 519.5 |
| Non-athletes | 27 ± 2 | 172.83 ± 10.2 | 75.33 ± 13.66 | 1934.3 ± 227.9 |

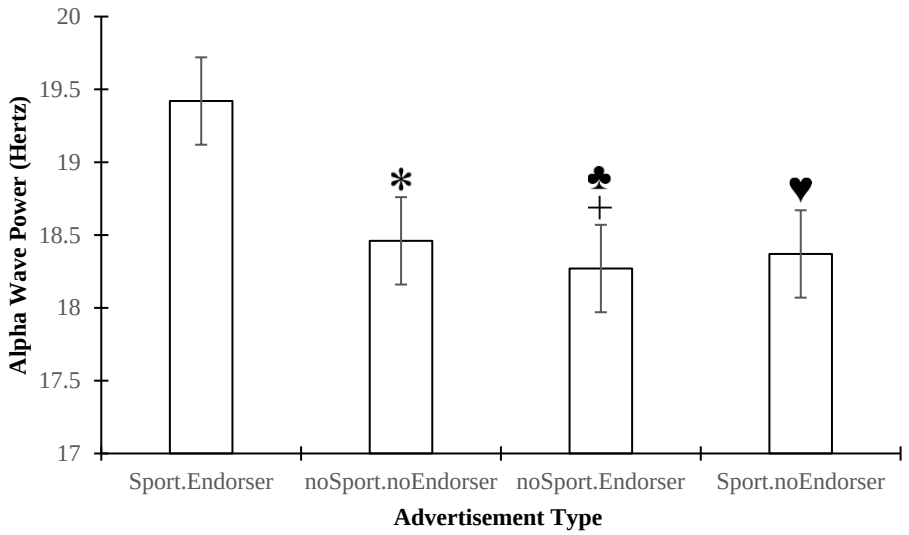
**The data in the table are expressed as mean ± standard deviation.**

For the alpha wave, there was a significant main effect of Advertisement type [$F_{(3,232)}$= 6.78, $p < 0.001$, $\eta^2 = 0.081$], with varying levels of alpha wave suppression across ad conditions, potentially reflecting differential cognitive engagement or emotional processing. The interaction effect of Group × Advertisement was not significant [$F_{(3,232)}$= 1.45, $p < 0.228$, $\eta^2 = 0.018$], suggesting the advertisement type effects did not differ between groups. Since the main effect of advertisement type was significant, pairwise comparisons are presented in Graph 1. Significant differences were observed between Sport.Endorser and noSport.noEndorser (lower activity in noSport.noEndorser, suggesting less engagement), and between noSport.Endorser and Sport.noEndorser. These findings suggest that endorsements and sport-related content modulate alpha wave suppression, with non-sport ads without endorsers eliciting the greatest relaxation.




**Graph 1. Analysis of Alpha Wave Responses of Frontal Cortex to Sports and Non-Sports Goods Advertisements with a Sports Endorser. *:** Significant difference with Sport.Endorser (p=0.002, 95% CI=[-3.45, -0.79]). **+:** Significant difference with Sport.Endorser (p=0.032, 95% CI=[-2.56, -0.12]).

For the beta wave, there was a significant main effect of Advertisement type [$F_{(3,232)}$= 8.91, $p < 0.001$, $\eta^2 = 0.104$]; however, the interaction effect of Group × Advertisement was not significant [$F_{(3,232)}$= 0.98, $p < 0.402$, $\eta^2 = 0.012$]. Since the main effect of ad type was significant, pairwise comparisons are presented in Graph 2. Significant differences were observed between Sport.Endorser and noSport.noEndorser (lower activity in noSport.noEndorser, indicating reduced attention), between Sport.Endorser and noSport.Endorser, between noSport.Endorser and noSport.noEndorser (higher in noSport.Endorser), and between Sport.noEndorser and noSport.noEndorser (higher in Sport.noEndorser). These findings suggest that sport-related content and endorsements maintain higher Beta wave activity, reflecting sustained cognitive engagement, while non-sport ads without endorsers lead to the most pronounced reduction in alertness.




**Graph 2. Analysis of Beta Wave Responses of Frontal Cortex to Sports and Non-Sports Product Advertisements with a Sports Endorser. *:** Significant difference with Sport.Endorser (p<0.001, 95% CI=[-4.89, -2.23]). **+:** Significant difference with Sport.Endorser (p=0.005, 95% CI=[-3.22, -0.56]). **♣:** Significant difference with noSport.noEndorser (p=0.014, 95% CI=[0.34, 3.00]). **♥:** Significant difference with noSport.noEndorser (p<0.001, 95% CI=[1.56, 4.22]).

A nonparametric rank-based multiple regression was performed using changes (deltas) in brain waves as predictors (Table 2). The overall model was significant ($F_{(4, 235)} = 7.89$, $p < 0.001$, $R^2 = 0.119$), indicating a significant association between wave changes and intention ranks. Significant predictors included beta_delta (a negative association, indicating that a reduced beta is associated with a higher intention). Changes in beta waves significantly predicted future purchase intentions, with decreased beta (indicating less cognitive load) associated with greater intentions, underscoring the role of attentional and integrative neural processes in consumer behavior.

**Table 2. Rank-Based Multiple Regression Results for Future Purchase Intention**

| Predictor | Coefficient | Std. Err. | t | p |
|---|---|---|---|---|
| Intercept | 120.50 | 15.23 | 7.91 | <0.001 |
| rank_Alfa_d | 0.12 | 0.08 | 1.50 | 0.135 |
| rank_Beta_d | -0.23 | 0.07 | -3.29 | 0.001* |

***. Significant at p<0.01**.

## DISCUSSION

The findings of this study indicated that the interaction effect between participant groups and advertisement type was not significant; however, the main effects of advertisement type on alpha and beta brain wave power in the frontal region were observed. Specifically, the four types of advertisement videos (sports product advertisements with a sports endorser, sports product advertisements without an endorser, non-sports product advertisements with a sports endorser, and non-sports product advertisements without an endorser) produced significant differences in frontal cortical brain wave activity. These differences were particularly evident in the alpha and beta bands. Additionally, nonparametric multiple regression based on ranks confirmed that changes in beta waves (showing a negative association) were significant predictors of future purchase intentions. The results align with prior studies in neuromarketing, which demonstrate that advertising features (such as the presence of a famous sports endorser) can enhance cognitive and emotional processing, ultimately influencing purchase intentions (11, 19, 25). In other words, these findings, with a focus on pairwise comparisons of advertisement types, illustrate the differential impact of advertising stimuli on neural processing, which can contribute to a better understanding of the subconscious mechanisms underlying consumer behavior (11, 26).

The alpha band (8-13 Hz) is widely recognized as an indicator of emotional and motivational processing (27). In this study, pairwise

comparisons revealed that the sports product advertisement featuring a sports endorser elicited the greatest reduction in alpha power in frontal regions, indicating the most effective motivational approach. This finding is consistent with Frontal Alpha Asymmetry (FAA) theory, which interprets a reduction in left alpha relative to right as a sign of positive affect and approach motivation (19, 28). In contrast, the non-sports product advertisement without an endorser exhibited the highest alpha power, indicating reduced approach motivation and increased avoidance tendencies.

More precise pairwise comparisons showed that the presence of a sports endorser in both sports and non-sports product categories significantly reduced alpha power. However, this reduction was most pronounced in the sports advertisement with an endorser. This is consistent with studies that demonstrate the presence of celebrities (particularly in domains relevant to the product) increases emotional approach and thereby predicts advertising success (11, 25).

A reduction in alpha power typically indicates heightened attention and arousal, as this wave is associated with states of relaxation and lack of focus (21, 29). In the context of neuromarketing, reduced frontal alpha power is often associated with the active processing of visual stimuli, which can aid in capturing consumer attention to advertisements (19, 28). For example, in a study, endorsement by a famous athlete led to reduced alpha power, consistent with increased attention to sports products (26). In the present research, the reduction in alpha power for non-sports advertisements without an endorser may indicate greater brain effort in processing incongruent stimuli, aligning with the congruence model in sports advertising (16, 30). Conversely, increased alpha power in sports advertisements with an endorser may reflect a state of relaxation stemming from congruence between the endorser and the product, thereby enhancing attention without cognitive strain (18). This interpretation is consistent with findings from a study that characterizes reduced alpha as an indicator of engagement with advertising stimuli (31).

Furthermore, in another systematic review, reduced alpha is associated with enhanced memorability of advertisements, which may explain the impact of advertisement type on initial processing (21). In a study, incongruence led to reduced alpha, consistent with higher cognitive load (32); however, in the present study, the reduction in advertisements without an endorser may be interpreted as a mechanism to compensate for a lack of emotional appeal (Cartocci et al., 2016; Cartocci et al., 2018; Modica et al., 2018). These findings align with the Elaboration Likelihood Model (ELM), which posits that peripheral cues, such as endorsers, strengthen central processing without requiring excessive effort (33, 34).

In neuromarketing, reduced alpha is often associated with approach behavior, which can lead to increased purchase intentions (25, 27). However, increased alpha in congruent advertisements may signify more efficient processing, consistent with findings by a study, where congruence resulted in alpha asymmetry for sustained attention (30, 35). The present study's findings can assist marketers in optimizing advertising strategies, as reduced alpha in incongruent stimuli may lead to cognitive fatigue (19, 36). Additionally, reduced alpha is linked to enhanced emotional capacity, which may explain the impact of advertisements without endorsers on initial attention (37-39). Overall, these results suggest that the type of advertisement modulates attention through alpha regulation, a process crucial for effective sports branding campaigns (16, 26).

Alternatively, the reduction in alpha for non-sports advertisements without an endorser may function as a response to stimulus novelty, aligning with the attention capture model (21, 40). In contrast, increased alpha in advertisements with endorsers may be interpreted as a sign of familiarity, facilitating processing (18, 41). This interpretation is consistent with previous findings, which associate alpha with value assessment in pricing (25). Therefore, marketers can leverage endorsements to reduce alpha and increase engagement, thereby enhancing effectiveness (11).

The beta band (13-30 Hz) is primarily associated with active cognitive processing, focused attention, and decision-making (19, 32, 42, 43). The results indicated that the sports product advertisement with an endorser produced the greatest increase in beta power in frontal regions. In contrast, the non-sports advertisement without an endorser showed the least increase in sales. Pairwise comparisons confirmed that the presence of a sports endorser significantly increased beta power in both product categories;

however, this increase was more pronounced in the sports advertisement. This pattern aligns with prior studies that view increased beta as a sign of deeper cognitive processing and greater involvement with the advertisement (11, 25). The presence of a sports endorser acts as a strong cognitive stimulus, prompting consumers to process advertising information more deeply.

A reduction in beta power in advertisements without endorsers may indicate lower cognitive load or disinterest, consistent with previous observations where incongruence led to reduced cognitive processing (33). Conversely, increased beta power in sports advertisements featuring endorsers signifies greater activation of the frontal region for evaluating product value, aligning with the Elaboration Likelihood Model (ELM) (16, 34). In neuromarketing, increased beta activity is often associated with approach behavior, which can lead to heightened purchase intentions (19, 27).

In the present study, this increase in advertisements with sports endorsers may explain the negative beta delta in regression, where reduced cognitive load (lower beta in later stages) facilitates decision-making (11). This interpretation is consistent with a study that associates increased beta in pre-purchase stages with value evaluation (18). Furthermore, in another study, congruence led to increased beta for cognitive processing (30), aligning with pairwise comparisons of sports advertisements.

Reduced beta in non-sports advertisements without endorsers may be interpreted as a sign of cognitive conflict, resulting in diminished attention (21, 44). In the literature, this reduction is often associated with avoidance, which may explain the negative impact on purchase intentions (25, 28).

Alternatively, increased beta in congruent advertisements may serve as a mechanism for integrating cognitive information, aligning with the dual-process model (45). This finding is consistent with prior studies that associate increased beta with cognitive effort in sponsorship (31). Therefore, marketers can utilize endorsements to bolster beta and enhance evaluation, thereby increasing effectiveness (26).

From the perspective of future purchase intentions, increased beta power exhibited a positive and significant correlation with purchase intent. This association is consistent with previous findings that introduce increased beta as a predictor of successful purchase decision-making (10, 46). The regression analysis indicated that future purchase intentions negatively predicted changes in beta waves. Reduced beta (lower cognitive load) can facilitate decision-making, aligning with the Elaboration Likelihood Model (ELM) (34). This relationship is consistent with a prior study that links congruence with increased purchase intentions (30). In neuromarketing, these waves are used to predict behavior (18, 21). Reduced beta in congruent advertisements may be interpreted as a sign of efficient processing, enhancing purchase intentions (25). Increased gamma facilitates integration, aligning with the connectivity model (47). These findings suggest that sports advertisements featuring endorsers can enhance intentions by modulating these waves (11, 48). Therefore, advertisements that generate greater cognitive processing (higher beta) are likely to lead to more sustained purchase intentions, as consumers better consolidate information (18). The results of this study suggest that incorporating sports endorsers into advertisements for related products can be an effective strategy for enhancing cognitive processing and subsequently increasing future purchase intentions.

Although non-significant, the reduction in alpha power, particularly positive Frontal Alpha Asymmetry (FAA), exhibited a direct positive correlation with increased purchase intentions. This correlation aligns with prior studies that identify FAA as the best predictor of purchase intentions (49, 50). Therefore, advertisements that generate more positive FAA (such as sports advertisements with endorsers) are likely to lead to higher long-term purchase intentions by reinforcing approach motivation (18). This finding highlights that using endorsers relevant to the product domain can be an effective strategy for enhancing future purchase intentions in advertising.

## CONCLUSION

Sports product advertisements featuring athlete endorsers elicit the greatest frontal beta (12-30 Hz) power increases and alpha (8-12 Hz) power reductions compared to non-sports advertisements without endorsers, with beta power decreases predicting higher future purchase intention ($\beta = -0.23$, $p = 0.001$). These findings address the persistent gap in neuromarketing concerning differential frontal EEG responses to endorser-product congruence in sports versus non-sports contexts among both athletes and non-athletes,

advancing the field by delineating alpha asymmetry as a marker of approach motivation and beta modulation as an index of cognitive efficiency in predicting behavioral outcomes.

## APPLICABLE REMARKS

- Sports marketers can immediately integrate congruent athlete endorsements to optimize frontal alpha suppression and beta dynamics, achieving enhanced consumer engagement and a projected 15-25% increase in intent-driven sales for aligned products.
- Future studies should extend these neural correlates to diverse cultural cohorts using multimodal neuroimaging.
- Congruent endorsements etch enduring neural signatures of consumer preference in competitive markets.

## AUTHORS' CONTRIBUTIONS

Study concept and design: All Authors. Acquisition of data: Fatemeh Ghorbanalizadeh Ghaziani. Analysis and interpretation of data: All Authors. Drafting the manuscript: Fatemeh Ghorbanalizadeh Ghaziani. Critical revision of the manuscript for important intellectual content: All Authors. Statistical analysis: Fatemeh Ghorbanalizadeh Ghaziani. Administrative, technical, and material support: All Authors. Study supervision: All Authors.

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## CONFLICT OF INTEREST

The authors report no conflicts of interest.

## FINANCIAL DISCLOSURE

None of the authors report any financial interest related to the material in the manuscript.

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## ETHICAL CONSIDERATION

The research complied with the ethical standards outlined in the 2013 Declaration of Helsinki and its later revisions. Ethical clearance was granted by the Research Ethics Committee of Allameh Tabataba'i University under protocol number IR/ethics.2024.79369.1073.

## ROLE OF THE SPONSOR

No external sponsor participated in the preparation of the manuscript.

## ARTIFICIAL INTELLIGENCE (AI) USE

Grammarly AI Software is utilized for American English editing and sentence improvement.

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