



PhD program in Communication, Markets and Society

Cycle XXXVIII

***MENTALIZING WITH THE CONSUMER BRAIN
FROM A REVIEW OF EEG-BASED MEASURES OF
CONSUMER PROCESSES TO THE DEFINITION OF
NEURAL CORRELATES OF CONSUMER
MENTALIZING***

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Introduction

*"If the human brain were so simple that we could understand it,
we would be so simple that we couldn't"*
Emerson M. Pugh, 1977

The present doctoral dissertation lies within the domains of *Consumer Neuroscience* and *Neuromarketing*, with the final objective of contributing to their advancement and refinement.

Consumer neuroscience and neuromarketing are two closely related sides of the same discipline. The former focuses on scientific and academic research, while the latter concentrates on more practical and industrial applications of these findings (Ramsøy, 2019). However, both of them apply neuroscientific theories and methods to the investigation of the different aspects of consumer behavior (Russo, 2024).

Indeed, over the years, research on consumer behavior has emphasized the complexity of human decision-making processes, challenging the traditional view of consumers as entirely rational actors (Knutson et al., 2007). Consumer neuroscience tries to address this complexity by investigating the psychological, cognitive and emotional processes underlying consumer behavior and decision-making through neuroscientific methods (Cherubino et al., 2019), overcoming the limitations associated with traditional methods such as questionnaires, interviews and focus groups, which are often subject to cognitive biases and interpretative challenges (Missaglia et al., 2017).

A foundational principle of these disciplines, to which I have been strongly committed since first approaching this field during my undergraduate studies, is that they do not intend to replace traditional methods. The efficacy of data collected through neuroscientific techniques should not be considered inherently superior to that collected through traditional methods, but rather, the former simply allows the measurement of consumer behavior responses that would otherwise be inaccessible. The added value of these disciplines thus lies in their **integration** of multiple methods, surpassing merely "conservative" approaches and allowing researchers to construct a more comprehensive, though still imperfect, representation of the consumer mind (Sung et al., 2019). However, while this integrative approach is certainly enriching and constitutes one of the defining strengths of these disciplines, it can also introduce significant methodological challenges, which often arise from the need to integrate different data types, methods, theories, and languages from different fields.

Indeed, neuromarketing and consumer neuroscience, despite their increasing prominence and application in market research (Casado-Aranda et al., 2023), remain relatively "young" disciplines, being formally established in the early 2000s (Smidts, 2002; Yoon et al., 2006). Over the past two decades, a growing number of researchers have worked on their advancement, yet they still face significant challenges in establishing themselves as mature, methodologically robust academic fields (Bigne et al., 2025).

During the course of my doctoral research experience, I have identified *two main challenges* that I personally consider to significantly obstruct the progress of these disciplines. These challenges,

as will be demonstrated throughout this dissertation, not only constrain theoretical advancements but also limit practical applications. In particular, they are represented by:

1. **The gap between academia and industry.** While neuromarketing is fundamentally related to the application of academic research findings to market studies and practical market research cases, a mismatch can often be found between these two worlds. Academic researchers prioritize methodological rigor, while businesses seek methods that are practical, readily applicable, accessible in terms of costs and expertise, and easily interpretable. *What steps can be taken to get these two worlds closer?*
2. **Methodological issues and limitations.** As a relatively young field, consumer neuroscience faces several methodological challenges. Among these is the need for standardized experimental protocols that ensure consistency and comparability across studies. Additionally, existing neuroscientific metrics require further development and a common taxonomy to reliably assess the subtle and often difficult-to-capture processes underlying market-relevant consumer behavior. *How can the field develop more robust methodologies that balance scientific rigor with practical relevance for industry applications?*

In response to these challenges, my doctoral research focused on addressing both issues, with the aim of proposing novel solutions and approaches to overcome them. Specifically, over the past three years, I have focused on...

1. **The gap between academia and industry.** To bridge the gap between academia and industry, I actively worked and collaborated with colleagues at the **Behavior and Brain Lab IULM** on consulting projects, trying to balance scientific rigor with the practical needs of businesses, creating a dialogue between these two worlds and facilitating a deeper connection between academic standards and industry needs to highlight the mutual benefits of such collaboration. I tried to show industries the value of integrating rigorous neuroscientific methods and data into their everyday research processes, encouraging their interest and engagement with this approach. I also made a concrete effort to “translate” our methods and data into simpler, more accessible language, ensuring that the information could be easily understood by non-academics, of course, without ruling out or compromising the scientific rigor and integrity of the work conducted.
2. **Methodological issues and limitations.** To address the methodological issues and limitations within my field of research, I developed this **doctoral thesis**. It presents a critical review of the metrics currently employed to measure key psychological processes relevant to consumer behavior through electroencephalography (EEG). The choice to focus on EEG was also strategic from a practical point of view: among neurophysiological tools, EEG is one of the most portable, relatively affordable, and widely adopted in market research practices, making it particularly suitable for connecting academic research with practical applications (McInnes et al., 2022). So, the aim of this thesis is not only to advance theoretical understanding, but also to ensure that professionals engaged in real-world consumer research can understand and adopt the findings. The main objective is to identify the strengths as well as the weaknesses of the actual consumer neuroscience approach, propose effective improvements, and eventually define new measures to be used in consumer

neuroscience research and practice. Therefore, this thesis is organized into the following main chapters:

The **first chapter** presents a systematic review of the EEG-based metrics used in consumer neuroscience. Adopting a critical perspective, this chapter highlights the main cognitive and emotional processes studied in the field and examines how they have been measured via EEG. Particular attention is given to the inconsistencies in the methodologies applied to measure the same cognitive process through “our brain waves”. The chapter also highlights those processes that, despite their significance, particularly according to more recent contributions, have received insufficient attention in the consumer neuroscience literature, and that should thus be further explored.

The **second chapter** focuses on one of those underexplored processes, that is, *mentalizing*. It defines the construct, explains its characteristics, and discusses its potential contributions to consumer research, specifically within the consumer neuroscience and neuromarketing fields. This chapter aims to clarify the theoretical relevance and practical applicability of mentalizing processes in our research field, providing a solid basis for further empirical and practical exploration.

The **third chapter**, experimental in nature, presents the main study designed and conducted to address the identified gap in the measurement of mentalizing processes in consumer research. It describes the development of an EEG-based measure for mentalizing and its practical testing in the context of the perception and evaluation of narrative advertising. The findings aim to validate the proposed measure's applicability and effectiveness in real-world scenarios, offering a novel tool for everyday consumer neuroscience research and neuromarketing applications.

The **fourth and final chapter** presents the conclusions of this dissertation. It provides a comprehensive synthesis of all the research conducted, looking back at the main insights and contributions that emerged across the chapters and highlighting their overall contribution to the fields of neuromarketing and consumer neuroscience. At the same time, it reflects on the limitations of this work and delineates potential directions for future research, outlining how these findings may serve as a basis for further advancements in both academic and applied neuromarketing practice.

For ease of reading, a reference list is provided at the end of each chapter.

I hope that my doctoral journey and the work I have conducted during it have made a meaningful, however small, contribution to these disciplines. Addressing these challenges, I hope I have helped and encouraged, even if only a very little bit, the integration of academic and industry perspectives and improved the methodological robustness of neuromarketing and consumer neuroscience, both theoretically and practically.

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CHAPTER 1

From EEG to Behavior: Toward a Standardized Methodological Approach for EEG in Consumer Research

"The brain is a monstrous, beautiful mess. Its billions of neurons lie in a tangled web that displays cognitive powers far exceeding any machine we have built to mimic it"
(William F. Allman)

This first Chapter aims to systematically examine how EEG is used in consumer research, with a particular emphasis on the metrics derived from it to compute measures of consumers' cognitive and emotional processes.

It begins with a brief discussion of EEG technology, highlighting its relevance compared to other neuroscientific tools and explaining its basic functioning, then reviews the main literature on EEG applications within consumer neuroscience, identifying its limitations and outlining how the present work aims to contribute to the field. It explores the psychological constructs that have been measured through EEG in marketing research, points out inconsistencies in how these constructs have been assessed, and organizes them into thematic clusters. These clusters are then re-examined in a more "neuroscientific" light, with a focus on their EEG correlates.

Finally, it highlights important consumer neuroscience processes that have been overlooked in the existing literature, thus establishing the foundation for the following Chapters 2 and 3, which will offer both theoretical and empirical analyses to identify both why (the role) and how (the EEG measure) we can capture these underexplored processes.

1. Introduction

In the disciplines of neuromarketing and consumer neuroscience, one of the most commonly used tools in both academic research and industry-related applications is electroencephalography (EEG), alongside – but not limited to – functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS), eye-tracking (ET), and physiological monitoring techniques such as galvanic skin response (GSR) and heart rate (HR) (Lim, 2018; Rawnaque et al., 2020).

These neuroscientific techniques allow for the collection of data directly from the brain, either through electrical (EEG) or magnetic activity (fMRI), as well as from physiological responses, measured via sensors placed on the skin (GSR and HR), or through behavioral indicators like facial expressions and eye movements (ET). What distinguishes these data is their *implicit* nature: they are not verbalized or consciously reported by consumers, yet they offer decisive insights into how individuals respond to marketing and communication stimuli. And exactly *for their non-verbal and often unconscious character, these measures provide an essential and non-negligible perspective* in fully understanding consumers and their responses.

It is for this reason that their integration into market research practices has gained increasing interest in both academia and industry, where these techniques have been shown to support improvements for advertising effectiveness, branding strategies, product design, pricing decisions, and online user experiences, finally enhancing campaign efficiency and return on investment (Camarrone & Van Hulle, 2019; Alvino et al., 2020; Alsharif et al., 2023).

A comprehensive comparison of these different neuro techniques, each with its own strengths, limitations, and methodological characteristics, falls beyond the scope of this Chapter and of the dissertation in general. For those interested in an in-depth methodological review, reference can be made to existing systematic overviews of the field, which are presented in Section 1.3 of this Chapter. However, as this Chapter in particular and the whole thesis focus specifically on the use of EEG in consumer research, I will briefly outline the rationale behind my decision to choose it over other available tools. EEG benefits from a:

1. **Widespread adoption in academic market research**, especially over the past decade, as supported by a growing body of systematic reviews and original studies utilizing EEG in consumer and decision-making contexts (Costa-Feito et al., 2023; Sabio et al., 2024).
2. **Strong presence in applied market research**, where EEG is increasingly used by companies and B2B practitioners to enhance the “neuro” validity of their findings, while still being more common in large companies due to the need for technical expertise and precise experimental design (Lin et al., 2018; McInnes et al., 2022).
3. **Capacity to capture a wide range of cognitive and emotional processes**, by “simply” directly measuring brain electrical activity (Vecchiato et al., 2011; Bazzani et al., 2020; McInnes et al., 2022; Alsharif et al., 2024; Wang et al., 2024).
4. **High temporal resolution**, which allows researchers to track very rapid changes in brain activity, making it particularly well-suited to studying a wide range of dynamic and time-sensitive stimuli, from video advertisements to different product types, interactive interfaces, or shopping environments (Vecchiato et al., 2011; Bazzani et al., 2020; McInnes et al., 2022).
5. **Less expensive and more portable**, especially in comparison to more complex techniques like fMRI, enabling larger sample sizes and real-world or field studies (Bazzani et al., 2020; Sabio et al., 2024).
6. **Wearability and ease of deployment**, especially with the advent of portable, wireless, and user-friendly EEG devices that can allow for out-of-the-lab studies, in real-world or simulated shopping environments (Sawangjai et al., 2020; Sabio et al., 2024).

These factors make EEG a unique and versatile tool, capable of producing insights with both theoretical relevance and practical applicability. Consequently, this specific work will focus on EEG-derived metrics, as their outcomes are *more likely to meet the interests and needs of both academic audiences and market research practitioners*.

1.1. On the EEG

What is EEG? What does it measure and how?

This paragraph aims to briefly answer these questions, offering a general overview, even though not an in-depth analysis, of how the EEG works and what it is used for, particularly in the field of consumer research.

EEG records brain activity by applying electrodes to the scalp, which detect the changes in the electrical fields generated by neurons in the underlying cortical regions to provide insights into an individual's brain response to stimuli or experiences.

Our cerebral cortex is made up of billions of neurons that communicate through electrical impulses. Among these, pyramidal neurons (named after the pyramid-like shape of their cell bodies)

are especially important for EEG. They are located on the surface of the cortex, particularly in the gyri (the cortex ridges), rather than in the sulci (the folds) where neuronal signals are harder to detect. Because of their orientation and location (perpendicular to the electrode sensor), pyramidal neurons' signals are particularly well-suited for EEG measurement (Jackson & Bolger, 2014).

Figure 1.1, adapted from Portillo-Lara et al. (2021), provides a clear and visual summary of how EEG recording works, starting with the very basic neurophysiological principles. Further details and descriptions of the related processes are provided in the figure *caption*.

That said, considering these signals “easier to detect” is a bit of a euphemism. While they are relatively more accessible than others, they are still extremely weak. EEG signals are usually in the range of microvolts (μV , millions of times weaker than a typical household electrical current) and must pass through several layers of biological tissue (e.g., the skull and the scalp), before they reach the electrodes (Jackson & Bolger, 2014).

To obtain a better signal strength, EEG devices are equipped with amplifiers that boost the tiny voltages to measurable levels, while to deal with the signal transmission through tissue challenge, researchers use high-conductivity materials. For example, electrodes are often made of silver/silver-chloride (Ag/AgCl), and the skin is prepared using abrasive scrub and conductive gels (Jackson & Bolger, 2014). This improves electrical contact with the skin and helps reduce impedance, something that will be discussed in more detail in Chapter 3, when EEG recording methods and electrode setups are described when presented along with the experimental study methodology.

The EEG signal reflects the difference in electrical potential between electrodes placed on the scalp and a designated reference¹ electrode, which serves as a sort of “point zero” for voltage measurements. The resulting brain waves are typically described in terms of their frequency (cycles per second, expressed in Hz), amplitude (measured in μV), and topography (the spatial location of the electrode capturing the signal) (Jackson & Bolger, 2014).

¹ There are different types of reference methods, considering for example the mastoid, the earlobe, or other scalp areas. In the main study presented here in Chapter 3, we used an average reference computed across all 64 scalp electrodes, a commonly employed reference method in EEG procedures involving a high number of electrodes, as in our setup, which also presents some advantages such as higher consistency across conditions (Candia-Rivera et al., 2021).

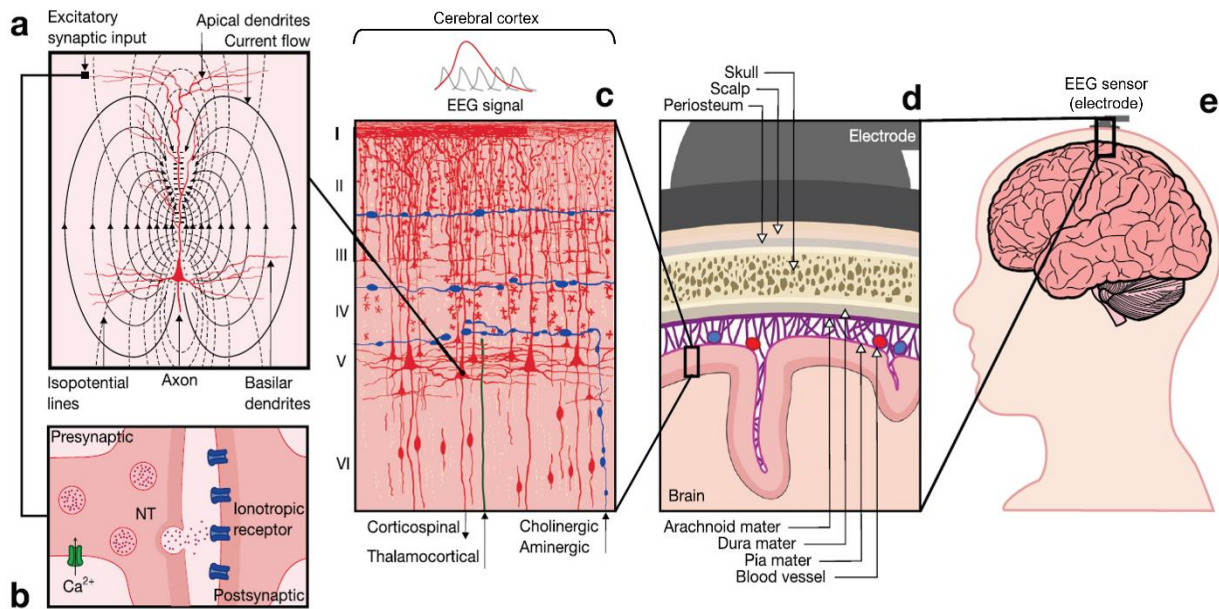


Figure 1.1. Neurophysiological basis of EEG recording (adapted from Portillo-Lara et al., 2021).

Generation of EEG signals: synchronized pyramidal neuron activity (a). EEG signals originate from the large-scale synchronization of electrical activity in pyramidal neurons located in the cerebral cortex. When they fire in synchrony, they produce excitatory postsynaptic potentials that generate measurable dipoles - regions of charge separation that result in measurable electric fields. This dipolar structure is essential for EEG, as it allows electrical activity to be summed and reach the scalp through spatial alignment.

Synaptic transmission and postsynaptic potentials (b). Communication between neurons occurs at the synapse, where an action potential arriving at the presynaptic terminal triggers the release of neurotransmitters (NT) into the synaptic cleft. They are molecules that bind to receptors on the postsynaptic membrane, allowing ions to flow into the neuron and causing a local change in membrane potential (the EPSP). Although a single EPSP is too weak to be detected, when thousands occur simultaneously in aligned pyramidal neurons, their cumulative effect becomes strong enough to contribute to the EEG signal.

Cortical layering and spatial summation of signals (c). The cerebral cortex is structured into six distinct layers (I–VI), each with unique cytoarchitectural features. EEG signals primarily arise from the postsynaptic potentials in pyramidal neurons, which lie in the III, IV, and V cortical layers and are ideally positioned in terms of orientation and distribution, spatially aligned perpendicular to the cortical surface. Their long apical dendrites extend toward the cortical surface, creating a dipole field when activated. EEG activity is measured as differences in voltages recorded at different locations on the scalp, which constitute the sum of postsynaptic potentials from thousands of neurons near each recording electrode.

Signal propagation through biological tissue (d). Before reaching the scalp electrodes, the electrical signal must pass through multiple layers of non-neural tissue: the meninges (pia, arachnoid, dura), cerebrospinal fluid, the skull, and the scalp. Each of these layers introduces attenuation and spatial blurring due to its different electrical conductivity. In particular, the skull introduces a significant barrier, reducing signal amplitude and distorting spatial resolution. This is one of the main reasons why EEG has excellent temporal resolution but relatively limited spatial specificity.

Electrode placement and recording configurations (e). To detect the signal at the scalp level, electrodes are placed according to standardized systems such as the 10–20 international system, which ensures consistent and symmetrical coverage of the cortical surface. Each electrode measures voltage differences between locations, capturing the summed electrical activity from neuronal populations beneath. The choice of montage influences both the sensitivity and spatial accuracy of EEG recordings and must be selected based on the specific cognitive or affective processes under investigation.

1.1.1. EEG preprocessing and analysis

Before being analyzed, EEG data undergo a series of preprocessing steps designed to clean the raw signal and ensure its quality and interpretability (Kim, 2018). This process typically begins with filtering the data to remove slow drifts (high-pass filter), higher ones, and power line noise (notch filter, often at 50Hz). Next, the signal is visually or algorithmically inspected to identify and reject noisy channels and large non-neural artifacts (e.g., those caused by muscle activity, eye movements, or external noise). In many cases, Independent Component Analysis (ICA) is then applied to isolate and remove components associated with artifacts. The continuous EEG signal is then segmented into epochs based on experimental events or conditions (e.g., stimuli presentation), to finally be analyzed in either the time or frequency domain, depending on the research goals (Kim, 2018).

One of the most common approaches is **Spectral Analysis**, which decomposes the EEG signal into its frequency components, each associated with specific mental states, and often achieved using mathematical transformations (e.g., the Fourier Transform). The main frequency “bands” or “rhythms” (**Figure 1.2**) include:

- **Delta, δ (0.5–4 Hz)**: Low-frequency waves, typically observed during deep sleep and associated with unconscious processes.
- **Theta, θ (4–8 Hz)**: Commonly linked to light or REM sleep, and memory encoding, theta activity is noticeable during states of internal focus, meditation, drowsiness and early sleep.
- **Alpha, α (8–13 Hz)**: This rhythm is related to relaxed wakefulness (when the eyes are closed). Most prominent in the occipital lobe, it is often interpreted as an (inverse) marker of inhibitory control and internal attention.
- **Beta, β (13–30 Hz)**: Associated with alertness, active thinking, concentration, and motor behavior, beta waves are often observed in frontal and central regions.
- **Gamma, γ (>30 Hz, often no more than 80/90 Hz)**: These high-frequency oscillations are linked to high-level information processing and integrative processes of perception, conscious awareness, and working memory, though their interpretation remains contested due to potential creation of artifacts (particularly muscular activity).

Another type of EEG-based analysis is the extraction of **Event-Related Potentials (ERPs)**, which focuses on the brain’s time-locked electrical responses to specific internal or external events, such as sensory stimuli, decisions, or feedback (Picton et al., 1995).

ERPs are extracted by averaging multiple EEG epochs aligned to the onset of an event. Their components are named based on polarity (positive, P, or negative, N) and latency (e.g., P300 for a Positive deflection at around 300 ms after stimulus presentation). Some examples of well-known ERPs are the P300, associated with attentional allocation, and the N400, linked to semantic processing and typically appearing around 400 ms after encountering semantically incongruent or unexpected stimuli (Luck, 2014).

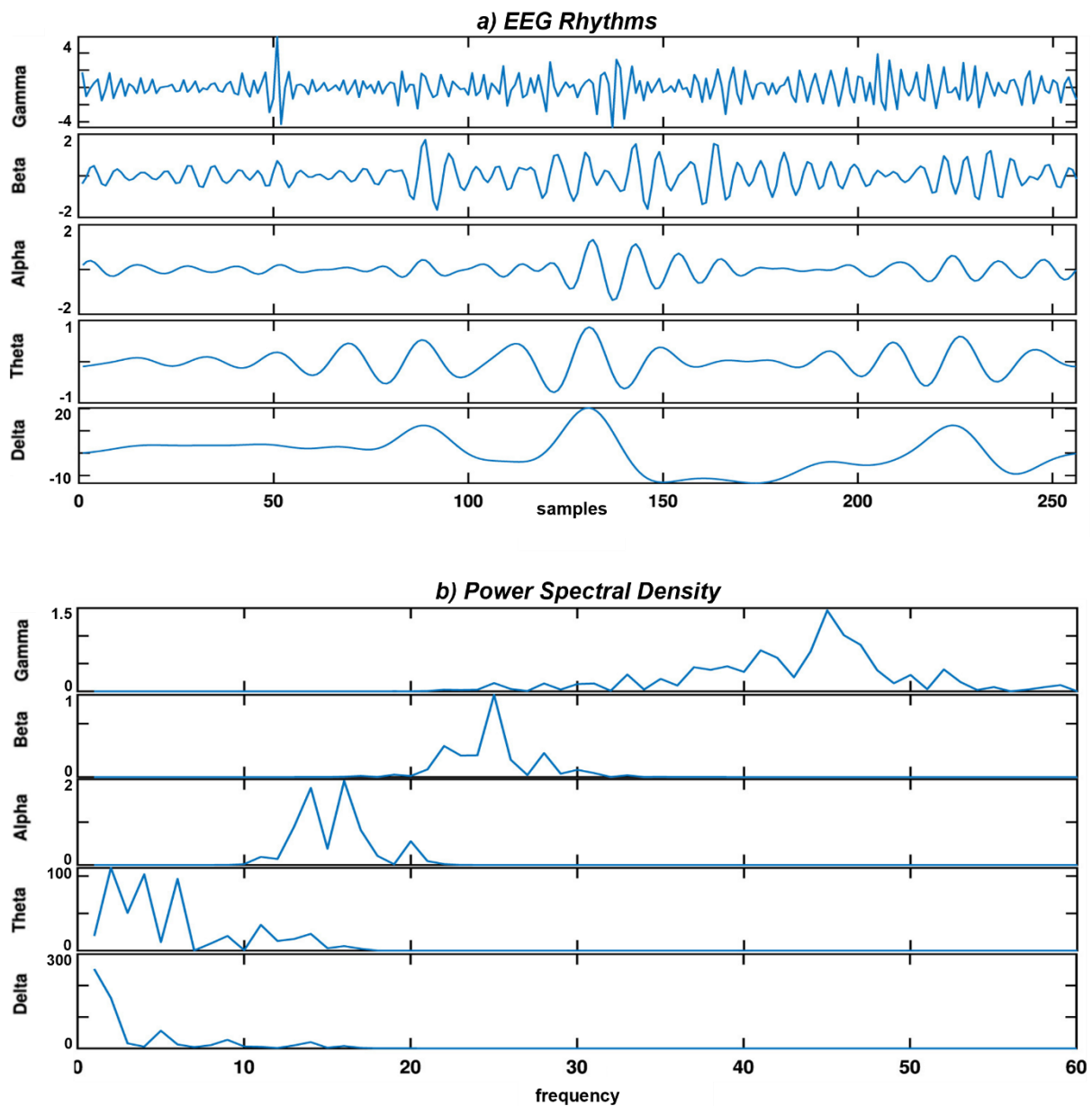


Figure 1.2. Time-domain and frequency-domain representations of EEG frequency bands (adapted from Vempati & Sharma, 2023). The upper figure (a) shows EEG waveforms in the time domain for the five main frequency bands (δ , θ , α , β , and γ). The lower figure (b) shows the corresponding spectral decomposition (frequency domain), highlighting the main frequency ranges for each band. This decomposition is typically achieved using a Fourier Transform, which allows the extraction of frequency-specific information from the raw EEG signal.

1.2. EEG application in consumer research

One of the main applications of EEG in consumer and market research is to measure implicit and immediate responses to marketing stimuli, such as advertisements, product displays, and branding elements, providing access to those emotional and cognitive reactions that are often inaccessible and not captured by traditional self-report methods (Wang et al., 2024; McInnes et al., 2022; Alsharif & Isa, 2024).

EEG has also been effectively used to predict consumer preferences and choices. For example, studies by Telpaz et al. (2015) and Golnar-Nik et al. (2019) have shown that EEG patterns can forecast product selection with significant accuracy. More recent approaches have in fact combined EEG data

with machine learning models to improve the prediction of individual preferences (e.g., Panda et al., 2024).

Moreover, EEG has been used to study how consumers respond to different pricing strategies and product features, revealing, for example, neural patterns linked to value perception and decision-making conflict (Wang et al., 2024; Bazzani et al., 2020).

Another frequent application of EEG is in evaluating how consumers emotionally and cognitively engage with marketing content. Measures such as attention, motivation, emotional valence, memory encoding, cognitive engagement, and mental workload are often used to assess the effectiveness of advertising campaigns (Yadava et al., 2017) as well as other media formats (Bazzani et al., 2020; Pei & Li, 2021; McInnes et al., 2022). In this way, EEG has helped identify neural measures capable of providing insights for adjusting content duration, pacing, and message clarity (Alsharif & Isa, 2024; Byrne et al., 2022).

Recent studies have also explored the combination of EEG with other technologies such as artificial intelligence (AI; Ghazvini et al., 2024) and other “neurotools”, for example, eye-tracking and facial expression analysis (Byrne et al., 2022; Alvino et al., 2020), in a multimodal approach aimed at improving the accuracy of consumer profiling and behavior predictions.

Finally, the growing accessibility of new EEG devices (wearable, wireless, easier to apply and suitable for naturalistic settings) has expanded research possibilities into new areas, including for example virtual reality experiences, tourism marketing, and health-related campaigns (Costa-Feito et al., 2023; Sabio et al., 2024; Khondakar et al., 2024).

1.3. Existing reviews on EEG in consumer research

But what have the existing literature reviews on the use of EEG and its metrics in consumer neuroscience addressed so far?

To provide an answer to this question, a first systematic search was conducted on both Scopus and Web of Science databases, following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) method (Page et al., 2021). We used the following keyword combination: “EEG” OR “electroencephalography” AND “consumer neuroscience” OR “neuromarketing” AND “review”, applied within the document title, abstract, and keywords fields. We limited our selection to review articles published between 2015 and 2025, written in English, and excluded conference papers and book chapters.

This search yielded 35 documents from Scopus and 141 from Web of Science. After screening the results based on the relevance of the content for our research scope (by reading the title and the abstract) and removing duplicates, we selected a total of 11 reviews specifically focused on EEG applications in consumer research. Additionally, we included 10 broader reviews addressing consumer neuroscience tools in general.

Table 1.1 provides an overview of these reviews and summarizes their main contribution

YEAR	TITLE	AUTHORS	JOURNAL	CONTRIBUTION
Dec 2024	Electroencephalography Studies on Marketing Stimuli: A Literature Review and Future Research Agenda	Alsharif, A. H. & Isa, S. M.	International Journal of Consumer Studies	Delineates the trends of scientific publications utilizing EEG tools in CB research. Classifies the most interesting and prevalent topics in the field (price, product, brand, advertising, decision making, emotional and cognitive processes). Identifies the consumer neuroscience research theories and models (focus on emotions, attention and memory).
Jun 2024	A Systematic Review on EEG-Based Neuromarketing: Recent Trends and Analyzing Techniques	Khondakar, F.K. et al.	Brain Informatics	Categorizes 2017–2023 neuromarketing EEG studies into five thematic clusters. Reviews CB-relevant brain regions and EEG brainwaves. Focuses on EEG preprocessing, feature extraction, ML/statistical methods. Provides a brief overview of CB-relevant EEG metrics (here categorized as arousal, valence, choice, and effort).
May 2024	A Review on the Use of EEG for the Investigation of the Factors That Affect Consumer's Behavior	Antiopi, P. et al.	Physiology & Behavior	Identifies the elements affecting CB, studied through EEG: marketing stimuli (product, price, place, promotional activities), internal characteristics (affect, cognition, demographics) environmental cues (social and cultural factors)
Aug 2023	Electroencephalography in Consumer Behaviour and Marketing: A Science Mapping Approach	Costa-Feito, A. et al.	Humanities and Social Sciences Communications	Maps the evolution of EEG-based consumer neuroscience by ranking and aggregating key topics. Identifies emerging areas of interest to guide future research.
Nov 2022	A Systematic Review of the Prediction of Consumer Preference Using EEG Measures and Machine-Learning in Neuromarketing Research	Byrne, A. et al.	Brain Informatics	Reviews only the EEG metrics related to consumer preference, highlighting FAA and ERP components (N400, N200, P300, P200, LPP). Mentions other EEG frequency bands.
Jul 2022	A Practical Review of EEG's Value to Consumer Research	McInnes, A.N. et al.	International Journal of Market Research	Provides methodological guidelines for using EEG in CB research. Describes how EEG and ERPs can assess processes such as attention (via ERP), recall and recognition (via EEG), motivational/emotional intensity (via ERP), approach motivation (EEG), and information complexity (via ERP).
Jul 2022	Current Trends in the Application of EEG in Neuromarketing: A Bibliometric Analysis	Alsharif, A. H.	Scientific Annals of Economics and Business	Performs a bibliometric analysis of EEG in CB research: authors, institutions, journals, and citation trends.
Jan 2022	Data Acquisition and Data Processing using Electroencephalogram in Neuromarketing: A Review	Amran, A.S. et al.	Pertanika Journal of Science & Technology	Provides a general introduction to EEG, including clinical applications, data repositories, typically computed bands, acquisition and analysis process. Overviews EEG implementation in CB research and outlines emerging trends in the field.
Dec 2020	Is EEG Suitable for Marketing Research? A Systematic Review	Bazzani, A. et al.	Frontiers in Neuroscience	Offers guidance on consumer neuroscience EEG study design. Uses the 4Ps marketing framework to review EEG applications, with a managerial focus. Mentions EEG-based measures (but only FAA), ERPs and steady-state probe topography.

Oct 2018	A Gateway to Consumers' Minds: Achievements, Caveats, and Prospects of EEG-Based Prediction in Neuromarketing	Hakim, A. & Levy, D.J.	WIREs Cognitive Science	Explores how EEG can predict marketing success, discussing ERPs (P300, N200, SST, ERN), spectral power across bands, hemispheric asymmetry (in alpha as well as theta and gamma bands), and ICS. Concludes that the predictive value of EEG features is still inconclusive, stressing the need for proper model fitting/testing
Jan 2018	Applying EEG in Consumer Neuroscience	Lin, M. et al.	European Journal of Marketing	Organizes EEG studies using Plassmann et al. (2015)'s 5 neuroscience functions for understanding CB. Emphasizes ERPs and links EEG features to key cognitive processes: attention and memory (N200, P300, theta and beta waves), decision-making (N200, P300), affect and emotions (LPP, alpha wave).
Other literature reviews on consumer neuroscience techniques - not only focused on EEG				
Dec 2024	Neuromarketing Insights for Effective Advertising Strategies: A Review and Future Research Agenda	Panwar, D. et al.	NeuroPhysiological Trends	Map the trends in the field (e.g., publication rate, leading authors, journals, and contributing countries).
Jun 2024	Tools in Marketing Research: Exploring Emotional Responses to Stimuli	Alsharif, A.H. & Khraiwish, A.	Scientific Annals of Economics and Business	Reviews neuroscientific tools for measuring consumers' emotions. Focusing on EMG, GSR, and ECG, with minimal coverage of EEG.
Jul 2024	Advances in Neuromarketing and Improved Understanding of Consumer Behaviour: Analysing Tool Possibilities and Research Trends	Seemaa, B. et al.	Cogent Business and Management	Reviews neuromarketing trends (past and future), application areas, tools used, and ethical issues.
Nov 2023	Consumer Neuroscience on Branding and Packaging: A Review and Future Research Agenda	Rodríguez, V.J.C. et al.	International Journal of Consumer Studies	Describes key processes (attention, memory, emotion, motivation, reward, decision-making) based on prior frameworks. Emphasizes brain area activation over specific EEG activity. Focuses mainly on packaging and branding, with emphasis on eye-tracking and fMRI findings.
Mar 2023	Neuromarketing Tools Used in the Marketing Mix: A Systematic Literature and Future Research Agenda	Alsharif, A.H. et al.	SAGE Open	Identifies the main application areas within CB research. Describes the brain regions involved in cognitive processes (e.g., right dlPFC for approach/avoidance, parietal areas for price processing). Mainly focuses on fMRI insights
Jun 2021	A Review of Research on Neuromarketing Using Content Analysis: Key Approaches and New Avenues	Robaina-Calderín, L. & Martín-Santana, J. D.	Cognitive Neurodynamics	Uses a text mining approach to cluster neuroscience contributions in CB research into 4 categories: theoretical papers, neuromarketing techniques, customer service, and neuromarketing as a secondary approach. Maps publication trends and identifies key authors in the field.
Dec 2020	Picking Your Brains: Where and How Neuroscience Tools Can Enhance Marketing Research	Alvino et al.	Frontiers in Neuroscience	Identifies 7 main neuroscientific tools for CB research, with EEG and eye tracking being the most common. Maps the tools application across CB domains: advertising, branding, online experience, pricing, product development, and product experience. Highlights the platforms for multimodal measurement. Maps for future research and practical applications in consumer neuroscience.
Sept 2020	Technological Advancements and Opportunities in Neuromarketing: A Systematic Review	Rawnaque, F.S. et al.	Brain Informatics	Reviews the tools, stimuli, and brain regions relevant in neuromarketing. Discusses FFA in relation to emotional valence.

				Highlights the role of ML in enhancing neural data interpretation for marketing.
Apr 2020	Neuromarketing Approach: An Overview and Future Research Directions	Alsharif, A.H. et al.	Journal of Theoretical and Applied Information Technology	Reviews and discusses all consumer neuroscience tools (classified into metabolic, physiological, and electrical methods).

Table 1.1. Overview of the available reviews on the use of EEG in consumer neuroscience and neuromarketing research.

Analyzing these recent review articles' contributions, it appears that they have primarily focused on addressing the following 5 main aims:

1. **Publication Mapping and Field Trends.** Reviews often map publication trends over time, identifying leading authors, journals, institutions, and contributing countries in the application of EEG and consumer research.
2. **Application Across Marketing Domains.** EEG is reviewed in relation to its marketing applications (advertising, branding, pricing, online experiences, and product development), often using preexisting frameworks such as the 4Ps of marketing.
3. **Methodological Guidance.** Several contributions provide methodological guidelines for EEG acquisition, preprocessing, feature extraction, and integration with machine learning or statistical models to improve interpretability and prediction.
4. **Review of EEG measures.** Reviews classify EEG features used in consumer research, including frontal alpha asymmetry (FAA), event-related potentials (ERPs) like P300, N200, LPP, and frequency bands (alpha, beta, theta, gamma), often mapped onto dimensions such as arousal, valence, choice, and effort.
5. **Future Research Directions.** Reviews outline open challenges and opportunities, calling for standardized methods and protocols, validation in more ecologically valid settings, and ethical considerations in the application of EEG and related tools in consumer research.

Although all the reviewed articles - some in greater depth, others more superficially - address or mention EEG-derived measures, none of them provides a systematic review and analysis of them. While a few reviews go beyond simple mentions and link EEG measures to consumer behavior-relevant constructs, there is still a lack of comprehensive frameworks that identify specific constructs and their associated EEG metrics.

This is the gap this work aims to address. In response to one of the recurring needs highlighted across previous reviews - i.e., the call for standardized methodologies and protocols in consumer neuroscience research - the objective is to delineate the key psychological constructs relevant to consumer behavior that can be assessed via EEG.

1.4. Research gaps and open questions

EEG data can provide insight into several relevant consumer-related processes, but it's the specific computation of EEG activity in specific bands and sites that can provide us the insight into these processes. However, this is not systematically reviewed and mapped. Thus, we put forward the following research question: *what are the consumer-related constructs* that can be studied using EEG, and how are the corresponding measures calculated?

Addressing this question is challenging due to several issues in neuromarketing studies using EEG. Firstly, the current literature displays **inconsistent terminology**: there is in fact a lack of uniformity in naming indices and measures across different studies, where the same processes are named differently or vice versa. Secondly, **inconsistent measurement methods** characterize the current literature, with the same process being often measured in different papers using different calculations (e.g., using different bands and channels to assess the same construct).

Both issues may stem from the inherently multidisciplinary nature of neuromarketing and consumer neuroscience, where scholars from diverse fields - such as psychology,

neuroscience, communication, marketing, and economics - approach similar research questions with different theoretical and methodological backgrounds. However, it should also be noted that while this diversity can lead to inconsistencies in methods and interpretations, it also represents a major strength of the field, which promotes cross-disciplinary innovation and makes it highly relevant both academically and practically.

1.5. Research questions and objectives

Starting from the just highlighted emerging problems, this project aims to address these issues and gaps by pursuing the following objectives:

RQ1. Which consumer behavior constructs have been investigated using EEG? As a first research objective, we aim to map the constructs in consumer research that have been analyzed using an EEG-based approach.

RQ2. How have these constructs been assessed via EEG? As a second research objective, we will focus on how each of these constructs has been measured, noting the discrepancies in measurement methods and trying to understand which measurement is the most appropriate for the construct in question. Regarding construct measurement, we will examine how it is operationalized, whether through spectral analysis or ERPs, and the studies they consider and cite to justify the choice of approach (operationalization and computation of the EEG signal).

2. Which consumer behavior constructs have been investigated using EEG?

The initial step to address the research objectives involved defining the consumer-relevant constructs that have been studied via EEG. To achieve this, we conducted a systematic review of the literature published in leading consumer behavior journals, focusing on top-tier publications.

2.1. Journal Selection

To identify the most relevant constructs investigated in consumer research using EEG, we focused on the top journals in the fields of (consumer) marketing and management. This choice reflects our aim to base the analysis on constructs that are theoretically and practically central to consumer research, rather than emphasizing purely neuroscientific perspectives that can result a bit disconnected from marketing applications.

The selection of these top journals was guided by the current *EJL* (ERIM - Erasmus Research Institute of Management - Journal List) 2024-2028, from Erasmus University Rotterdam (<https://www.erim.eur.nl/about-erim/erim-journals-list-ejl/>), which classifies scientific journals based on judgment by peers and (ISI) impact scores. Specifically, it targeted journals classified in the highest categories: "P*" (Primary Set STAR journals, containing the real top ones, truly distinctive among the best journals in the field) and "P" (Primary Set journals, containing the best journals in the field).

In total, 16 journals were analyzed. The P* journals included the *Journal of Marketing*, *Journal of Marketing Research*, *Marketing Science*, *Journal of Consumer Research*, *International Journal of Research in Marketing*, *Journal of Consumer Psychology*, and *Journal of the Academy of Marketing Science*. The P journals comprised the *Journal of Advertising*, *Journal of Retailing*, *Journal of Interactive Marketing*, *Journal of Service Research*, *Journal of the Association for*

Consumer Research, Quantitative Marketing and Economics, Marketing Letters, Journal of Public Policy and Marketing, and Journal of Advertising Research.

The journals considered in this review, as well as their key bibliometric indicators, are reported in **Table 1.2**.

JOURNAL NAME	IF	CS	QUARTILES & DISCIPLINES
<i>P* journals</i>			
Journal of Marketing	11.5	24.1	Q1 for Business and International Management, Economics and Econometrics, Marketing
Journal of Marketing Research	5.1	10.3	Q1 for Business and International Management, Economics and Econometrics, Marketing
Marketing Science	4	6.5	Q1 for Business and International Management, Economics and Econometrics, Marketing
Journal of Consumer Research	7.2	12.2	Q1 for Anthropology, Arts and Humanities, Business and International Management, Economics and Econometrics, Marketing
International Journal of Research in Marketing	5.9	11.8	Q1 for Marketing
Journal of Consumer Psychology	4	8.4	Q1 for Applied Psychology, Marketing
Journal of the Academy of Marketing Science	9.5	15.2	Q1 for Business and International Management, Economics and Econometrics, Marketing
<i>P journals</i>			
Journal of Advertising	5.4	11.2	Q1 for Business and International Management, Communication, Marketing
Journal of Retailing	8	15.9	Q1 for Marketing
Journal of Interactive Marketing	6.8	20.2	Q1 for Business and International Management, Marketing
Journal of Service Research	9.8	20.3	Q1 for Information Systems, Organizational Behavior and Human Resource Management, Sociology and Political Science
Journal of the Association for Consumer Research	2.1	4.6	Q1 for Applied Psychology, Economics and Econometrics, Marketing
Quantitative Marketing and Economics	1.3	2.5	Q1 for Economics and Econometrics, Marketing
Marketing Letters	2.5	3.4	Q1 for Business and International Management, Economics and Econometrics, Marketing
Journal of Public Policy and Marketing	5.1	10.2	Q1 for Business and International Management, Economics and Econometrics, Marketing
Journal of Advertising Research	2.1	4.2	Q1 for Communication; Q2 for Marketing

Table 1.2. Overview of the main academic journals included in the review, with their key bibliometric indicators (IF = Impact Factor, CS = Cite Score, SJR Quartiles). The selection includes top journals in marketing, consumer research, and advertising. Metrics were retrieved from the journals' websites and from Scimago.

2.2. Constructs identification

Again, a systematic review following the PRISMA method (Page et al., 2021) was conducted within these journals. Searches were performed directly on the websites of the journals presented in section 2.1, using the keywords "EEG" OR "electroencephalography" OR "electroencephalogram". We limited our selection to research articles - excluding other article types - published between 2015 and 2025, and written in English. This process yielded a total of 109 articles. However, after screening them, only 17 of these articles met the criteria for inclusion in the subsequent analysis. These articles are summarized in **Table 1.3**, which also briefly reports the cognitive constructs addressed in each study and the methodology employed (EEG-based extracted metrics: ERPs or Power Spectral Density analysis).

At first glance, it can be easily noticed that the number of relevant articles is rather limited, suggesting that studies employing EEG tools and measures to investigate consumer behavior are still relatively underrepresented in top-tier marketing and management journals. This observation is supported by with existing literature reviews (e.g., Casado-Aranda et al., 2023), which point out that consumer neuroscience research is more frequently published in journals focused on psychology, neuroscience, or interdisciplinary fields.

Analyzing the distribution of articles across the journals considered, among the P* journals, the *Journal of Marketing* contained no relevant articles, the *Journal of Marketing Research* had 4, *Marketing Science* had none, the *Journal of Consumer Research* had 1, the *International Journal of Research in Marketing* had 1, the *Journal of Consumer Psychology* had 1, and the *Journal of the Academy of Marketing Science* also had 1. Among the P journals, the *Journal of Advertising* had 3 articles, while the *Journal of Retailing*, *Journal of Interactive Marketing*, *Journal of the Association for Consumer Research*, *Quantitative Marketing and Economics*, *Marketing Letters*, and *Journal of Public Policy and Marketing* had none. The *Journal of Service Research* published 1, while the *Journal of Advertising Research* had the highest number of contributions, with 5 relevant articles. It is important to note that our selection included only empirical studies that measured and discussed consumer-relevant cognitive or emotional constructs through EEG-related measures. While several of these journals also contained literature reviews or conceptual perspectives on the topic, such publications were not included in our analysis.

Among the 17 articles identified, 6 employed EEG setups aimed at extracting ERP measures, whereas the remaining 11 relied on traditional spectral analysis methods, calculating EEG frequency activity in specific brain regions based on prior psychological or neuroscientific studies. Two of these latter studies (Ciceri et al., 2020; Kristofferson & Dunn, 2022) used automatic indices provided by the Emotiv EPOC headset system, which are pre-associated with specific cognitive and emotional processes.

Analyzing the constructs discussed in the papers, they cover a wide range of cognitive and emotional processes, which can be classified into 5 main clusters relevant to the field of consumer neuroscience: *Attentional Processes*, *Affective and Approach Processes*, *Workload Processes*, *Decision-Making Processes*, and *Engagement Processes*.

2.2.1. Cluster 1: Attentional Processes

This category refers to the ability to select and focus on relevant stimuli in the environment, and includes constructs commonly defined in the examined literature as: *attention*, *visual attention*, *attention allocation*, *alertness*, and *arousal*.

In the context of consumer behavior research, attentional processes describe how individuals allocate their cognitive resources toward specific products, messages, or features,

often at the expense of others (Mormann et al., 2020). These mechanisms can operate both consciously and unconsciously and determine which elements are noticed and elaborated during the decision-making process, finally shaping what consumers notice, consider, and decide to purchase (Lynch & Srull, 1982; Mormann et al., 2020).

Attentional processes are fundamental to understanding a variety of marketing and consumer phenomena. From a more managerial perspective, marketing strategies depend on attention-related insights to design advertisements, product placements, and in-store displays that capture consumer attention and interest (Khachatryan et al., 2018; Han et al., 2022). For this reason, attentional processes have also been examined in relation to personality traits and behaviors; for example, visual attention to point-of-sale displays can trigger impulsive purchases in highly impulsive consumers (Khachatryan et al., 2018). Moreover, attention can interact with contextual factors such as monetary constraints or promotional cues, altering how consumers assess value and make trade-offs during their purchasing decisions (Amasino et al., 2023).

Attentional metrics – often derived through neurophysiological or behavioral tools such as EEG or eye-tracking – can be used to predict consumer behavior and uncover latent motivations (Mormann et al., 2020; Pawar et al., 2023). Specifically, eye tracking is widely used to study consumers' attentional processes. These derived insights can also support the development of more robust and dynamic models of consumer decision-making, allowing both researchers and practitioners to design interventions and marketing strategies that align with specific (attentional) moments of the purchase decision journey (Mormann et al., 2020; Ye et al., 2024). Furthermore, understanding the dynamic and selective nature of attention can support innovation by guiding the design of products and experiences that better follow consumers' perceptual mechanisms, with their limits and strengths (Ye et al., 2024).

2.2.2. Cluster 2: Affective and Approach Processes

This category involves emotions, motivation, and subjective evaluations related to stimuli, and includes constructs commonly defined in the examined literature as: *emotions, valence, interest, pleasantness, approach behavior, and motivational behavior*.

Affective and approach processes play a central role in shaping consumer behavior, as they encompass the emotional reactions elicited by marketing stimuli and the motivational tendencies to "move" toward or away from products, brands, or experiences. These processes can offer insights into consumers' decision-making processes (Lerner et al., 2015), often beyond conscious deliberation (Cohen et al., 2008).

Affective responses - whether conceptualized as discrete emotions (Tomkins, 1962; 1963) or along dimensions such as emotional valence and arousal (Russell, 1980) - inform consumers' perceptions of products and services, influencing both immediate judgments and longer-term attitudes (Westbrook, 1987; Cohen et al., 2008; Palací et al., 2019).

Approach tendencies, on the other hand, refer to behavioral inclinations to engage with stimuli that evoke a positive affect, while avoidance responses emerge in the presence of a negative affect (Davidson, 1992a). These motivational dynamics are closely linked to affective states, which explains why they are often examined within the same context, measured using similar methods, and sometimes used interchangeably in the literature.

Relatively recent developments, building on the original work by Davidson (1992a), suggest that the *direction of motivation* (approach vs. withdrawal) is a more accurate framework for interpreting these processes, particularly in relation to prefrontal asymmetry – an EEG measure that will be discussed in more detail later. These perspectives challenge the

earlier and more simplistic interpretation based solely on emotional valence (i.e., positive vs. negative affect), arguing that such a view overlooks the motivational dimension underlying emotional responses (Harmon-Jones & Allen, 1998; Harmon-Jones, 2004).

Emotional reactions and approach/withdrawal motivational tendencies have been shown to influence not only decision-making, but also consumer satisfaction, sustainable consumption, brand attitudes, attachment, loyalty, and post-purchase behaviors such as complaints or positive word-of-mouth (Yoo & MacInnis, 2005; Bagozzi et al., 2016; Wang & Wu, 2016; Palací et al., 2019). They are also essential for understanding how consumers respond to atmospheres, service encounters, and advertising content, particularly in those consumption contexts that have been designed to evoke specific emotional responses (Yoo & MacInnis, 2005; Poels & Dewitte, 2006; Kranzbühler et al., 2019).

Studying affective and motivational mechanisms can enable the development of consumer behavioral models that account for non-rational and implicit emotional processes (Cohen et al., 2008) and also allow for the design of “emotionally resonant” marketing strategies that encourage consumer engagement and loyalty by aligning emotional triggers with motivational orientation (Kranzbühler et al., 2019). They can be useful even for managing service recovery, as they inform how emotional responses guide consumer reactions to service failures (Cummings & Yule, 2020).

2.2.3. Cluster 3: Workload Processes

This category refers to the mental effort and the (over-)use of cognitive resources to process information, make decisions, and interact with products, services, or environments. It includes constructs defined in the examined literature as: *workload, mental load, cognitive load, working memory load, fatigue, and demand*.

According to *Cognitive Load Theory* (Sweller, 1988), humans can process only a limited amount of information at a time, a core constraint in consumer contexts, where individuals are frequently exposed to a large volume of information to be assessed during everyday decision-making. An excessive load can indeed impair consumers' ability to effectively evaluate options, often resulting in increased perceived stress, frustration, and a heightened sense of risk (Kusi et al., 2022). It can also lead to decision fatigue, greater reliance on *heuristics* (Zhang et al., 2023), and a poorer final decision quality (Zhang et al., 2017).

For example, retail studies have shown that under higher cognitive load, consumers are more likely to choose food bundles, even without a price discount, as these require less cognitive effort and simplify the shopping experience (Carroll et al., 2022). Similarly, in the context of social media advertising, under high workload conditions participants tend to rely on heuristic-based cues such as the number of likes and comments of the visualized content (Pittman & Haley, 2022). In addition, high cognitive demands can negatively affect consumers' emotional responses (Kim et al., 2022; Fici et al., 2024), contributing to an overall poorer consumer experience.

These outcomes are particularly important in environments where user experience (UX), clarity of communication, or ease of decision-making are central to consumer experience, such as online and virtual shopping platforms (e.g., Kakaria et al., 2023; Fici et al., 2024), where minimizing cognitive load is a primary goal. Indeed, a reduced cognitive load and enhanced cognitive fluency can improve product attitude (Fan et al., 2020), purchase intentions, and willingness to pay more for the product (Barta et al., 2022).

For all these reasons, assessing consumers' cognitive load can be useful for both researchers and practitioners to design consumption systems that support more effective,

satisfying, fluent, and accessible decisions. It thus represents a core construct for interpreting how individuals engage with consumer environments at both cognitive and behavioral levels.

We need to specify that in this analysis working memory was included within the workload-related cluster of processes because, although it contributes to information processing, it primarily reflects the active maintenance and manipulation of information necessary for task performance. As such, it represents a core component of real-time cognitive effort rather than long-term memory storage or retrieval (Chen et al., 2018; Sepp et al., 2019) that characterizes Cluster 3.

2.2.4. Cluster 4: Decision-Making Processes

This category involves the processes related to the selection between alternatives, often influenced by both affective and cognitive mechanisms (which may overlap with other categories), and includes constructs defined in the examined literature as *(product) choice and preference*, as well as other processes of judgment, evaluation, risk assessment, and preference formation.

From everyday purchases to long-term brand loyalty, consumer behavior intrinsically involves continuous, complex decisions. While traditional descriptive economic models framed decision-making as a purely rational and utility-maximizing activity, other perspectives, such as those from behavioral economics and consumer psychology, emphasize the “bounded”, heuristic-driven, often biased, and context-dependent nature of consumer choices (Kahneman & Tversky, 1979). Now we know that these processes are shaped by both “rational” and “non-rational” factors, and can be affected by internal (e.g., emotions, memory, goals, cognitive capacity) and external cues (e.g., product attributes, social cues, time constraints).

In marketing contexts, decision-making is particularly relevant as it reflects the “final consumer behavior outcome” and directly influences purchase choices and intentions. Understanding how consumers make decisions allows marketers to design interventions that facilitate more effective, efficient, and generally “better” choice experiences and outcomes. For instance, simplifying decision environments through choice architecture or *nudge* interventions can reduce decision fatigue, increase conversion rates, and promote more beneficial choices for the consumer (Thaler & Sunstein, 2008)

Recent neurophysiological research has further explored the dynamics of decision-making, identifying neural markers of conflict detection, reward evaluation, and risk sensitivity that precede explicit consumer choices (Plassmann et al., 2015). These findings not only support the integration of decision-making models into consumer neuroscience but also emphasize the importance of capturing both conscious deliberation and implicit preference in consumer choices.

2.2.5. Cluster 5: Engagement Processes

This category refers to the composite construct of *engagement*, which reflects the overall level of involvement of the individual with a stimulus.

Consumer engagement is not easy to define, but, based on the marketing literature, it can be conceptualized following three main dimensions: cognitive (i.e., relationship with a brand/product through processing and elaboration), affective (i.e., degree of positive affective relation with a brand/product), and behavioral (i.e., energy, effort and time spent on a brand/product) (Hollebeek et al., 2014; Bilro & Loureiro, 2020). Others emphasize the importance of *trust*, *commitment*, and *emotional bonding* in defining and fostering

engagement (Pansari & Kumar, 2016), as well as the consumer's voluntary contribution of resources to a brand (Harmeling et al., 2017; Bilro & Loureiro, 2020).

From a more psychological perspective - which is the level of analysis relevant for understanding how engagement is measured at the neural level with EEG - engagement refers to the *depth of processing* directed toward new information (in our case, a marketing stimulus). It is often considered a predictor of memory and learning processes (Greene, 2015), and as such, it is closely related to both the cluster of Memorization processes and that of Workload ones.

Unlike passive or automatic reactions, engagement involves an active response, which may manifest at the neural level as increased mental activity, or at the behavioral level through observable consumer actions such as sharing, commenting, or interacting with content, products, and brands (Brodie et al., 2011). Indeed, in the consumer behavior domain, engagement processes play a fundamental role in evaluating the quality of interaction between the consumer and marketing content or stimulus. High levels of engagement are associated with better recall of advertising messages (Wang, 2006), more favorable attitudes toward brands (Calder et al., 2009), and increased likelihood of purchase intention, brand loyalty, and positive word-of-mouth (Hollebeek, 2011).

Assessing engagement processes can be particularly important in highly stimulating contexts, where competition for consumer resources is very strong. Identifying which elements successfully drive engagement can help not only to improve performance metrics (e.g., time spent, click-through rates, sharing, etc) but also to build stronger, longer-lasting consumer-brand and consumer-product relationships (Hollebeek et al., 2014).

YEAR	JOURNAL	AUTHORS	ARTICLE TITLE	CONSTRUCTS	ERPs	PSD
Aug 2015	Journal of Marketing Research	Telpaz, A. et al.	Using EEG to Predict Consumers' Future Choices	Product preference		
Mar 2015	Journal of Marketing Research	Pozharliev, R. et al.	Merely Being with you Increases My Attention to Luxury Products: Using EEG to Understand Consumers' Emotional Experience with Luxury Branded Products	Attention		
Aug 2015	Journal of Marketing Research	Boksem, M.A.S. & Smidts, A.	Brain Responses to Movie Trailers Predict Individual Preferences for Movies and Their Population-Wide Commercial Success	Product preference		
Aug 2015	Journal of Marketing Research	Venkatraman, V. et al.	Predicting Advertising success beyond Traditional Measures: New Insights from Neurophysiological Methods and Market Response Modeling	Attention, Approach behavior, Memory		
Jan 2017	Journal of Consumer Research	Barnett, S.B. & Cerf, M.	A ticket for your thoughts: Method for predicting content recall and sales using neural similarity of moviegoers	Engagement		
Sept 2021	International Journal of Research in Marketing	Hakim, A. et al.	Machines learn neuromarketing: Improving preference prediction from self-reports using multiple EEG measures and machine learning	Product preference		
Nov 2015	Journal of Consumer Psychology	Wang, C.	Experiencing haptic roughness promotes empathy	Attention		
Oct 2022	Journal of the Academy of Marketing Science	Kristofferson, K. & Dunn, L.	The brand that wasn't there: The impact of brand displacement on viewer engagement and brand attitude	Engagement		
Jul 2023	Journal of Advertising	Lee, S. et al.	The Effects of In-Stream Video Advertising on Ad Information Encoding: A Neurophysiological Study.	Attention, Emotional valence		
Feb 2024	Journal of Advertising	Read, G.L. et al	Biometric Tools in a Computational Advertising Context: An Overview of Use and Application.	Attention, Interest, Desire, Action		
Mar 2018	Journal of Advertising	Lin, M.H.(J). et al.	The Sniffing Effect: Olfactory Sensitivity and Olfactory Imagery in Advertising	Attention, Emotional valence		
Aug 2012	Journal of Service Research	Boshoff, C.	A Neurophysiological Assessment of Consumers' Emotional Responses to Service Recovery Behaviors: The Impact of Ethnic Group and Gender Similarity	Emotional valence		
Dec 2021	Journal of Advertising Research	Kolar, T. et al	How Moment-to-Moment EEG Measures Enhance Ad Effectiveness Evaluation	Attention, Emotional valence		
Jun 2016	Journal of Advertising Research	Deitz, G.D. et al.	EEG-Based Measures versus Panel Ratings Predicting Social Media-Based Behavioral Response to Super Bowl Ads	Engagement		
Mar 2020	Journal of Advertising Research	Ciceri, A., et al.	A Neuroscientific Method for Assessing Effectiveness of Digital vs. Print Ads. Using Biometric Techniques to Measure Cross-Media Ad Experience and Recall	Emotional valence		
Jun 2016	Journal of Advertising Research	Matukin, M. et al.	Toward a Better Understanding Of Advertising Stimuli Processing. Exploring the Link Between Consumers' Eye Fixation and Their Subconscious Responses	Emotional valence		
Sept 2018	Journal of Advertising Research	Clark, K.R. et al.	How Advertisers Can Keep Mobile Users Engaged and Reduce Video-Ad Blocking. Best Practices for Video-Ad Placement and Delivery Based on Consumer Neuroscience Measures	Approach behavior, Engagement, Workload		

Table 1.3. Overview of key management article employing EEG to assess CB-relevant constructs. *The table summarizes the main contributions of each article, including the cognitive constructs investigated and the EEG-based methodology used (e.g., ERP or Power Spectral Density - PSD). Articles are listed in the order of journals presented in Table 1.2.*

2.3. Brief discussion on the identified processes

The EEG-based constructs identified in this review (attentional processes, affective and approach mechanisms, memorization, cognitive load, decision-making, and engagement) represent some of the core components of consumer information processing. These components are well-aligned with established psychological and consumer behavior models, which consistently emphasize their importance and stress the need to properly assess them via implicit measures, such as neuroscientific ones, due to their inherently complex nature, often almost impossible to be verbally described. As also highlighted in consumer neuroscience papers (e.g., Cherubino et al., 2019), these constructs are particularly relevant due to their direct applicability to marketing outcomes, such as advertising effectiveness, purchase intention, and consumer satisfaction. Thus, together they can offer a strong foundation for understanding key mechanisms that drive consumer behavior in both controlled experiments and real-world contexts.

However, this framework also raises important questions about *what has not been explored* using EEG in consumer behavior literature. While the identified constructs are central and cannot be avoided, they also mostly reflect individual-level cognitive and affective responses to stimuli, often in contexts that are too simple or decontextualized. Several additional domains, highly relevant to real-world consumer decision-making, can thus appear underrepresented or absent.

One of these areas is, for sure, the one regarding **social cognition**, which involves how individuals perceive, interpret, and respond to others. Constructs such as social comparison, conformity, trust, and empathy are based on more basic social cognition processes of mentalizing and theory of mind, and are fundamental in understanding how consumers perceive stimuli and make decisions in social environments, including peer influence, testimonial content, communication and advertising perception and liking, and social media dynamics (Chan et al., 2023; van Brussel et al., 2025). Despite their relevance, the limited attention these constructs have received in EEG-based consumer research is surprising, especially considering the recognition that consumption is often a socially embedded activity (e.g., Argo et al., 2005).

These gaps suggest that, although current EEG-based research has primarily focused on specific cognitive or affective processes, future work could greatly benefit from the integration of broader, more comprehensive models. This need is particularly evident given the increasing recognition that cognitive and emotional functions are not as distinct as once believed, especially at the neural level (Pessoa, 2008).

This implies that ***identifying (EEG) measurements which are exclusively linked to a single mental process is not only extremely challenging but also potentially misleading, given the inherently interconnected and overlapped nature of mental functions, both structurally and functionally. At the same time, this complexity highlights the importance of further clarifying all the facets of these processes, encouraging a more careful and sophisticated analysis rather than an oversimplified categorization of what happens in the consumer mind.***

3. How have these constructs been assessed via EEG?

Having identified the key consumer behavior processes examined through EEG in marketing research, this section outlines how each process has been operationalized and measured in the examined papers.

3.1 Attentional Processes

3.1.1 How are they measured?

Attentional mechanisms have been primarily measured using both ERPs and EEG spectral analyses. ERP studies have linked attention to increased amplitudes in specific components such as the Late Positive Potential (LPP) (Pozharliev et al., 2015; Wang et al., 2015), P3 (Pozharliev et al., 2015; Wang et al., 2015), P2 (Pozharliev et al., 2015), as well as heightened N2 (Wang et al., 2015).

Spectral approaches have identified attention-related effects through occipital alpha: decreased alpha power in occipital regions (e.g., Oz) (Venkatraman et al., 2015), and alpha wave desynchronization in the occipital cortex (Kolar et al., 2021). Lee et al. (2023) employed a different approach: Global Field Power (GFP) analysis within the delta band across frontal electrodes (Fp1, Fpz, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6) to capture attention-related neural activity.

3.1.2 Which sources do they refer to?

To justify the choice of EEG-based attention measures, the ERP studies draw primarily from foundational neurophysiological research. In Pozharliev et al. (2015), P2 has been associated with increased attentional processing or arousal responses in the context of attention (Amrhein et al., 2004; Olofsson et al., 2007), while P3 is linked to the work of Di Russo et al. (2006). As for the LPP component, it has been widely interpreted as a marker of sustained and voluntary attention toward emotionally or motivationally significant stimuli, referring to studies such as Cuthbert et al. (2000), Keil et al. (2002), and Lang and Bradley (2009). On the other hand, Wang et al. (2015) reference earlier neurophysiological work identifying ERP components of N2, P3, and LPP as relevant markers of attentional processing, especially when elicited by emotionally salient stimuli (Eason et al., 1969).

Regarding attention assessed through EEG spectral analysis, the considered studies emphasize the role of occipital alpha reduction or desynchronization as an indicator of increased visual attention, attentional control, and visual processing. Specifically, Venkatraman et al. (2015) reference neuroscientific studies such as Jensen and Mazaheri (2010) and Foxe and Snyder (2011), which discuss alpha modulation in relation to attention (note that these studies are not among the most foundational in the field as can be for example seen from the type of journals in which they were published, but they still offer useful theoretical grounding).

Kolar et al. (2021), in contrast, reference earlier work already in the marketing context, such as Rothschild et al. (1988), one of the first studies applying EEG in the consumer research field, linking alpha rhythms to attention, although the study itself focused more on memory encoding and hemispheric lateralization. Kolar also cites Klimesch et al. (2006), a key neuroscientific paper that explores how occipital alpha desynchronization relates not only to attention but also to cognitive processing, performance and memory – already suggesting how difficult it is to link one specific neural marker to only one specific mental process.

Finally, Lee et al. (2021) use global field power in the delta band at frontal electrodes. They refer to Knyazev (2012), which associates frontal delta with bottom-up attention and salience detection, as well as Guixeres et al. (2017), who observed this activity during the viewing of stimuli that were later remembered, linking it to a form of attention that supports subsequent memory encoding.

Thus, while specific ERP components appear to show relatively consistent associations with attentional processes, spectral analyses reveal two distinct patterns: occipital alpha desynchronization tends to reflect more top-down, sustained, and goal-directed attention, whereas

increased frontal delta activity seems to be linked to bottom-up, stimulus-driven attention and salience detection.

3.2 Affective and Approach Processes

3.2.1 How are they measured?

Affective and approach-related emotional processes are most consistently associated with frontal asymmetry. Specific studies have demonstrated this effect using electrode pairs such as F3–F4 (Lee et al., 2023; Venkatraman et al., 2015), supporting the notion that greater left frontal activation reflects approach motivation and positive affect (Kolar et al., 2021; Matukin et al., 2016; Boshoff, 2012). Some studies employ proprietary or automatic indices such as the Emotiv Epoc Index to infer affective responses, although in this case the precise computational details are not disclosed (Ciceri et al., 2020).

3.2.2 Which sources do they refer to?

In this group of studies on affective and motivational processes, most rely on the measurement of *prefrontal asymmetry*, drawing on foundational research such as Davidson et al. (1979), which first introduced the concept. This early work by Davidson primarily linked prefrontal asymmetry to emotional valence, distinguishing between positive and negative emotional states (Davidson, 1992b; Wheeler et al., 1993). Later studies, particularly those by Harmon-Jones and colleagues (Harmon-Jones, 2003; Harmon-Jones & Peterson, 2008; Harmon-Jones et al., 2010), expanded this framework interpreting prefrontal asymmetry as a marker of motivational tendencies: approach vs avoidance or withdrawal behaviors. This shift from emotional valence to motivational direction has shaped much of the subsequent research framework. Some studies have also applied this framework to more practical consumer neuroscience, for example, see Briesemeister et al. (2013), Ohme et al. (2010), and Read et al. (2019).

Venkatraman and colleagues (2015), for instance, focus specifically on the *prefrontal* and clearly interpret it within the framework of approach motivation, rather than emotional valence. They cite foundational neurophysiological and psychological work to support this interpretation, including Harmon-Jones et al. (2010), Davidson (2004), Sutton and Davidson (1997), and Harmon-Jones et al. (2006).

Lastly, Ciceri et al. (2020), using the Emotiv EPOC headset and its proprietary Affective Suite algorithm, extract an automatic “frustration index”, interpreted as reflecting an unpleasant emotional experience. In this case, the specific computational method for this index is not reported.

3.3 Workload Processes

3.3.1 How are they measured?

Cognitive workload has been investigated through several EEG-based metrics.

One approach is inter-subject synchronization within the alpha band, which reflects shared cognitive effort across individuals (Barnett & Cerf, 2017). Another commonly used metric is the Beta-to-(Alpha+Theta) Ratio (BATR), which has been shown to correlate with mental workload even though it is often also interpreted as a proxy for engagement (Clark et al., 2018).

3.3.2 Which sources do they refer to?

Regarding cognitive load and workload, Clark et al. (2018) refer to the applied EEG study by Berka et al. (2007), which investigated cognitive processes in pilots under varying task demands. In this research, increased cognitive load was associated with elevated frontal midline theta activity,

along with a concurrent reduction in alpha activity. Since this is already an applied EEG study, Berka et al. based their interpretation mainly on earlier cognitive EEG research by Gevins, Smith, and colleagues (1997, 1998, 2005), who had extensively explored how EEG activity reflects mental workload and task difficulty.

3.4 Decision-Making Processes

3.4.1 How are they measured?

Decision-making processes, product preference and choice in particular, have been examined using both ERP components and spectral features.

For instance, higher N200 amplitudes have been associated with product preference (Telpaz et al., 2015). Spectral analyses have identified several relevant – but still very different – markers, such as reduced theta activity at mid-frontal and parietal sites (Fz, Pz) (Telpaz et al., 2015), increased beta power at frontal and frontocentral sites (AFz, F2, FC1, FCz) (Boksem & Smidts, 2015), and frequency band differences in delta, theta, alpha activity (Hakim et al., 2021) and gamma (Boksem & Smidts, 2015), all linked to evaluative and choice-related processes.

3.4.2 Which sources do they refer to?

Among the studies investigating the relationship between stimulus preference and subsequent choice prediction using ERP measures, Telpaz et al. (2015) found that higher N200 amplitudes at fronto-central and parietal sites (Fz and Pz) were associated with product preference. They refer to neurophysiological studies by Patel and Azzam (2005) and Walsh and Anderson (2012), which link the N200 component to decision-making and choice behavior.

In terms of spectral EEG analysis, Telpaz et al. (2015) observed reduced theta power at Fz in response to preferred products and refer to earlier work showing that theta activity tends to increase in response to negative stimuli, such as unfavorable outcomes vs favorable ones (Cohen et al., 2007), or monetary losses vs gains (Gehring et al., 2011).

Boksem and Smidts (2015) reported increased beta activity over frontal and fronto-central electrodes in response to film trailers that participants rated as preferred. They relate this pattern to reward-related neural processes, drawing on high-quality neuroscientific studies (Cohen et al., 2007; Marco-Pallarés et al., 2008; Kawasaki & Yamaguchi, 2012), which link frontal beta activity to reward anticipation. On the other hand, higher gamma power over fronto-central and centro-parietal sites was found to predict U.S. box office outcomes (out-of-sample prediction of population-level preferences). In this case, the authors refer to foundational consumer neuroscience works and associate gamma with the activity of brain regions involved in preference formation and choice behavior (Berns & Moore, 2011; Falk et al., 2012). More generally, the authors also argue that gamma power has been linked to a variety of cognitive functions (attention, memory encoding, recognition, evaluation, and learning), which can support the idea that it reflects a heightened level of engagement with stimuli that ultimately drives its preference.

Finally, the study by Hakim et al. (2021) found that frontal delta, theta, and alpha activity – as well as hemispheric asymmetry in the delta and theta bands – were associated with product preference. However, the authors do not provide a clear explanation for these findings or offer a detailed neuroscientific rationale linking these specific EEG patterns to underlying cognitive or emotional processes. They justify their methodological approach by referencing prior consumer neuroscience studies that have employed similar prediction-based approaches.

3.5 Engagement Processes

3.5.1 How are they measured?

Neural engagement has often been measured using indices that overlap with workload measures. Inter-subject correlation (ISC) in the alpha band has been interpreted as a marker of shared attentional focus and engagement (Barnett & Cerf, 2017). Similarly, the BATR index (Beta on Alpha plus Theta Ratio) (Clark et al., 2018) has been used to quantify engagement in a manner closely aligned with cognitive load. Additionally, some studies utilize commercial or automatic metrics such as the Emotiv EPOC Index to infer consumers' engagement levels, but without disclosing detailed computational methods (Kristofferson & Dunn, 2022).

3.5.2 Which sources do they refer to?

Barnett and Cerf use (ISC) in the alpha band, drawing on Klimesch (2012) for the role of alpha oscillations in attention and cognition, and on Dmochowski et al. (2014) for the application of ISC as a neural measure of audience engagement. In contrast, Clark and colleagues (2018) rely on the engagement index proposed by Berka et al. (2007), which is calculated as the ratio of beta activity to the sum of alpha and theta activity. According to the authors, this index was originally developed by Prinzel and colleagues at NASA Langley and Old Dominion University (Prinzel et al., 2000; 2003), based on the earlier work of, for example Gevins et al. (1997), and has since been used in applied settings. However, this metric has faced some criticism and it was initially designed for ergonomics and aviation performance monitoring. As such, it may require careful adaptation when applied to consumer research.

Finally, Kristofferson and Dunn (2022) also use the Emotiv EPOC headset to extract the engagement EEG measure, so they do not provide specific details on the computational methods employed.

4. Discussion

The systematic review and analysis carried out in this first thesis Chapter highlight the potential of EEG in consumer behavior research, while identifying its current limitations, particularly on the "academic side".

While EEG has seen a significant increase in applications for investigating fundamental psychological processes such as attention, emotion, cognitive load, decision-making, and engagement, its presence in leading marketing and management journals remains marginal. A limited number of empirical contributions have been published in these highest-ranked outlets, suggesting that ***despite the tool's potential, EEG-based research still struggles to gain visibility and legitimacy in the "mainstream" marketing discipline.***

One potential explanation for this could lie in the multidisciplinary nature of Consumer Neuroscience and Neuromarketing. Many EEG-based studies remain deeply rooted in neuroscientific terminology and methods, which may appear overly technical and insufficiently connected to marketing theory. On the other hand, when translated into marketing contexts, EEG findings are sometimes presented without a strong theoretical or practical contribution, reducing their perceived value for advancing consumer behavior models. This imbalance creates the impression of research that is either "too neuro" for marketing journals or "too applied" or even "too consumerist" for psychology and neuroscience outlets. This *misalignment of disciplinary frameworks* creates structural barriers to publication, which hinders the fast recognition of consumer neuroscience as a credible

and impactful field of research. Moreover, researchers in marketing frequently lack interdisciplinary expertise, which can result in improper interpretation or “black box” use of EEG and other consumer neuroscience tools (Bigne et al., 2025). As a result, the body of work is fragmented, which could make people question the legitimacy of the discipline.

Furthermore, our review shows a clear ***incongruity in the methods by which EEG constructs are measured and reported*** in marketing research contexts. Indeed, often, across different papers, identical processes are assessed using different frequency bands, electrode sites, or ERP components. But this practice causes inconsistencies that make it harder to compare studies and draw conclusions. Moreover, not having standards makes it more difficult to build collective knowledge to define the research field. In fact, this lack of standardized protocols, which makes cross-study comparisons difficult, along with persistent challenges related to physiological noise and artifacts in signal interpretation, is still highlighted even in the most recent reviews (Bigne et al., 2025).

Additional limitations include small sample sizes, individual variability, and restricted generalizability, as the need for strongly controlled experimental settings can undermine ecological validity by reducing the extent to which findings reflect real-world consumer behavior contexts. The complexity of neurophysiological data complicates causal inference further, and there is still a risk of overinterpretation or of the “neuroscientific hype.” Finally, ethical concerns related to privacy, informed consent, and potential consumer manipulation persist.

To make progress in the Consumer Neuroscience research domain, it is thus essential to ***establish guidelines that clearly delineate the methodology*** for measuring psychological phenomena related to consumer behavior using EEG. *Standardizing* our methods will make it more feasible to replicate our results and enhance the field’s credibility among the academic community.

It’s also important to acknowledge the significant yet largely unexplored domains. The majority of extant EEG-based studies have focused on individual-level cognitive and affective responses to marketing stimuli, while ***socially grounded processes such as empathy, trust, conformity, mentalizing, and theory of mind are still largely absent***. This gap calls for further research on these domains, as consumption is rarely an individual act but it is rather embedded in strong social contexts. Integrating such social cognition processes into the consumer neuroscience set of measures would broaden the scope of investigation and provide a more realistic account of our everyday decision-making contexts.

Finally, although the present Chapter has focused on EEG, ***these broader implications can surely be extended to other neuroscientific methods applied to consumer research***: fMRI, fNIRS, GSR, and HR, among others. As with EEG, research employing these tools would benefit from increased systematicity and construct-based frameworks that clarify how consumer processes can be reliably studied across different modalities. It is only through the pursuit of such integration that the fields of consumer neuroscience and neuromarketing can provide a contribution to marketing science that is not only more coherent and theoretically grounded, but that can also be more easily translated to business practice.

4.1. Future Directions

Based on the emerged and discussed findings, I think that future research in this area should move in two *main* directions.

On the one hand, we should ***strengthen the “academic legitimacy” of consumer neuroscience EEG studies by 1) aligning them more closely with established marketing theories***

and 2) adopting greater methodological standardization. As for now, similar – if not identical – processes are often measured with different bands, electrodes, or ERP components, which makes it difficult to compare findings across studies and to build EEG-based consumer behavior knowledge. Establishing clearer guidelines would allow scholars to replicate results more reliably and to integrate individual contributions into a coherent body of evidence.

On the other hand, the scope of research should be expanded beyond the cognitive and affective processes most frequently investigated to include those domains that remain underexplored but are central to everyday consumption, such as **social cognition**. Processes like empathy, perspective-taking, or mentalizing play a core role in how consumers make decisions in strongly social contexts, yet they are almost absent from the current EEG literature.

Of course, it is important to note that what is highlighted here are simply those two main directions that I personally consider most central and that I aim to address in this doctoral work. However, they are merely two among many possible paths, which leaves *considerable* room for further investigation and development in the field.

Addressing these gaps requires not only empirical studies but also **systematic reviews of the general neuroscientific literature**, to clarify how such processes have been measured in their “original” field and how those methods can be adapted to marketing research. Such reviews would be important to examine, for example, how the clusters identified in this first Chapter (Attentional Processes, Affective and Approach Processes, Workload Processes, Decision-Making Processes, and Engagement Processes) have been originally conceptualized and measured in their primary disciplinary context (cognitive and affective neuroscience), particularly in leading neuroscience journals (e.g., Q1 ones). The same applies to other domains that emerged as relevant yet largely absent from the current consumer behavior-oriented EEG literature, such as social cognition processes. By systematically mapping the investigation of these processes in neuroscience, we can clarify which neural measures and paradigms are most robust, to finally define the most appropriate metrics for capturing them through EEG in a more grounded and rigorous way for consumer research.

I personally consider this specific work to be central if consumer neuroscience is to progress toward a more mature discipline. Only **through systematic, standardized, and construct-based approaches across different methods**, our field will be able to offer contributions that are theoretically solid, empirically robust, and at the same time relevant for applied marketing practice.

4.2. Conclusions

The analysis and the resulting insights presented in this first thesis Chapter define the potential of EEG research in consumer studies and identify its current limitations. EEG can offer significant opportunities to investigate processes such as attention, emotion, cognitive load, decision-making, and engagement, as it provides implicit measures that reach beyond traditional self-report methods (Sung et al., 2020). However, its visibility in top marketing and management journals remains limited, and the lack of methodological standardization still restricts the power of the academic evidence produced to date. All of these issues contribute to a fragmented body of research that puts at risk the credibility of consumer neuroscience as a field.

At the same time, this review has demonstrated that significant areas of consumer behavior have yet to be thoroughly explored. For example, social cognition processes, which are central to real-world consumption embedded in social contexts, are absent from EEG-based marketing studies.

Addressing this gap is both theoretically and practically necessary for making consumer neuroscience more relevant for understanding everyday consumer behavior. Systematic reviews of the broader neuroscientific literature will be fundamental in this regard, as they can clarify how such processes have been operationalized and measured in their core domains and provide guidance on adapting and applying these measures to marketing research.

All these reflections suggest that the future of consumer neuroscience will depend on two complementary efforts: the consolidation of methodological rigor through shared guidelines and construct-based frameworks, and the expansion of research focus to include socially grounded measures within ecologically valid contexts.

This first Chapter has mapped the current state of EEG research in consumer behavior, highlighting both its contributions and its limitations, and setting the stage for a more systematic and socially grounded approach that will be further developed in the following Chapters.

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CHAPTER 2

What's the role of Mentalizing in Consumer Neuroscience research?

"Human beings are social information processors before they are processors of facts, figures, and logical arguments"
(Slater & Rouner, 2002, p. 179)

1. Introduction

A Forbes article from the early 2000s (Wells, 2003) affirmed that *"brain waves do not lie"*. *Is it true?* We cannot be sure. What we are sure of is that, in recent years, the analysis of these brain waves has become one of the main methods for exploring the cognitive and emotional processes influencing consumer responses to marketing stimuli, providing new insights into consumer behavior that could not be captured by traditional marketing methods.

As previously discussed in Chapter 1, the analysis of these brain waves through EEG plays a central role in understanding consumer responses. When combined with other advanced neuroscientific techniques, such as functional magnetic resonance imaging (fMRI), heart rate monitoring, skin conductance measurements, eye-tracking, and implicit response measures, EEG creates the basis for the emerging interdisciplinary research fields of Consumer Neuroscience and Neuromarketing (Harris et al., 2018), where the integration of physiological and psychological methods offers a comprehensive approach to studying consumer behavior (Hubert & Kenning, 2008; Plassmann et al., 2015), complementing rather than replacing traditional approaches (Solnais et al., 2013).

Although the first studies in the field date back to the late 1990s, it is only since the early 2000s, and especially since 2015, that the discipline has experienced a rapid expansion (Casado-Aranda et al., 2023). Building on early frameworks highlighting the neural and emotional components of our decisions (Bechara et al., 2000), consumer neuroscience research has significantly contributed to our understanding of consumer responses to various stimuli, such as advertisements (Venkatraman et al., 2015; Russo et al., 2023), websites, packaging, and media content (Bilucaglia et al., 2024) – even in the area of the intangible, such as social communication (Zito et al., 2021) – and across diverse settings, including laboratories (Casiraghi et al., 2025), physical stores (Balconi et al., 2021), virtual environments (Bigne et al., 2024), and the metaverse (Fici et al., 2024).

Despite these advances, consumer neuroscience remains a **young and niche discipline with several conceptual aspects, methods, and metrics that require further clarification and development** (Ramsøy, 2019). Moreover, very recent reviews emphasize persistent limitations, such as the lack of standardized protocols that hinders cross-study comparability, the sensitivity of neurophysiological data to noise and artefacts, high costs and technical requirements that limit the use of certain methods (e.g., fMRI), as well as the trade-offs in spatial and temporal resolution associated with more accessible tools such as EEG or eye-tracking (Bigne et al., 2025). In particular, EEG data, thanks to its ability to decode consumers' responses with high temporal precision, should

be further used to establish additional metrics of consumers' cognitions and emotions in response to marketing stimuli (Kolar et al., 2021).

EEG can indeed provide a range of metrics to explore key consumer behavior processes. These include the attention paid to a marketing stimulus (e.g., Lee et al., 2023), product and brand associations (e.g., Camarrone & Van Hulle, 2019), the level of engagement generated (e.g., Kang et al., 2015), the memorability of the stimulus (e.g., Shestyuk et al., 2019), the emotions it evokes (e.g., Vecchiato et al., 2014), and the risk of cognitive overload it may cause (e.g., Clark et al., 2018). While there is still no consensus on which EEG measures and practical computation are best suited for assessing each one of these processes, as presented and analyzed in Chapter 1, numerous studies have demonstrated the effectiveness of EEG in assessing them.

However, rather than just focusing on what EEG has already measured, it is equally important to also explore those consumer behavior processes that remain underexplored but hold significant potential for enhancing our understanding of consumer decision-making. As highlighted in the systematic review conducted and presented in Chapter 1, one such process is **mentalizing**, i.e., the ability to infer the intentions and emotions of others. This cognitive ability appears to play a central role in various contexts, such as influencing advertising perception, particularly their liking (Chan et al., 2023), and their persuasion mechanisms (Van Brussel et al., 2015). Despite its relevance, mentalizing has not yet been thoroughly investigated within the domain of consumer neuroscience, presenting an opportunity for further exploration.

This second Chapter will thus be dedicated to an in-depth examination of the concept of mentalizing. It begins by thoroughly defining the construct, followed by a detailed discussion of the tools available to measure it, with a specific focus on the consumer neuroscience ones. The chapter then explores the role of mentalizing within the context of consumer behavior research, with a specific focus on consumer neuroscience research, highlighting its relevance and potential impact. The chapter aims to emphasize the need for further social cognition research in consumer neuroscience, laying a foundation for the subsequent analysis presented in the third and final Chapter of this doctoral dissertation.

2. Mentalizing: definitions and theoretical foundations

Mentalizing, perspective-taking, and Theory of Mind (ToM) are all terms frequently used interchangeably in the literature, as they all refer to our general capacity to infer and reason about the mental and emotional states of others (Frith & Frith, 2005). These concepts are central to *social cognition*, a broad category encompassing the fundamental cognitive processes that support interpersonal interactions within a species (Blume, 2015). However, very recently, significant efforts have been made to define and, more importantly, distinguish these terms as much as possible (Quesque et al., 2024), a shift that has also been driven, in part, by the growing recognition of the importance of such processes in our daily lives and across a range of academic fields.

This work will specifically focus on the concept of mentalizing. What exactly do we mean by mentalizing, and how does it differ from other closely related concepts?

Although sometimes - especially in the past - "negatively" misdescribed as "mind reading" (Quesque et al., 2024), mentalizing actually refers to a high-level cognitive process, which differs from *basic factual reasoning*, a low-level action understanding (van Overwalle, 2011) limited to assessing others' actions without involving social or mental state inferences (e.g., "This person is using this product"). It also goes beyond simply attributing intentions, thoughts, and beliefs, and involves

understanding and responding to another person's mental state beyond the mere observation of his/her behavior, thus actively "reading" his/her mind (Abell et al., 2000) (e.g., "This person thinks it is a good idea to use this product because it can be useful to pursue this action and he's happy about it"). Mentalizing is also distinct from more simplistic reasoning on other's actions even at the neural level: when the task requires mentalizing, we see higher activation in the medial prefrontal cortex (mPFC), an area that is inherently involved in higher-level social cognitive and affective processing (Lieberman et al., 2019), whereas more basic reasoning does not activate the mPFC (van Overwalle, 2011).

Mentalizing should also be distinguished from *empathy*, a more complex process that involves sharing and embodying others' affective states (Singer, 2006). While mentalizing refers to the understanding of other's thoughts, intentions, and emotions, empathy is strictly related to the affective component and reflects the ability to resonate with the other person's emotional state, actively experiencing it, and feel compassion (e.g., "This person is sad because he/she is not satisfied with this product, and I feel sad too"; Kanske et al., 2015; Quesque et al., 2024). Although similar, mentalizing and empathy processes also involve different neural networks: the anterior insula and dorsal temporoparietal junction are most involved in empathy, whereas the ventral temporoparietal junction is specific to mentalizing (Kanske et al., 2015). On the other side, studies show that predicting another's future emotional response engages both mentalizing and empathy regions, including the superior temporal sulcus, medial prefrontal cortex, temporal poles, inferior frontal gyrus (IFG), somatosensory cortices, and thalamus, with greater activation in emotion-related regions (e.g., right somatosensory cortex and bilateral thalamus) correlating with higher self-reported empathy (Hooker et al., 2008).

Finally, it is important to distinguish mentalizing from two last concepts that are related but distinct under several points of view: ToM and perspective-taking. *ToM* specifically involves the use of folk psychological knowledge and heuristics to interpret and attribute mental states, reflecting a specific and socially constructed approach to mentalizing. On the other hand, *perspective-taking* is more closely related to the ability to represent another individual's mental state by specifically adopting their perspective and point of view (Quesque et al., 2024).

Another reason for the scarce empirical study of mentalizing could be its consideration under broad labels such as *cognitive or emotional processing*. These categories, though widely used in consumer neuroscience, collapse distinct mechanisms and "support" too reductive accounts of consumer cognition. Mentalizing provides greater conceptual precision, and even if at the neural level these processes overlap and cannot be completely and clearly isolated, this complexity demonstrates the importance of clear conceptual boundaries, which support more accurate interpretations of consumer cognitive functions.

3. Mentalizing: how does it work?

Humans are fundamentally social information processors (Slater & Rouner, 2002), equipped with a sophisticated ability to mentalize, a cognitive capacity crucial for developing social skills and fostering interpersonal relationships (We et al., 2022). However, in practical terms, how do we engage in mentalizing during our everyday interactions?

Achim and colleagues (2013) propose that mentalizing relies on eight principal sources of information. First, it needs an understanding of the individual whose mental state is being inferred, as well as the contextual elements surrounding that individual, including both social and physical factors. These informational inputs may then be derived from immediate perception or stored knowledge and can be acquired through verbal communication or non-verbal perceptual cues. The

integration of all these diverse sources is fundamental to mentalizing, making it a highly cognitively demanding mental process compared to other ones (Achim et al., 2013).

4. Mentalizing relevance in consumer research

But now you may ask, what does mentalizing have to do with consumer behavior? Investigating whether a marketing or communication stimulus, such as an advertisement, can prompt consumers to engage in mentalizing processes – i.e., encouraging them to reflect on the mental states and emotions of individuals shown as interacting with one another or with products, brands, and services, rather than merely perceiving the action or the interaction itself – can yield useful insights into the effectiveness of the advertising strategies. Such an understanding can help explore another one among the cognitive and emotional mechanisms that drive consumer responses.

Imagine you are observing an individual, either in real life or within an advertisement, interacting with another person, engaging with a product, or using a service. This observation can occur on two distinct cognitive levels. On a basic, low-level processing level, you might simply register the interaction as a factual event. Alternatively, on a higher-level processing, you can engage in mentalizing processes, fully and deeply understanding the individual's mental state, emotions, and intentions related to the interaction (**Figure 2.1**).

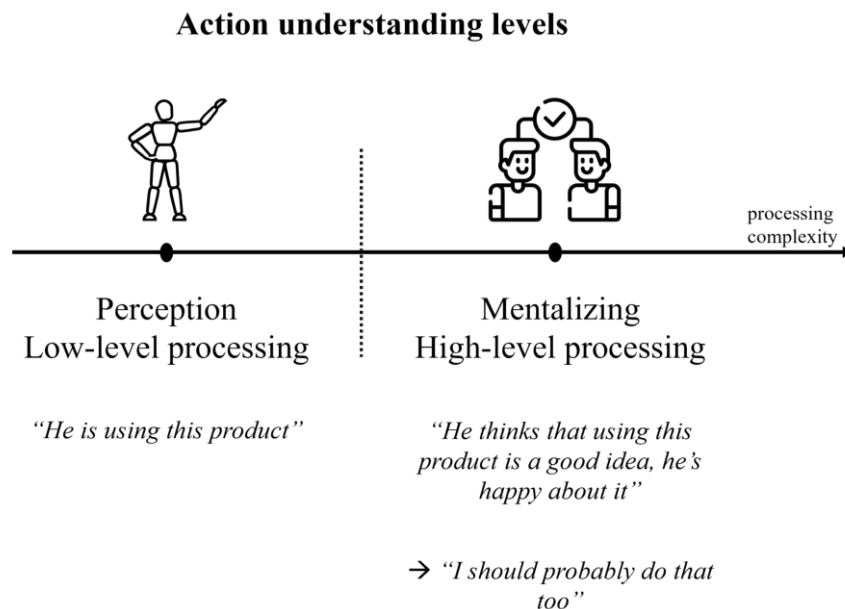


Figure 2.1. Human interactions can be processed on two main levels, distinguished by the depth and complexity involved. The first (low-level processing), is simpler in nature and primarily factual and descriptive. The second (high-level processing), involves a deeper understanding of the thoughts and emotions of the individuals engaged in the interaction, engaging in mentalizing processes.

But what’s the difference between these two levels of processing?

The distinction between these two processing levels **is not simply a deeper perception, but the recruitment of social-cognition processing**, which builds representations of others’ mental states and, in turn, can alter affective responses, attitudes, and choices. Moreover, observing someone using a service or purchasing a product can trigger similar behaviors in the observer,

influenced by social psychological phenomena such as observational learning (Bandura, 1977), social comparison theory (Festinger, 1954), social proof, and popularity bias (Powell et al., 2017).

For instance, understanding another person's mental states and adopting his/her perspective can increase the likelihood of adopting their attitudes too (De Graaf et al., 2012). This can hold significant implications for understanding and predicting consumer behavior: for example, if I observe a character happily using a specific perfume to feel more attractive, I may be more inclined to believe that the same perfume could make me feel attractive as well. Moreover, engaging in higher levels of cognitive and emotional processing, such as mentalizing, can enhance the observer's engagement with the presented content. This deeper processing is associated with improved memory retention and a stronger overall impact of the experience (Tyng et al., 2017).

Mentalizing with another individual thus seems to play a significant role in shaping attitudes and behaviors. In the context of marketing-relevant communications and interactions, this process can be hypothesized to not only influence individual responses and decision-making processes (Polezzi et al., 2008) but also enhance the overall impact of the observed interaction, increasing its effectiveness and reaching a wider audience.

Building on the principles of social cognition, it can thus be hypothesized that marketing relevant stimuli capable of eliciting mentalizing processes – so engaging with the mental states of others – rather than the mere observation, may exert a major influence on the consumer's decision-making process. Such stimuli could have the potential to enhance the effectiveness of communication strategies, particularly in contexts where purchase decisions occur within social environments. In these settings, consumers' choices may be significantly influenced by the presence of others and their behaviors, emotional states, and intentions.

Given its potential to enhance engagement and influence consumer decision-making, the assessment of mentalizing presents important opportunities across multiple domains of consumer behavior research. These applications span across different areas, for example, they can be related to – but not only – the optimization of advertising strategies and communication approaches, such as selling techniques, and to the improvement of the design of user interfaces to enhance usability.

Table 2.1 provides an overview and some examples of the areas of application where the assessment of mentalizing can provide meaningful and practical insights.

5. Assessing mentalizing: from traditional approaches...

If mentalizing plays a central role in shaping consumer responses to marketing stimuli, the next step is to identify *how* it can be reliably measured in consumer research.

Various paradigms have indeed been employed to evaluate mentalizing abilities, with researchers often relying on picture-based or video-based tasks. Picture-based tasks typically require participants to assess what a character, presented through a picture, can see (e.g., Samson et al., 2010; Conway et al., 2017; Samuel et al., 2020) or to infer mental states only from a character's eyes (e.g., Baron-Cohen et al., 2001).

Video-based tasks, on the other hand, range from animations depicting another character's perspective (e.g., Nijhof et al., 2016) to scenarios involving simple geometric shapes designed to elicit mental state attributions, such as the "famous" animated triangles (e.g., Abell et al., 2000; Castelli et al., 2000; Livingston et al., 2021). Other video-based tasks adopt a more realistic approach by

featuring human actors (e.g., Roeyers et al., 2001; Dziobek et al., 2006) or clips from movies and television shows (e.g., Heavey et al., 2000; Golan et al., 2006).

In addition to these tasks, several scales and questionnaires have been developed to measure mentalizing abilities (e.g., Dimitrijević et al., 2017; Hausberg et al., 2012; Gori et al., 2021; Wu et al., 2022; Stefana et al., 2024).

Application	Contribution description	Example
Advertising Optimization	Creating effective advertising campaigns by accurately assessing how consumers process, interpret and respond to the ad message.	An advertising company tests its new ad, which shows a character interacting with a product or using a service, to examine whether it elicits viewers' mentalizing processes about the character's thoughts and emotions.
Product development, UX, Ergonomics	Improving product interaction and the development of user-friendly interfaces.	A design company tests whether a new product or interface elicits mentalizing to determine if it makes users understand the intended modes and purposes of interaction, as an additional measure of its usability.
Selling strategies	Defining effective communication strategies that are able to build trust, engagement, and mutual alignment in selling contexts.	A communication company investigates whether a selling strategy effectively encourages the recipient to mentalize with the other party - the seller, influencer, or other stakeholders involved in the interaction.

Table 2.1: Key applications of mentalizing in consumer behavior research, with practical examples and recommended measurement techniques.

While all these methods have proven effective, they are predominantly applied in clinical settings given the central role that mentalizing processes play in many psychopathological conditions (e.g., Luyten et al., 2020), particularly for disorders characterized by social impairments, such as autism spectrum disorder (ASD; e.g., Lombardo et al., 2011), borderline personality disorder (BPD; e.g., Dimaggio & Lysaker, 2015), depression (e.g., Fischer-Kern et al., 2013; Belvederi Murri et al., 2016), anxiety (e.g., Chevalier et al., 2023), eating disorders (e.g., Simonsen et al., 2020), or schizophrenia (e.g., White et al., 2009). They are also frequently applied in the context of neurodegenerative diseases, including Parkinson's disease and multiple sclerosis (Adenzato & Poletti, 2013). This can be due to the growing recognition of mentalizing's importance, which has spurred rapid expansion primarily in its clinically relevant research (Cosenza et al., 2024).

However, investigations of mentalizing in non-clinical populations remain comparatively limited. Indeed, recent electrocorticographic² evidence has shown that naturalistic social interactions

² Electrocorticography (ECoG) is a neurophysiological technique that records brain activity directly from the cortical surface using electrodes placed beneath the skull. Compared to traditional EEG, which captures signals from the scalp, ECoG provides much higher spatial resolution and signal quality, but it is invasive and therefore

elicit dynamic synchronization across core mentalizing regions even in neurotypical adults, highlighting the importance of moving beyond traditional clinical paradigms (Tan et al., 2022).

6. ... to neuroscientific ones: why EEG?

The study of mentalizing has increasingly benefited from *neuroscientific approaches*, which are particularly useful given the inherent complexity of the process. Traditional assessments developed in the clinical psychology field are not only limited in their applicability to consumer samples outside clinical settings, but also insufficient to fully capture this multidimensional process (Achim et al., 2013). In contrast, neuroscientific measures, due to their implicit nature, can provide a more detailed and objective assessment, allowing researchers to explore mentalizing more comprehensively and accurately.

For example, the meta-analyses conducted on fMRI studies identified a network of brain regions integral to mentalizing: the temporoparietal junction (TPJ), precuneus, anterior temporal lobe, ventromedial prefrontal cortex (vmPFC), and IFG (Schurz et al., 2014; Monticelli et al., 2021) – a series of areas that demonstrate increased synchronization as mentalizing demands intensify (Wang et al., 2021). Structurally, this network is organized into two primary subsystems: one dedicated to reasoning about one's own mental states and another focused on understanding the mental states of others (Wang et al., 2021).

Moreover, another meta-analysis by Fehlbaum and colleagues (2022) showed that the neural basis of mentalizing develops gradually across age groups. In adults, robust activation is observed in the medial prefrontal cortex, the middle and inferior frontal cortices, the precuneus, the TPJ, and the middle temporal gyri. These regions also appear to be functionally connected to parietal and subcortical structures, such as the thalamus and the striatum. On the other hand, children and adolescents engage similar but fewer regions within this network: younger children consistently activate the medial prefrontal cortex, precuneus, and right TPJ, while adolescents also activate the left TPJ and the middle and inferior temporal cortices (Fehlbaum et al., 2022).

Another interesting work was carried out by Yordanova et al (2019), which combined resting-state fMRI with intraoperative cortical stimulation to map the face-based mentalizing network. Stimulation sites in the right dorsolateral prefrontal cortex and IFG showed functional coupling with a broader network including prefrontal, temporoparietal, and posterior temporal regions.

Although **fMRI dominates the research field on the neural bases of mentalizing**, EEG has also been used to explore it, although less extensively (Rochas et al., 2023). EEG studies on this topic indeed present a complex and sometimes inconsistent picture.

For example, theta band activity has been observed to increase with the complexity of social interaction processing (Blume et al., 2015), while shifts in activation from posterior visual regions to frontal areas occur during mentalizing tasks (Rochas et al., 2023). Resting-state parietal theta activity has also been associated with mentalizing ability (Yun et al., 2021). Beyond specific frequency bands, Zhang et al. (2025) identified the frontal area as a key intermediary hub between the mirror and mentalizing systems, supporting both the maintenance and supervision of perceptual information for mirror matching and the control of mentalizing processes involved in decoding others' action

primarily applied in clinical contexts, such as neurosurgical procedures for epilepsy (Parvizi & Kastner, 2018), but not in consumer research settings.

intentions. Other findings include left-lateralized μ suppression³ in the 8–10 Hz range, highlighting a general relationship with the mirroring system (Cole et al., 2018; Hyder et al., 2024) and elevated theta-to-alpha activity ratios in parietal regions (Imperatori et al., 2017). Additionally, beta oscillations in the temporoparietal region (Soto-Icaza, 2019) and gamma activity in the posterior superior temporal sulcus (pSTS) (Cohen et al., 2008) have been linked to mentalizing.

Other studies have employed ERPs, showing, for example, that mentalizing processes occur in two stages: an early N170 reflecting rapid mind detection, and a later P300 indicating more complex mind attribution (Ruzzante & Vaes, 2021).

But also in this case, an extensive body of EEG studies investigating mentalizing processes focuses on clinical populations. For example, Yun et al. (2024) demonstrated that individuals with BPD – a condition characterized by impaired mentalizing abilities – exhibit a significant reduction in overall alpha band activity. This limit becomes particularly problematic considering that, among neuroscientific methods, EEG emerges as a particularly promising approach for measuring mentalizing. Its *high temporal resolution, portability, and relative ease of implementation* make it especially suitable for investigating consumer responses to dynamic and time-sensitive marketing stimuli such as video advertisements across a variety of real-world contexts (McInnes et al., 2022). These qualities make ***EEG particularly well-suited for further exploration aimed at establishing additional metrics of consumer responses*** (Kolar et al., 2021). Moreover, EEG is significantly more cost-effective than other neuroscientific techniques, and all these practical advantages explain why it is more commonly adopted in both academic research and applied market studies, where more complex and expensive tools are often unfeasible.

For example, although fMRI can be useful for mapping the neural bases of mentalizing and provides high spatial resolution for identifying the specific brain regions involved (e.g., Açıl et al., 2025), it is, in contrast, more costly, immobile, and unsuitable for investigating consumer responses in ecologically valid, real-world scenarios. Moreover, eye-tracking, which is the most frequently used consumer neuroscience tool in practice (Casado-Aranda et al., 2023) and has proven effective beyond simple visual attention assessment, does not provide direct access to complex cognitive processes such as mentalizing. Other techniques, such as functional near-infrared spectroscopy (fNIRS), are less expensive, portable, and tolerant to motion, but limited by spatial resolution and related interpretative challenges (Casado-Aranda et al., 2023). Similarly, physiological measures of galvanic skin response and heart rate variability can be useful for tracking consumers' affective valence and arousal (e.g., Fici et al., 2024), yet they lack the specificity to isolate the cognitive, inferential, and highly multidimensional features of mentalizing.

EEG, therefore, proves to be the most appropriate method for assessing mentalizing in consumer research, offering an optimal balance between precise assessment and practical implementation in real-world market research, particularly when paired with robust, ecologically valid consumer research paradigms.

³ Mu rhythm suppression, a reduction in brain oscillations registered at 8-13 Hz in the sensorimotor cortex, reflects the brain's response to observing or imagining actions, allowing us to "mirror" others. It has been widely linked to the mirror neuron system, another key network that constitutes the neural basis of social cognition (Hobson & Bishop, 2017).

7. Discussion

In this second Chapter, mentalizing was proposed as *a core yet overlooked component* in the study of consumer behavior. Drawing from research in social, cognitive, affective psychology and neuroscience, it discussed that the ability to infer others' mental states – both cognitions and emotions – plays a significant role in shaping how consumers interpret, engage with, and respond to marketing and communication messages. This process becomes particularly relevant in contexts where other people are present, such as advertising that depicts people's interactions, influencer marketing, or in-store sales dynamics.

Despite its theoretical relevance, mentalizing remains largely under-investigated in marketing science. One likely reason is the difficulty in measuring such a complex, multidimensional process in an ecologically valid way. Traditional tools developed in clinical psychology offer only partial insights and are often unsuited to consumer research settings. This is where neuroscience methods, and in particular EEG, for its inherent and practical advantages, may offer added value. In any case, both the other neuroscientific tools and traditional methods should not be seen in opposition. A multimethod approach, combining EEG with other measures, could offer a more complete picture, capturing both the “what” (e.g., product liking) and the “why” (e.g., mentalizing) of consumer responses.

7.1 Conclusion and Future Directions

This second Chapter highlights the relevance of mentalizing as an essential social cognitive process in consumer behavior. Despite its importance, it remains underexplored in marketing research, particularly within the context of consumer neuroscience. EEG represents a promising method for assessing mentalizing due to its portability, affordability, and capacity for real-time measurement. All these advantages can also contribute to its widespread use in industry, facilitating the transfer of theoretical insights from academic research to practical applications in market research studies.

Future research could and thus should aim to adapt established mentalizing tasks (e.g., Abell et al., 2000) for EEG use, validate them in non-clinical populations, with different groups of consumers, and test their predictive power in marketing-relevant contexts. In any case, a multimethod approach, combining EEG with other neuroscientific tools (especially the ones most adopted also in industry practices) as well as behavioral and self-report data, may enhance the robustness of measurement. Practical applications for this EEG-based mentalizing measure could include the optimization of communications and advertisements, product design improvement, and tailoring sales strategies to better engage consumers. ***Integrating mentalizing into the “set” of consumer neuroscience measures holds strong potential for our understanding of how consumers interpret, feel, and decide, particularly within socially complex and interactive contexts.***

To this end, the following chapter (Chapter 3) will focus on theoretical research advancement, specifically designing an experimental study aimed at developing an EEG-based measure capable of capturing consumers' mentalizing processes. It will also address the practical applications of this EEG-based measure within a marketing context, specifically by evaluating its utility in assessing the effectiveness of advertising campaigns. I truly hope that the experimental findings of this research will not only advance academic knowledge but also prove valuable for everyday market research practices.

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CHAPTER 3

EEG Correlates of Mentalizing in Consumer Responses to Advertising

*"We organize our experience and our memory of human happenings
mainly in the form of narrative"
(Bruner, 1992)*

After reviewing EEG-based metrics in consumer neuroscience and highlighting the need for a better understanding of social cognition processes, such as mentalizing (Chapter 1), and defining mentalizing while establishing its theoretical and practical relevance (Chapter 2), this third Chapter moves to the empirical level. Here, I present the experimental work conducted to develop and test an EEG-based metric for mentalizing and to place it within a model applied to advertising research.

1. Introduction

Understanding how consumers perceive and process communication messages is a central aim of consumer neuroscience. While most of the literature has focused on attention, memory, and emotional responses, less is known about the higher-order cognitive mechanisms that allow consumers to interpret and connect with communication content. Among these, mentalizing has recently been proposed as a key process in shaping consumer responses but, despite its potential relevance, it has not yet received considerable attention in consumer research, and the few existing investigations remain very fragmented and limited, particularly those employing EEG.

Among the different domains in which consumer mentalizing can be examined through neuroscientific methods, such as EEG, **advertising** - and particularly video advertising - represents one of the most extensively studied applications within consumer neuroscience (Bazzani et al., 2020; Wang et al., 2024). Indeed, the high temporal resolution of EEG makes it particularly well-suited to capturing consumers' responses to dynamic stimuli of video advertising. It allows precise tracking of brain activity throughout the ad visualization, enabling the optimization of advertising content by identifying or editing scenes that elicit weaker engagement (van Diepen et al., 2024).

Moreover, advertising represents one of the most "pervasive" and ecologically valid forms of mediated communication, as consumers are exposed to dozens of ads daily across both digital (e.g., social media, online video channels) and traditional (e.g., TV) media, while also being at a great spot of interest for its constant transformation, with recent years marked by rapid changes in formats, platforms, and modes of consumption (Dahlen & Rosengren, 2016). At the same time, it has a highly relevant "applied side": understanding how mechanisms such as mentalizing shape consumer responses has implications not only for advancing consumer neuroscience theory but also for practical applications in applied market research.

Starting from these premises, this third Chapter examines how mentalizing processes are involved in advertising perception, particularly in the way consumers engage with the narrative dimension of ads, and how these processes contribute to advertising effectiveness. While the first objective remains to identify the EEG correlates of mentalizing (drawing on one of the tasks

introduced in Chapter 2), it also aims at putting this new measure into a broader and more practical model. So, it uses both EEG and self-report data to develop behavioral and neuroscientific models that integrate the roles of narrative and mentalizing in shaping consumer responses to advertising.

2. Literature review and research aims definition

2.1. The study of advertising perception and effectiveness

Research on advertising perception and effectiveness has a long tradition and has developed following changes in media and consumption practices. Its main purpose was to provide objective evidence to guide campaign design, reducing reliance on assumptions and protecting advertising investments and offering, in this sense, a solution to the problem famously described by John Wanamaker: *“Half the money I spend on advertising is wasted; the trouble is, I don’t know which half”*.

Continuous advertising research is also essential to adapt strategies to emerging media, technologies, and products (Danaher et al., 2020) and beyond its practical role in strengthening brand identity and building long-term engagement (Dehghani & Tumer, 2015), advertising research also contributes to broader scientific knowledge by advancing our understanding of how consumers process (marketing) information to make decisions (Aitken et al., 2008).

Early studies in this field focused primarily on direct outcomes such as sales, brand recall, and attitude change, often relying on econometric models (Bendixen, 1993) and hierarchical frameworks. A well-known example is the hierarchy-of-effects model, which proposed that advertising operates through a sequence of rational “steps”: awareness, knowledge, liking, preference, conviction, and purchase (Lavidge & Steiner, 1961). At that stage, measurement was mostly quantitative, focused on observable consumer responses and sales data, with little consideration of the underlying psychological processes. While informative, such measures were limited, as they captured *only explicit outcomes without explaining how* people actually perceive and respond to advertising.

Indeed, it is now widely recognized that advertising effectiveness depends not only on surface-level elements (such as exposure frequency or memorable slogans) but also on deeper, implicit processes. Consumers are not passive recipients of information: **consumers actively interpret, construct, and integrate** messages with their prior knowledge and personal experiences. This shift has led scholars to place greater emphasis on the **emotional, cognitive, and social dimensions of advertising**, including unconscious responses. Contemporary research therefore sees the consumer as the main character (Aitken et al., 2008) and explores their attitudes (Mehta, 2000), the influence of their peers (Munnukka et al., 2016), their cultural context, and the role of digital (Stewart et al., 2019; Santoso et al., 2020) and social media environments (Yang et al., 2016).

Recent studies further highlight the importance of factors such as message uniqueness and consistency (Mafael et al., 2021), personalization (Bleier & Eisenbeiss, 2015), and transparency (Kim et al., 2019), as well as the psychological dimension, particularly the affective and emotional resonance with audiences (Otamendi & Martín, 2020). Finally, involvement, identification, and narrative transportation, which describe the extent to which consumers immerse themselves in the advertising stories, seem to be additional fundamental constructs (Green & Brock, 2000; Van Laer et al., 2014).

Nevertheless, a major challenge remains: **why and how do these dynamics occur?** For instance, although many studies confirm that narrative transportation predicts advertising

effectiveness, the cognitive mechanisms driving this relationship are still not fully understood. Moreover, much of the existing evidence relies on self-reports, which – while valuable – cannot capture the implicit processes underlying consumer responses. These limitations have driven the **growing interest in neuroscientific approaches to advertising research**, which aim to shed light on the deeper mechanisms that shape consumer perception and responses.

2.2. EEG contribution to advertising research

Over the past two decades, EEG has become increasingly adopted in advertising research as a reliable tool that can not only replicate traditional findings (Daugherty et al., 2018), but also capture implicit cognitive and affective responses that self-report measures cannot fully detect. Its main advantage lies in its millisecond-level temporal resolution, which makes it particularly well suited to investigate dynamic media such as advertisements (van Diepen et al., 2024). This feature allows researchers to trace moment-to-moment fluctuations in consumer processes when exposed to an ad, particularly those related to **attention, memory, and emotion** (Sánchez-Fernández et al., 2021).

Conducting a systematic review of all EEG applications in advertising research is beyond the scope of this work, but a series of important examples can be highlighted. For example, one of the most widely cited findings concerns frontal EEG asymmetry, which – as discussed in Chapter 1 – is linked to motivational tendencies of approach or withdrawal. In this context, Ohme et al. (2010) showed that the most **emotional** segments of the famous Sony Bravia “Balls” commercial elicited left-hemispheric dominance, indicative of approach motivation, whereas other ads did not. Emotional responses to ads have also been examined in terms of **arousal**, with evidence that arousal is positively associated with the notability of ads in the general population (Eijlers et al., 2020). Similarly, Yang et al. (2015) derived indices of happiness, surprise, and attention from the temporal dynamics of EEG signals recorded during television ad exposure.

Other studies have sought more direct correlates of advertising effectiveness. For example, Golnar-Nik and colleagues (2019) found that differences between **liked and disliked** commercials were linked to EEG activity in the frontal electrodes.

EEG has also been used to investigate the role of specific ad characteristics. Wang et al. (2016) demonstrated that commercials with strong **narrative elements** and frequent brand exposure increased viewer preference, through EEG measures of emotional engagement and cognitive integration such as heightened theta activity in left-frontal and occipital regions, beta, and gamma in temporo-parietal areas. **Branding** scenes have been further analyzed by Kolar et al. (2021), who proposed an integrated EEG index of emotional and attentional responses. Beyond branding, EEG research has examined the presence of **celebrities, jingles**, and specific animations, showing that these elements are associated with increased theta band activity in frontal regions (Adalarasu et al., 2025).

EEG studies have also revealed differences not only in ad features but also in viewer characteristics. For instance, Cartocci and colleagues (2016) observed variations in EEG responses across **gender and age groups** during ad viewing.

More recently, research has also expanded to novel advertising formats. Ausín-Azofra et al. (2021) compared immersive **360-degree ads** with conventional 2D ones using EEG, eye-tracking and facial coding. Their results indicated lower brand logo recognition and reduced visual attention in immersive ads, though sometimes accompanied by greater emotional engagement, highlighting the complex cognitive dynamics introduced by emerging media environments.

Although EEG measures have become increasingly popular over the past two decades as a tool for testing commercials before their release, their reliability remains unclear. In a recent review, Van Diepen and colleagues (2024) tried to provide an answer by examining the reliability of **six key EEG metrics for evaluating video advertisements**. 1) *centro-parietal alpha* activity (8–12 Hz; CP1, CP2, and Pz), which is an indicator of attention and arousal; 2) *frontal beta* activity (16–20 Hz; FC1, FC2, Fz), which is a marker of reward and ad liking; 3) *frontocentral gamma* activity (75–95 Hz; Fz, FC1, FC2, C3, and C4), reflecting higher-order cognitive processing involved in understanding content, and has also been shown to predict movie sales in the general population; 4) *fronto-central theta* activity (4–7 Hz; FC1, FC2, and Fz), which is an index of memory processes as well as negative evaluation; 5) *frontal alpha asymmetry* (AF3, F3, FC5/AF4, F4, and FC6), which is an indicator of approach motivation; and 6) *inter-subject correlation (ISC)*⁴, as a measure of engagement (Van Diepen et al., 2024). They found that the reliability of EEG metrics varies considerably, ranging from poor to excellent. ISC demonstrated the highest reliability, while alpha and beta activity also showed good reliability. Theta and gamma activity showed lower reliability, and *alpha asymmetry exhibited the weakest performance*, not reaching an acceptable threshold. This last finding is particularly important because frontal alpha asymmetry is one of the most widely used EEG indices and is closely linked to approach-withdrawal processes (as also discussed in Chapter 1): recognizing that this commonly applied, “theoretically robust” measure actually exhibits poor reliability highlights the significant amount of research and work that remains to be done in this area.

Moreover, despite these advances (and limitations), most EEG studies in advertising remain centered on processes such as emotion, memory, attention, and engagement. A step further has been taken by Ciorciari et al. (2019), who examined the role of **emotional intelligence**, showing not only preferences for different types of ads but also differences in brain connectivity, particularly in the medial prefrontal cortex, during ad viewing. Nevertheless, higher-order functions such as those related to mentalizing are largely unexplored. Addressing this gap represents a promising direction and provides the rationale for the empirical work presented in this third Chapter.

2.3. From Narration to Mentalizing

Now that we have a better picture of advertising research and the core processes that shape how consumers perceive and process ads, it appears clear that effectiveness cannot be explained by surface features alone or by isolated cognitive or emotional reactions. A central question concerns how consumers engage with the *stories* that advertising conveys, and how this narrative dimension shapes their perceptions and responses. Among the various constructs proposed to capture such dynamics, **narrative transportation (NT)** has emerged as one of the most influential.

NT refers to the process by which a story captivates its audience, immersing them in its narrative world. This phenomenon can influence attitudes, intentions, and behaviors, making it a cornerstone of persuasive storytelling in advertising (Thomas & Grigsby, 2023). That is why it is often also referred to as *narrative persuasion* (e.g., Appel, 2022; Hamby & Brinberg, 2016) (Thomas & Grigsby, 2023). According to Narrative Transportation Theory (Green & Brock, 2000), when

⁴ Inter-subject correlation (ISC), also known as *neural synchronization*, refers to the temporal alignment of EEG responses among a sample of individuals exposed to the same stimulus, reflecting shared neural processing and engagement.

consumers are transported into a story, they connect with their characters and events, temporarily disconnecting from their physical surroundings.

When describing NT, we should pay attention to some distinctions. NT differs from mere *involvement*, which is more instrumental and focuses on outcomes, while transportation is intrinsic to the experience of the narrative itself (Petty & Cacioppo, 1979; Zaichkowsky, 1985). It also differs from *flow* and *immersion*: flow is a general state achievable across various activities (Bracken, 2006), and immersion is a response to sensory elements (Phillips & McQuarrie, 2010), while NT is specifically tied to the audience's consumption of a story (Van Laer et al., 2014). Indeed, narrative, as conceptualized in this context, is not the story itself but rather the story-recipient's consumption of the story (Van Laer et al., 2014).

In this sense, NT therefore involves **two dimensions: the characteristics of the narrative as a stimulus and the active role of the recipient**. In this interaction, consumers (the recipients) play an active role in observing, interpreting, and encoding the actions, intentions, and emotions of the characters within the narrative. This process can lead to changes in attitudes and intentions aligned with the narrative (Green, 2008). For instance, NT has been shown to enhance brand recall (Campbell et al., 2023), improve attitudes toward the product, brand, and advertisement, and increase purchase intention (Bhatnagar & Wan, 2011). Ads that tell compelling stories not only entertain consumers more but also demonstrate how products can be used to create meaning in their lives (Escalas, 2004).

Given its relevance for both the design of advertising and its impact on consumer attitudes, NT has attracted sustained interest from both practitioners and scholars. It is therefore measured in a variety of ways, most commonly through self-report instruments such as the Transportation Scale developed by Green and Brock (2000). Yet, considering that this scale is now more than two decades old, one might question why it has not been revised or updated, especially given the advances in both narrative theory and measurement techniques.

For example, more recent work has shifted away from treating NT as a single, unique state and instead breaks it down into complementary components. Boksem et al. (2025) distinguish between **narrative understanding** (i.e., comprehension, meaning making, and clarity of the narrative) and attentional engagement with the story. Similarly, Busselle & Bilandzic (2009) subdivide narrative engagement into attentional focus and comprehension, but also **narrative presence** (i.e., a felt sense of "being in the story" world that emerges from comprehension processes and perspective taking). So, these accounts suggest that NT is fundamentally multidimensional.

Moreover, measuring narrative perception and transportation remains inherently complex, as it involves multiple processes of attentional focus, story comprehension, and emotional engagement. This is one reason why neurophysiological measures are increasingly employed, as they provide a more direct picture of these dynamics. For example, Gordon et al. (2018) used EEG to show that transportation was associated with neural activation related to working memory, attention, emotion, and imagination. Looking forward, there remains a need to identify specific neural correlates of narrative versus non-narrative advertising, as well as of high versus low transportation experiences, an area where EEG, with its high temporal resolution, can offer promising opportunities for future research.

2.3.1. Ad characteristics: Narrative Structure

To evoke NT, stories need to meet specific characteristics, building the so-called "narrative structure" (NS) that enables causal reasoning on the story by linking goals, actions, and outcomes

over time (Escalas et al., 2004). This concept refers to the organized development of a story, which typically unfolds both temporally and relationally. Temporally, narratives progress through distinct phases, beginning, middle, and end. Relationally, narratives establish connections between their elements (Escalas, 2004). Dahlstrom (2014) adds a third defining characteristic of narratives, namely the presence of characters (i.e., individuals or entities exhibiting human-like qualities). Another fundamental feature of narratives is their capacity to generate emotional arcs, which serve as a key structural element of storytelling (Green & Appel, 2024). Finally, Van Laer and colleagues (2014) argue that narratives capable of evoking transportation often include identifiable characters, a vivid and imaginable plot, and a sense of verisimilitude.

The mode of story presentation is also a significant factor in determining the extent to which narratives can evoke transportation. For example, this study focuses on the analysis of commercials, stories delivered through audiovisual media. *So does this narrative presentation format facilitate the evocation of transportation?* The answer seems to be yes. Indeed, audiovisual narratives provide greater sensory richness, which can increase attention, while requiring less cognitive effort to mentally represent the story, leading to stronger narrative transportation (Green & Appel, 2024), as also evidenced by empirical studies (e.g., Walter et al., 2017) (Green & Appel, 2024).

The majority of studies that aimed at assessing the narrative structure of their stimuli relied on the Narrative Structure Coding Scale (Escalas, 2004b), a multi-item instrument based on the framework introduced by Pennington and Hastie (1986, 1992) and which mainly concentrates on the narrative attributes of temporality and relationality (Escalas, 2004b).

Although research has explored narratives in a wide range of formats – health and prevention messages, advertisements, short stories, novels, films, plays, radio content, audiobooks, games, and even virtual reality experiences (Green & Appel, 2024), the term is often used more broadly to describe a way of thinking characterized by “*mental simulation*” (Green & Appel, 2024).

As it helps interpret and make sense of the world, narrative structure also provides the framework for causal inferences about the meaning of brands and consumers' experiences with brands (Escalas, 2004), which can be provided, for example, by the structure of an ad. This can explain why narrative is so widely studied in communication, marketing, and consumer research.

However, while some studies have determined the features of stimuli that evoke narrative transportation (i.e., structure characteristics), others have sought to clarify the key recipient characteristics (i.e., the consumer) that drive this process.

2.3.2. Recipient characteristics

Green and Appel (2024) highlight the close relationship between NT and individual traits, such as transportability (i.e., the tendency to be transported by narratives), narrative involvement, and imaginative involvement (i.e., the propensity to actively imagine the narrative). In addition to these traits, broader constructs have been identified as potential explanatory factors for individual differences in propensity to narrative transportation. These factors are the need for cognition – the inclination to pursue and engage in cognitively demanding activities – and the need for affect – the propensity to address emotionally evocative situations (Green & Appel, 2024). Other recipient characteristics that influence narrative transport include trait empathy (Hall & Bracken, 2011), mind-reading motivation (Carpenter et al., 2016), prior knowledge of the topic and its personal relevance (Slater & Rouner, 2002; Green & Appel, 2024).

It can be seen that a key recipient component is closely linked to individuals' capacity to attribute mental and emotional states to characters. This enables them to experience empathy and engage in mind-reading towards them. As previously discussed, this capacity is referred to as *mentalizing*.

2.3.3. How does narrative transportation work? The processes behind it

Having identified the key characteristics of stimuli that evoke NT as well as the factors related to the recipient that facilitate it, further investigation is required into the psychological mechanisms that make narrative transportation possible. As Thomas and Grigsby (2023) highlight in their review, NT theory itself does not account for the mechanisms explaining how or why it is so persuasive. *So, what are the processes behind it?*

Several authors tried to answer this question. Already in the early 2000s, Escalas developed a model that places mental simulation – i.e., the cognitive ability to create hypothetical scenarios - at the core of ad narrative persuasion (2004). Identification with characters has also been proposed to be central in shaping narrative persuasion: adopting the perspective of a character can make the consumer also adopt its attitudes, with tangible behavioral effects (De Graaf et al., 2012). Similarly, Wojcieszak and Kim (2016) found that when participants are presented with a message and are asked to imagine how their characters feel, this perspective-taking activity will result in higher message acceptance.

Nevertheless, these attempts are constrained by some limitations. Firstly, most of these studies focus on written narratives, with little consideration given to advertisements. This introduces not only a different type of stimulus but also a failure to measure persuasion in terms that are relevant to the marketing field. Furthermore, participants are often already provided with a perspective to adopt, and the process through which they adopt this perspective is not assessed. Similarly, although several variables that may facilitate narrative transportation have been identified, the mechanisms driving this process remain unclear. Rather than clarifying the mechanisms of narrative transportation itself, these studies frequently describe factors that contribute to it, which can be considered more as outcomes rather than their underlying processes. Finally, these studies employ traditional measurement methods, such as self-report questionnaires, to assess these variables. Given the inherent difficulty in quantifying and articulating implicit processes of this kind, these measures should be complemented with neuroscientific techniques that can capture unconscious and unbiased responses, which traditional self-report methods often fail to account for. So, it can be said that these advancements and attempts still fail to address the core question of what processes underlie narrative transportation.

2.3.4. Mentalizing and Narration: A new framework

Attempts to formalize the construct that lies behind the narrative experience of an advertisement are not new. Several similar ideas have already been explored, some close to what we would now call *mentalizing*. An example is Escalas' model (2004a), who proposed that mental simulation plays a role in narration: by encouraging people to imagine how a story unfolds and where they might fit inside it (that is the definition of mental simulation), the ad persuades through narrative transportation, which in turn shapes attitudes towards the advertisement, the product, and the brand. Yet this could raise a question: what exactly is meant by "mental simulation"? My working view is that it may at least rely on a more fundamental process: ***mentalizing***, which can be seen in this

context as the ability to infer characters' thoughts, intentions, and feelings, and to integrate those inferences with one's own goals and experiences while the story unfolds.

So, the model proposed here places such mental processes at the centre, along with the stimulus features of the advertisement itself, to better account for why some ads prove effective and others do not. On the stimulus side, certain characteristics of the ad can facilitate persuasion (i.e., NS), but this is only part of the story. On the recipient side, we know that consumers are active interpreters: they perceive, process, and integrate what is presented to them before any attitude is formed. Beyond the established narrative constructs (e.g., involvement, identification, transportation), it can be hypothesized a specific role for mentalizing. It may act as a primary driver, potentially exerting effects above perceived narration, or it may operate in parallel, amplifying or modulating the influence of transportation on the final outcomes.

A further issue concerns **measurement**. Since narrative responses and mentalizing are complex, unfold quickly, and often outside conscious awareness, self-report scales alone are unlikely to properly capture their dynamics. This motivates the use of neurophysiological indices, and EEG in particular, given its millisecond-level temporal resolution and the other advantages already outlined throughout this work. In the empirical work that follows, I will therefore compare self-report operationalizations with EEG-derived measures, asking whether mentalizing explains unique variance in advertising effectiveness once its narration and related constructs are taken into account, and whether EEG-based indices provide better sensitivity in assessing narrative and mentalizing-related experiences. These questions frame the experimental study that follows and guide our evaluation of the proposed self-report or EEG-based model.

2.4. Research aims and questions

Prior work shows that narratives in advertising can be persuasive, but three gaps remain. First, most evidence relies on self-reports that cannot capture implicit processes. Second, the cognitive mechanisms by which narration exerts its effects are still under-specified. Three, the specific role of mentalizing in narrative perception and advertising effectiveness has rarely been tested directly. Building on these gaps, this project pursues the following aims:

Aim 1. Test a behavioral model in which narrative structure (NS) influences advertising effectiveness through narrative perception and mentalizing, each measured via self-report.

- **RQ1.1** Does stronger NS improve advertising outcomes (measures of its effectiveness)?
- **RQ1.2** Do narrative perception and mentalizing *mediate* the effect of NS on these outcomes?
- **RQ1.3** When considered jointly, which mediator (mentalizing vs narrative measures) shows the stronger or unique indirect effect?

Aim 2. Identify **EEG correlates** of (a) mentalizing and (b) narrative perception during ad exposure.

- **RQ2.1** Which EEG features are associated with the activation of mentalizing processes?
- **RQ2.2** Which EEG features are reliably associated with the perception of narratives?
- **RQ2.3** How do these two EEG correlates of mentalizing processes and narrative perception relate to those previously identified during ad perception (e.g., Van Diepen et al., 2024)?

Aim 3. Compare the **behavioral model** (self-report) vs the EEG-based **model**.

- **RQ3.1** Do EEG-based indices explain **additional variance** in ad effectiveness outcomes beyond self-reports?

- **RQ3.2** Which model provides the best predictive performance for explaining advertising effectiveness?

3. Method

The study took place between January and February 2025 at the Erasmus Behavioral Lab (EBL; <https://www.eur.nl/en/essb/research/erasmus-behavioural-lab>) of the School of Social and Behavioral Sciences and the Erasmus Research Institute of Management from the Erasmus University Rotterdam. It was first preregistered on AsPredicted.org (reference number: 210082) and approved by the Institutional Review Board of Erasmus University Rotterdam (reference number: ETH2425-0339). It was conducted in accordance with the General Data Protection Regulation and the Declaration of Helsinki (World Medical Association, 2024), adhering to ethical guidelines for research involving human participants.

3.1. Sample

A total of 46 participants (23 females, 23 males; $M_{Age} = 23.78$) took part in the study, recruited through EBL procedure. The sample size was determined according to recent guidelines recommending a minimum of 40 subjects for EEG studies in consumer neuroscience research on advertising (van Diepen et al., 2024).

Demographic characteristics of the participants are summarized in **Table 3.1**, and their countries of origin are illustrated in **Figure 3.1**. As shown, the sample comprises individuals from diverse national backgrounds, which contributes to the generalizability of the findings across different cultural contexts and supports the validity of causal inferences (Deffner et al., 2022).

All participants provided written informed consent, which detailed the nature of the study, the non-invasive nature of the instrumentation used, the anonymity of their data, and the voluntary nature of their participation. However, to prevent bias, they were not fully informed about the specific purpose of the study, which was disclosed only at the end of the procedure in a debriefing session. Participants received a €30 compensation for their participation in the study.

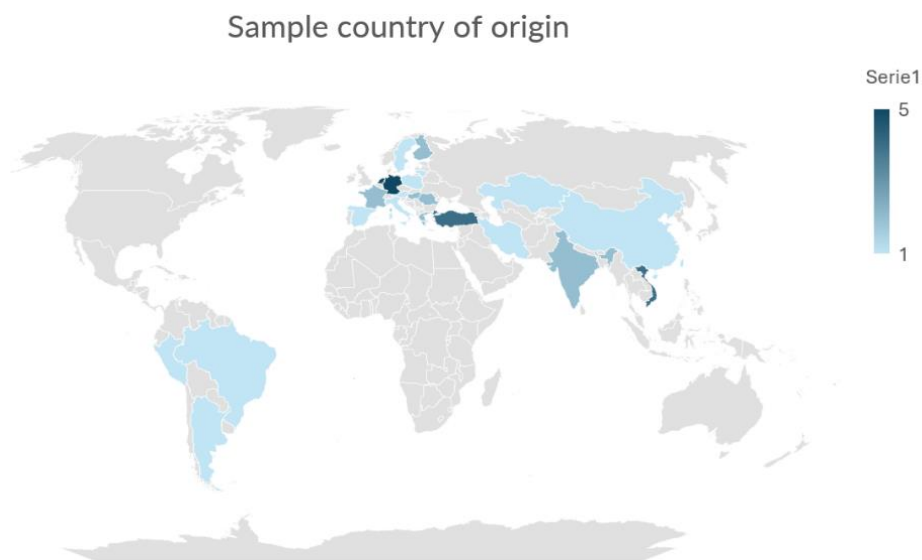


Figure 3.1. Countries of origin of the participants included in the final sample.

Age	Mean	St. Dev	Min	Max
	22.76	5.63	18	41

Gender	Count	%
	F	23
M	22	48.9

Country of origin	Count	%
	Germany	5
The Netherlands	5	11.11
Turkey	4	8.89
Vietnam	4	8.89
Greece	2	4.44
France	2	4.44
India	2	4.44
Romania	2	4.44
Hungary	2	4.44
Finland	2	4.44
Kazakhstan	1	2.22
Iran	1	2.22
Spain	1	2.22
Lithuania	1	2.22
Poland	1	2.22
Taiwan	1	2.22
Sweden	1	2.22
Italy	1	2.22
China	1	2.22
Austria	1	2.22
Curaçao	1	2.22
Aruba	1	2.22
Peru	1	2.22
Argentina	1	2.22
Brazil	1	2.22

Table 3.1. Demographic characteristics of the final sample (N = 45). The table reports the age distribution (mean, standard deviation, and range), gender breakdown, and participants' countries of origin.

3.2. Stimuli

3.2.1. Advertisement Selection and Assessment

The advertisements were selected from the “Ads of the World” database, with a 30-second length format and a temporal range from 2018 to 2024 (newest ads). Ads regarding specific holidays or events (e.g., Christmas, Halloween, Thanksgiving, etc) were excluded, as well as ads featuring celebrities (Knoll & Matthes, 2016) or brand collaborations. To ensure the results were as generalizable as possible, they spanned various product categories (food, cars, beverages, clothing, technology, services...). They were all from popular, globally recognized brands and were in the English language. Ad volume was checked, corrected, and standardized across all advertisements to ensure uniform audio conditions.

Two trained raters, blinded to the study's aims and hypotheses, independently rated the narrative structure of the advertisements using the Narrative Structure Scale (NSS; Escalas, 2004b). They first received training on the meanings of each scale item and, following a training session, independently rated an initial sample of $N = 50$ advertisements across all dimensions of the NSS. They also indicated whether the ad brand was popular and globally recognized: all responses were affirmative.

Inter-rater reliability across their ratings was assessed using the Intraclass Correlation Coefficient (ICC), calculated with a Two-Way Mixed Effects Model for fixed raters and averaged items. The resulting ICC demonstrated excellent reliability ($ICC = .921$; Shrout & Fleiss, 1979). Further details about the NS scale and its items are provided in the Appendix (Section 1).

From the initial sample, advertisements with ambiguous NS scoring (e.g., positioned closer to the midpoint between high and low narrative structure) were excluded. The final ad stimuli sample (detailed in Appendix, Section 2) thus included a total of 30 advertisements, comprising two ads per brand: one with the lowest NS and one with the highest. An example presenting a more detailed analysis of high-NS versus low-NS ads from the same brand is reported in Appendix, Section 12.

3.2.2. Mentalizing EEG localizer

Participants were presented with stimuli from a well-established video-based mentalizing task, the **Frith-Happé Triangles** (Abell et al., 2000). This task consisted of 12 short videos (average duration: 40s), depicting geometric triangles (a small, black triangle and a bigger red triangle) moving in a space. There are three experimental conditions (4 videos per condition):

- **Random:** The triangles move within their space without any apparent purpose.
- **Goal-Directed:** The triangles interact meaningfully but without attempting to influence each other's mental states.
- **Theory of Mind (ToM):** One triangle's movements are designed to manipulate or respond to the inferred mental state of the other, requiring observers to engage in mental state attribution.

Given the nature of these stimuli, mentalizing processes are expected to be engaged in the ToM condition, as it demands the inference of intentions and emotions based on movement cues. This aligns with the notion that human observers rely on learned associations between their own sensory-motor experiences and internal states to interpret the mental states underlying others' actions (Schuster et al., 2024).

The original videos for this task were sourced from University College London. However, due to their lower quality compared to the advertisements used in the study, they were recreated by the author using Adobe After Effects software (v 25.0; Adobe, 2025). Appendix, Section 3, includes examples and detailed descriptions of representative stimuli used in each of the 3 conditions.

3.2.3. Narrative perception EEG localizer

Participants were presented with a video-based stimulus task featuring simple geometric shapes (triangles and lines, just as in the mentalizing localizer task), engaging in movements designed to evoke a **narration** (reference video from Nguyen et al., 2019). Two narrative stimuli of this type were shown. EEG activity recorded during these narrative videos was then compared to that elicited by two **control** stimuli, which were created by rearranging the same video frames into sequences that lacked coherent narrative content.

Each participant thus saw a total of 4 videos related to this localizer task, with the average duration of each stimulus being approximately 1 minute and 40 seconds. Appendix, Section 4, provides examples and detailed descriptions of representative stimuli used in both the narrative and control conditions.

As for mentalizing ones, the Narrative and Narrative Control stimuli were created by the author based on those used in Nguyen et al. (2019) using Adobe After Effects software (v 25.0; Adobe, 2025).

3.3. Instruments and Measures

Both EEG and self-report measures were employed to assess the different variables of interest. EEG was used to assess the extent of mentalizing processes (Section 2.2.1) and narrative perception (Section 2.2.2). Questionnaire items measured ad effectiveness (Section 2.4.2), self-reported counterpart of mentalizing and narrative perception (Section 2.4.3), and recipient characteristics as covariates (Section 2.4.4).

3.3.1. EEG

EEG data were acquired using the BioSemi ActiveTwo system and recorded via the ActiView software. 64 active Ag-AgCl electrodes were used, with 4 additional electrodes placed around the eye region to record electrooculogram (EOG), as well as 2 on the right and left mastoids to be used as reference sites. Electrodes followed the extended 10–20 layout, with CMS and DRL electrodes positioned near the vertex to form the active reference loop (**Figure 3.2**).

Signals were sampled at 512 Hz with DC amplifiers and time-locked to stimulus events via TTL triggers sent from the controller computer.

To optimize signal quality, before applying the EEG sensors, the skin was gently prepared by applying conductive gel (Signigel Electrode Gel, Parker Laboratories), so that the electrode offsets were kept within ± 20 mV throughout recording (also thanks to signal adjustment breaks during the protocol, as described in Section 3.4).

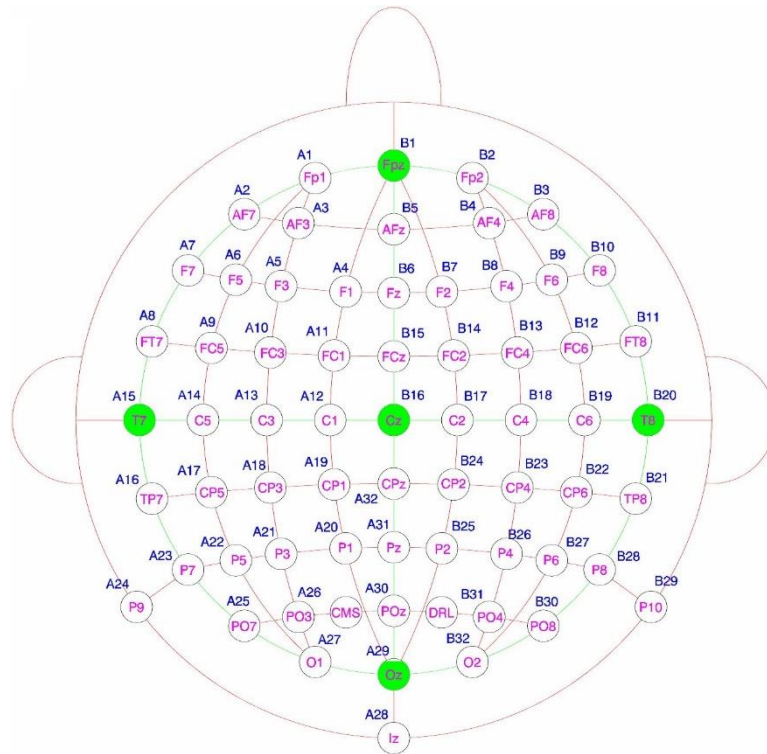


Figure 3.2. Schematic representation of the BioSemi 64-channel EEG cap layout, showing electrode positions according to the international 10–20 system. Green markers indicate reference points commonly used for orientation (Fpz, Cz, Oz, T7, T8). Figure credits to Biosemi Website material.

3.3.2. Ad effectiveness measures

To measure ad effectiveness, our final dependent variable of interest, we employed items capturing its different dimensions, each rated on a 7-point scale from 1 (Not at all) to 7 (Very much). Specifically, we assessed **ad liking** ("How much did you like the ad?"), **purchase intent** ("Would you buy this product/service?"), **recommendation intent** ("Would you recommend this product/service to friends and family?"), and **sharing intent** ("How likely are you to share this ad with friends and family?").

3.3.3. Self-report mentalizing and narrative transportation measures

To measure the **self-reported mentalizing extent**, we adapted a single item from Chan et al. (2023) ("The ad made me think about the characters' feelings and intentions"). **Narrative transportation** was assessed via two items ("I could picture myself in the scene of the events described in the ad" and "The ad affected me emotionally") of the Transportation Scale–Short Form (TS–SF) by (Appel et al., 2015) a shorter and improved in terms of factor loading version of the original Narrative Transportation scale (Green and Brock, 2000). Moreover, measures of **narrative understanding** and **presence** were taken employing items used to assess those constructs in, respectively, Boksem et al. (2025) and Busselle & Bilandzic (2009). All answers were given on a 7-point scale (1–7). More details on narrative understanding and presence items are presented in the Appendix (Sections 5 and 6).

3.3.4. Recipient characteristics measures

Section 2.3.2 discussed how the recipient characteristics can significantly influence not only the final effectiveness but also earlier cognitive processes such as mentalizing extent and narrative

transportation extent. Participants' **mentalizing ability** was assessed via the Mentalization Scale – Brief Version (MENTS-12) (Stefana et al., 2024). Furthermore, since consumer involvement and its personal relevance for the ad content can affect narrative transportation (Slater & Rouner, 2002; Green & Appel, 2024), additional questions were included as control variables to assess participants' **involvement with the product and brand featured** (based on the definition by Mittal, 1995), as well as **brand familiarity**. Details on these scales, their items, and their ratings are provided in the Appendix, in sections 8, 9, and 10, respectively.

3.4. Experimental procedure

After providing informed consent, participants were guided to the EEG cubicle, a soundproof room in which lighting, temperature, and ads' audio volume were monitored and kept constant across stimuli and experimental sessions. They sat in a comfortable chair, and the sensors described in Section 3.3.1 were applied. Participants were then provided a mouse with a mouse pad to respond to on-screen questionnaires appearing on the screen (32") placed in front of them (**Figure 3.3**). Four speakers were positioned at the four corners of the room (front-left, front-right, rear-left, rear-right) to reproduce the audio of the advertisements.

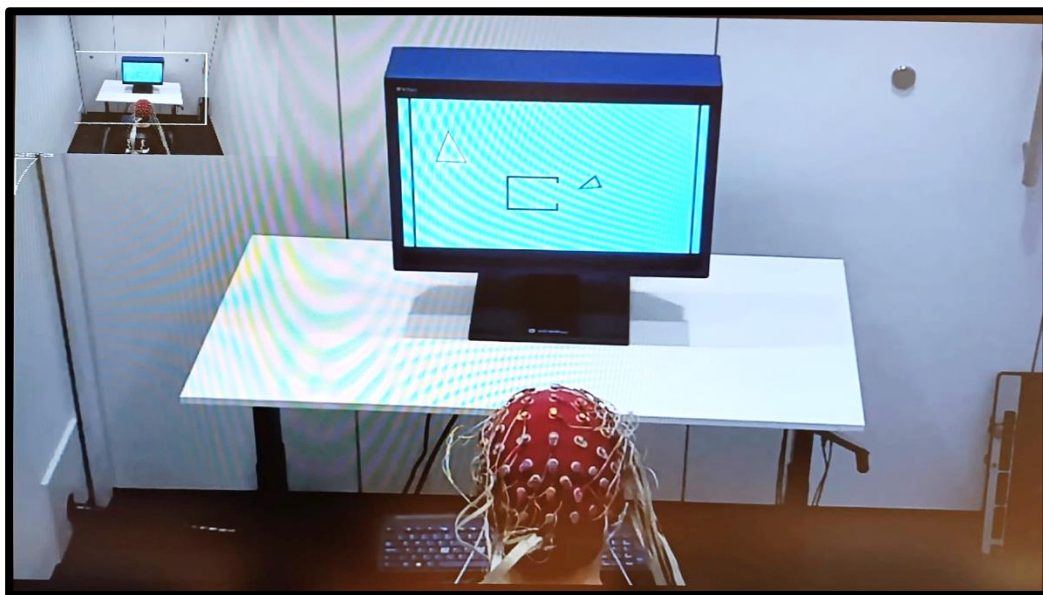


Figure 3.3.: Experimental setup. *The participant is seated in the EEG cubicle, viewing a mentalizing-localizer stimulus on the display while EEG activity is recorded. The photograph was captured from the control computer via the cubicle's internal camera, enabling the experimenter to monitor both the participant and the protocol remotely, without entering the room or disrupting the session.*

Once preparation was complete, the experimental protocol began and followed the structure shown in **Figure 3.4**. Specifically, participants viewed the set of 30 ads twice, following the recommendations of van Diepen et al. (2024), which suggest that multiple stimulus exposures enhance the reliability of EEG recordings. After the second viewing of each ad, participants completed the questionnaire described in Sections 3.3.2 and 3.3.3.

In both the first and second presentations, the ads were shown in subblocks of 10 ads, with an equal division between those featuring a low narrative structure and those with a high narrative structure. The order of the ads within each subblock was randomized, as was the sequence of the

three subblocks. To create a more ecologically valid viewing experience, the ad subblocks were embedded within a marine documentary, simulating a natural commercial break. They were presented in segments of 2.5 minutes, extracted from two BBC documentaries (https://www.youtube.com/watch?v=CSgDjZ_Vv8g and <https://www.youtube.com/watch?v=EF8C4v7JlbA&t=1677s>). Only calm narration segments were selected, avoiding scenes with arousing scenes/and or arousing background music, which could have influenced participants' emotional states and potentially affected their responses to the subsequent advertisements. For further details on the documentaries, please refer to Section 11 of the Appendix. Following the advertisement presentations, participants completed two localizer tasks for Mentalizing and Narration EEG assessment, as described in sections 3.2.2. and 3.2.3, respectively. EEG signal adjustments occurred during two documentary breaks between major experimental phases. The procedure concluded with a final survey to measure control variables and demographic information.

Both the stimuli (ads, documentaries, and localizers videos) presentation and the questionnaire items were prepared and administered using E-Prime software. The final survey on covariates and demographic information was prepared and administered on the Qualtrics platform.

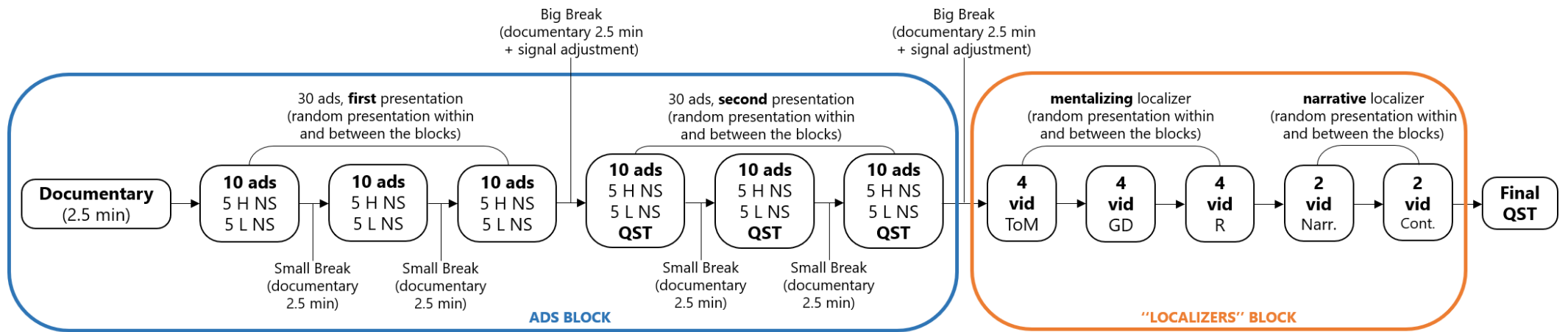


Figure 3.4. Experimental protocol Flowchart. The protocol consisted of two main presentation blocks of advertisements (30 ads in the first presentation, and the same sample of 30 ads in the second presentation). Each round of presentation comprised 3 blocks of 10 advertisements (5 with high narrative structure – H NS – and 5 with low narrative structure – L NS – presented randomly). Each ad block was separated by short documentary breaks (2.5 min). Participants then completed two main localizer tasks: a Mentalizing localizer (3 sets of 4 stimuli each reflecting different levels of mentalizing processing, where ToM = Theory of Mind, highest mentalizing processing level, GD = Goal Directed, and R = Random) and a Narrative localizer (a total of 4 stimuli, 2 with a narration, Narr., and 2 controls, Cont.). A survey for control variables and demographic information assessment concluded the procedure.

3.5. Analyses

3.5.1. Self-report data

As a first step, items were cleaned and reverse-coded where necessary. Composite scores (e.g., for Narrative presence or narrative understanding scales) were then created by aggregating the related items into their respective dimensions. Internal consistency of each scale was assessed using McDonald's omega.

All the analyses were conducted using R version 4.5.0 (R Core Team, 2025), employing the specific packages required for each analysis.

Correlation analyses were conducted to examine the relationships among the key variables, using the *ggplot2* package (v. 3.5.2; Wickham, 2016). Further details on this preliminary analysis step are reported in the Appendix, Section 14.

Then, the effect of the main experimental manipulation – high (H) vs. low (L) narrative structure (NS) – was tested on both the narrative-related variables and the final dependent variables related to perceived ad effectiveness. Additional details and descriptive results for this step are provided in the Appendix to Section 15. To statistically estimate and test the significance of the manipulation, we used a linear mixed model (LMM) to account for the repeated-measures design. The general model structure was specified as:

```
variablename ~ NS + (1 | Sbj)
```

where NS was included as a fixed effect and subject as a random intercept, to account for the intersubjective variance. The Satterthwaite test method was used to estimate the significance of fixed effects. LMM analyses were conducted using the R packages *afex* (v. 1.4-1; Singmann et al., 2024), *lme4* (v. 1.11.1; Bates et al., 2015), and *emmeans* (Lenth, 2024).

Following the initial exploration of the effect of NS on both narration-related and ad effectiveness variables, we conducted a further analysis focusing specifically on the narrative measures. The aim was to better understand their underlying structure to appropriately include them in the final mediation model. An Exploratory Factor Analysis (EFA) was thus performed using the 9 items individually: 2 items from narrative transportation, 3 from narrative presence, and 4 from narrative understanding. Given the observed correlations among these variables, an oblique rotation (oblimin) was applied, and factors with eigenvalues greater than 1 were extracted. Factor scores were then computed using the *ten Berge* estimation method. The analysis was conducted with *psych* (v. 2.5.3; Revelle, 2024), and plots were produced via *ggplot2* (v. 3.5.2; Wickham, 2016) and *qgraph* (v. 1.9.8; Epskamp et al., 2012).

Finally, a multilevel mediation model was estimated to account for the nested structure of the dataset (SBJ; 45 clusters, 1350 observations). The goal was to examine whether the narration-related variables – i.e., the two factors identified through EFA - as well as mentalizing, mediated the effect of NS on the outcome variables related to ad effectiveness (ad liking, sharing intent, purchase intent, and recommendation intent). The model was implemented in R using the *lavaan* package (Rosseel, 2012) and visualized with *lavaanPlot* (v. 0.8.1; Schulte, 2022). The exact model specification is provided in the Appendix, Section 15.

3.5.1. EEG data

EEG data preprocessing was carried out in MATLAB (The Mathworks, Inc., Natick, MA, USA) using the EEGLAB toolbox (Delorme & Makeig, 2004).

The data were imported, downsampled to 256 Hz, and re-referenced to the average of all channels. A band-pass filter was applied with a high-pass cutoff at 1 Hz and a low-pass cutoff at 100 Hz. Power line noise at 50 Hz was removed using the CleanLine plugin (Mullen, 2012). Artifact Subspace Reconstruction (ASR) was then used to clean the data from transient artifacts (Plechawska-Wojcik et al., 2019). Finally, Independent Component Analysis (ICA) was performed using the FastICA algorithm (Hyvärinen & Oja, 2000) to identify via ICLabel (Pion-Tonachini et al., 2019) and remove components classified as artifacts, specifically those with a probability ≥ 0.9 of being eye movements, muscle activity, cardiac signals, external or line noise sources.

Then, for each subject and for each stimulus, trials were retained only if less than 30% were rejected. Participants were maintained in the analysis only if at least 80% of the stimuli remained valid after this filtering step. For the same reason, epochs related to one stimulus (for one participant) and to two stimuli (for another participant) were rejected and not considered in the analyses (they were marked as "NaN" for compatibility with the R software used for analysis. The same as done for those time periods from which EEG data could not be extracted, e.g., too high frequencies).

Based on these preprocessing criteria, two male participants were excluded due to insufficient signal quality. The final sample thus involved 44 participants (23 females, 21 males), aged 18–50 years ($M = 22.76$; $SD = 5.63$) and gender-balanced in terms of mean age ($M_{\text{Females}} = 23.70$, $SD = 7.33$; $M_{\text{Males}} = 21.77$, $SD = 2.86$; $t(43) = 1.150$, $p = .257$).

Following preprocessing, spectral decomposition was performed using a Fast Fourier Transform (FFT). For each of the main stimuli (30 Ads presented twice, 12 Mentalizing Localizer stimuli, and 4 Narrative Localizer stimuli), power spectra were extracted across 64 channels and computed for 125 frequency bins (1-125 Hz).

First, to control for within-set variability for the Mentalizing localizer (Section 3.2.2), the four GD stimuli were contrasted among themselves, and the four ToM stimuli were contrasted among themselves⁵. Because of the highly multilevel structure of the dataset (repeated measures across channels within participants), a separate LMM was fitted for each EEG frequency (128 freq)⁶. In each model, Stim (four levels within each set) and Chan (64 levels) were treated as fixed effects, including their interaction, with a random intercept for participant (Sbj) to account for repeated measures:

$$\text{Freq} \sim \text{Stim} * \text{Chan} + (1 | \text{Sbj})$$

Sum-to-zero contrasts were used for fixed factors, and Type-III F-tests were computed with Satterthwaite degrees of freedom (lmerTest). To control for multiple testing across frequencies, p-values for the fixed-effect terms were adjusted across the 128 frequency-wise models using the Bonferroni correction. Results for the Mentalizing localizer are reported in the Appendix, Section 16.

The same procedure was then applied to the Narrative localizer (Section 3.2.3), assessing variability among the two Narrative stimuli and among the two Control stimuli. Results for the Narrative localizer are reported in the Appendix, Section 17.

⁵ Note that this analysis section considers only the "GD" and "ToM" stimulus subsets of the Mentalizing task. The "Random" subset - although administered to participants as described in Section 3.2.2 and reported in the Appendix - has not been analyzed here. The analyses have been restricted only to GD vs. ToM as the GD stimuli are the closest to the ToM ones in all respects, except for the specific elicitation of *mentalizing* processes.

⁶ Since the last three frequencies (126, 127, and 128 Hz) were all *NA*, only the frequencies from 1 to 125 Hz were considered in the EEG analyses.

All analyses were conducted within the R software using *lme4* (v. 1.11.1; Bates et al., 2015), *lmerTest* (v. 3.1-3; Kuznetsova et al., 2017), *emmeans* (Lenth, 2024), and *ggplot2* (v. 3.5.2; Wickham, 2016) packages.

a) Mentalizing EEG Localizer estimation. To assess the EEG differences between the two Mentalizing experimental conditions (ToM vs. GD), the EEG signal was analyzed at the level of single channels and single frequencies. For each subject, channel, and frequency, we estimated spectral power and ran a series of LMMs. The models included the stimulus type (StimType: ToM vs. GD) as a fixed effect and the subject (Sbj) as a random intercept, accounting for inter-individual variability while testing for significant differences between stimuli conditions. The model can be written in formula notation (R/lme4) as:

$$\text{Value} \sim \text{StimType} + (1|\text{Sbj})$$

Where Value is the spectral power for subject i , at channel c , and frequency f , StimType is the experimental condition (GD vs. ToM), entered as a fixed effect, and (1|Sbj) is the random intercept for each subject.

Then, pairwise contrasts between GD and ToM were derived via *emmeans*, with Holm's correction applied within each model. Across all Channel(64) x Frequency(125) combinations, a total of 328 significant contrasts were identified as significant ($p_{\text{Holm}} < .05$). However, another selection criterion was applied to consider only the most robust differences, without considering whether they were statistically significant or not. Out of the total possible contrasts ($125 \times 64 = 8,000$), only 7,903 were considered because those with missing estimated values (NA) were excluded, which made it impossible to compute a valid contrast (this mainly applies to the highest frequency values, such as 124 and 125 Hz). Of those, only the top 10% with the largest differences (in terms of absolute estimate values) were retained for further analysis ($N = 790$, as presented in the Results section 4.2.1, subdivided by frequency bands). Only those that were statistically significant ($P_{\text{Holm}} < .05$) and had an estimated difference between conditions of $> .01$ were considered more robust and finally selected as final EEG correlates.

b) Narrative EEG Localizer estimation. The analysis of the differences between the two Narrative-related experimental conditions (Narrative vs. Narrative control), followed the same pipeline as described for the Mentalizing EEG localizer estimation. The EEG signal was analyzed at the level of single channels and single frequencies. For each subject, channel, and frequency, we estimated spectral power and ran a series of LMMs. The models included the stimulus type (StimType: Narr. vs. Contr.) as a fixed effect and the subject (Sbj) as a random intercept, accounting for inter-individual variability while testing for significant differences between stimuli conditions. The model can be written in formula notation (R/lme4) as:

$$\text{Value} \sim \text{StimType} + (1|\text{Sbj})$$

Where Value is the spectral power for subject i , at channel c , and frequency f , StimType is the condition (Narr. vs. Contr.) entered as a fixed effect, and (1|Sbj) is the random intercept for each subject.

Then, pairwise contrasts between Narr. vs. Contr. were derived via *emmeans*, with Holm's correction applied within each model. Across all Channel(64) x Frequency(125) combinations, a total of 764 significant contrasts were identified as significant ($p_{\text{Holm}} < .05$). However, another selection criterion was applied to consider only the most robust differences, without considering whether they

were statistically significant or not. Out of the total possible contrasts ($125 \times 64 = 8,000$), only 7,913 were considered because those with missing estimated values (NA) were excluded, which made it impossible to compute a valid contrast (this mainly applies to the highest frequency values, such as 124 and 125 Hz). Of those, only the top 10% with the largest differences (in terms of absolute estimate values) were retained for further analysis ($N = 791$, as presented in the Results section 4.2.2, subdivided by frequency bands). Only those that were statistically significant ($P_{\text{Holm}} < .05$) and had an estimated difference between conditions of $> .01$ were considered more robust and finally selected as final EEG correlates.

Once the final correlated EEGs relating to mentalizing and narrative perception processes had been estimated from the video-based task analysis, they were computed on sets of 30 advertisements. As each ad was presented twice, the EEG data relating to the first and second presentations of the same ad were averaged (according to the guidelines of Van Diepen et al., 2024).

Subsequently, as with the self-report data, correlation analyses (Pearson r) were conducted to examine the relationship between the EEG correlates of mentalizing and narrative perception, using the `ggplot2` package (v. 3.5.2; Wickham, 2016). Further details on this analysis can be found in Section 4.2.3 of the Results.

The next step was to estimate on our set of ads the key EEG measures of consumer neuroscience advertising research (Van Diepen et al., 2024), specifically:

- Alpha activity (8–12 Hz) at CP1, CP2 and Pz for attention/arousal
- Beta activity (16–20 Hz) at FC1, FC2 and Fz for reward/liking
- Theta activity (4–7 Hz) at FC1, FC2 and Fz for memory/disliking
- Gamma activity (75–95 Hz) at Fz, FC1, FC2, C3 and C4 for understanding

Correlations (Pearson r) were then run between these EEG measures and the estimated EEG correlates of mentalizing and narrative perception to statistically estimate links with these processes. Results of this analysis can be found in Section 4.2.3 of the Results.

Then, the effect of the main experimental manipulation (H vs. L NS) was tested on both mentalizing and narrative perception EEG correlates computed during ad viewing, via two LMMs to account for the repeated-measures design, with NS included as a fixed effect and subject as a random intercept. The general model structure was specified as:

```
variablename ~ NS + (1 | Sbj).
```

The Satterthwaite test method was used to estimate the significance of fixed effects. LMM analyses were conducted using the R packages *afex* (v. 1.4-1; Singmann et al., 2024), *lme4* (v. 1.11.1; Bates et al., 2015), and *emmeans* (Lenth, 2024). Results of this analysis are reported in Section 4.2.4.

Finally, a multilevel mediation model was estimated to account for the dataset nested structure (44 SBJs; 30 stim, 1320 observations) to examine whether the Mentalizing EEG correlates and the Narrative perception EEG correlates mediated the effect of NS on the ad effectiveness outcome variables (ad liking, sharing intent, purchase intent, and recommendation intent), thus following the model that was estimated with the self-report data but fitting the newly extracted EEG correlates of Mentalizing and Narrative perception as mediators. The model was implemented in R using the *lavaan* package (Rosseel, 2012) and visualized with *lavaanPlot* (v. 0.8.1; Schulte, 2022). The exact model specification and the results of this analysis are reported in Section 4.2.5.

4. Results

4.1. Self-report results

Regarding internal reliability of the narrative-related scores, the Narrative Understanding scale showed acceptable internal reliability ($\omega = 0.789$), while the Narrative Presence scale demonstrated excellent internal reliability ($\omega = 0.910$).

Correlation analyses revealed that mentalizing, narrative transportation, narrative presence, and narrative understanding were all highly intercorrelated (Spearman's ρ , $p < .001$). Similarly, strong positive correlations were observed among the dependent variables related to perceived ad effectiveness (ad liking, recommendation intent, sharing intention, and purchase intention) (Spearman's ρ , $p < .001$). Further details on these results are reported in the Appendix, Section 14.

LMMs results revealed a significant effect of NS across all key variables.

Regarding narration-related variables, self-reported *Mentalizing* was significantly higher in the *High* NS condition compared to the *Low* one ($\beta = 1.169$, $SE = 0.077$, $df = 44$, $t = 15.201$, $p < .001$), *Narrative Transportation* was significantly higher in the *High* NS condition compared to the *Low* one ($\beta = 0.516$, $SE = 0.057$, $df = 43.999$, $t = 8.982$, $p < .001$), *Narrative Understanding* was significantly higher in the *High* NS condition ($\beta = 0.464$, $SE = 0.054$, $df = 43.999$, $t = 8.555$, $p < .001$) than in the *Low* one, as was *Narrative Presence* ($\beta = 0.442$, $SE = 0.057$, $df = 43.999$, $t = 7.761$, $p < .001$). Estimated marginal means for each narrative variable by condition (NS) are reported in **Table 3.2**.

Note how, among all the narration-related variables examined in relation to NS, the mentalizing score - rather than the narrative scales - emerges as the one most strongly influenced by the presence of a high NS.

<i>Estimated Marginal Means</i>					
Narration-related Variable	NS	Estimate	SE	95% CI	
				Lower	Upper
Mentalizing	High	4.329	0.180	3.976	4.682
	Low	1.991	0.130	1.736	2.246
Narrative Transportation	High	3.201	0.155	2.896	3.505
	Low	2.168	0.125	1.923	2.413
Narrative Understanding	High	5.695	0.092	5.514	5.876
	Low	4.767	0.100	4.572	4.962
Narrative Presence	High	3.183	0.185	2.821	3.545
	Low	2.300	0.169	1.969	2.630

Table 3.2. Estimated Marginal Means for Narration-related Variables by NS Condition. *Estimated marginal means (EMMs), standard errors (SE), and 95% confidence intervals (CI) for Mentalizing, Narrative Transportation, Narrative Understanding, and Narrative Presence, presented separately for the High and Low Narrative Structure conditions.*

Regarding Ad effectiveness measures (our dependent variables), LMMs results also revealed a significant effect of NS across all key variables.

Specifically, *Ad liking* was significantly higher in the *High* NS condition compared to the *Low* one ($\beta = 0.406$, $SE = 0.066$, $df = 44$, $t = 6.156$, $p < .001$), *Sharing intent* was significantly higher in the *High* NS condition compared to the *Low* one ($\beta = 0.356$, $SE = 0.059$, $df = 44$, $t = 6.072$, $p < .001$), *Purchase intent* was significantly higher in the *High* NS condition ($\beta = 0.165$, $SE = 0.046$, $df = 43.583$,

$t = 3.580, p < .001$) than in the *Low* one, as was *Recommendation intent* ($\beta = 0.187, SE = 0.043, df = 44, t = 4.356, p < .001$). Estimated marginal means for each Ad effectiveness measure by condition (NS) are reported in **Table 3.3**.

LMMs were also estimated with the Brand variable as a random effect (to account for brand-related effects), using the model:

`variablename ~ NS + (1 | Sbj) + (1 + NS | Brand)`

The inclusion of the brand did not substantially alter the results: all fixed effects remained highly significant, indicating that **the effect of NS on the variables is robust** and not influenced or partially driven by brand-level variability.

Regarding the EFA conducted on the individual items of the narration-related variables, Sampling adequacy was confirmed by a Kaiser-Meyer-Olkin (KMO) measure of 0.821, with all individual measures of sampling adequacy (MSA) above 0.75. Bartlett's test of sphericity was significant, $\chi^2(36.000) = 5735.633, p < .001$, indicating that the correlation matrix was factorable. The EFA revealed a **clear two-factor structure (Figure 3.5)**. It accounted for 55.8% of the total variance (**Table 3.4**), which is considered acceptable and satisfactory for psychological constructs exploration.

Ad effectiveness measures	NS	Estimate	SE	95% CI	
				Lower	Upper
Ad liking	High	4.486	0.163	4.167	4.805
	Low	3.674	0.141	3.398	3.950
Sharing intent	High	3.064	0.163	2.744	3.384
	Low	2.351	0.133	2.090	4.214
Purchase intent	High	3.921	0.149	3.629	3.855
	Low	3.591	0.135	3.327	4.962
Recommendation intent	High	3.505	0.158	3.196	3.815
	Low	3.132	0.145	2.848	3.415

Table 3.3. Estimated Marginal Means for Dependent Variables (ad effectiveness measures) by NS Condition. Estimated marginal means (EMMs), standard errors (SE), and 95% confidence intervals (CI) for Ad liking, Sharing intent, Purchase intent, and Recommendation intent, separately for the High and Low Narrative Structure conditions. Overall, significantly higher values were found with High NS stimuli.

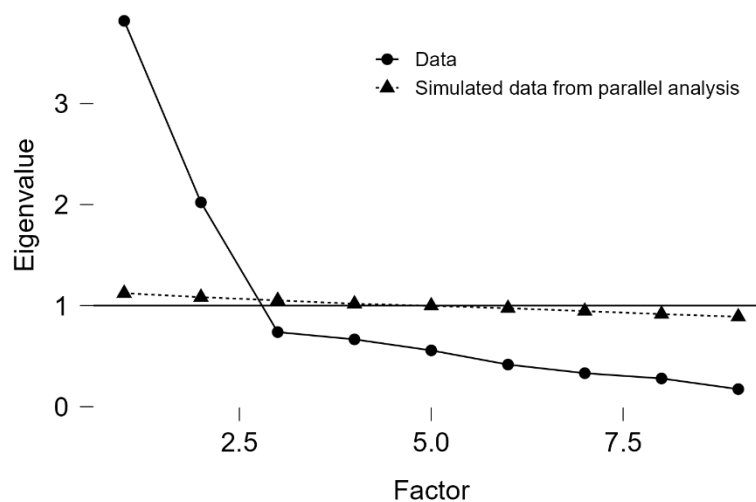


Figure 3.5: Scree plot showing eigenvalues of extracted factors. The inflection point after factor 2 suggests a two-factor solution, in line with Kaiser criterion (eigenvalues > 1) and the EFA results.

Factor Characteristics

	Eigenvalues	Unrotated solution			Rotated solution		
		SumSq. Loadings	Proportion var.	Cumulative	SumSq. Loadings	Proportion var.	Cumulative
Factor 1	3.818	3.432	0.381	0.381	2.975	0.331	0.331
Factor 2	2.022	1.591	0.177	0.558	2.047	0.227	0.558

Table 3.4: Factor characteristics of the EFA. The table reports eigenvalues, loadings, variance explained, and cumulative variance for both the unrotated and oblimin-rotated solutions. The two extracted factors together explain 55.8% of the total variance after rotation, supporting the retention of a two-factor model.

The first factor included items from the Narrative transportation, and Narrative presence scales, while the second factor was composed of items from the Narrative understanding scale (**Figure 3.6**). All factor loadings exceeded .578 (**Table 3.5**). The correlation between the two factors was positive and “weak” ($r = 0.281$).

Factor loadings

Item	Factor 1	Factor 2	Uniqueness
Narrative presence 1	0.909		0.177
Narrative presence 3	0.858		0.258
Narrative presence 2	0.842		0.316
Narrative transportation 1	0.590		0.571
Narrative transportation 2	0.536		0.698
Narrative understanding 1		0.822	0.332
Narrative understanding 4		0.718	0.512
Narrative understanding 3		0.645	0.492
Narrative understanding 2		0.614	0.622

Table 3.5: Factor loadings from the oblimin-rotated EFA. The table displays the loadings of each item on the two extracted factors. Items related to narrative transportation and narrative presence load predominantly on Factor 1, while items on narrative understanding load on Factor 2. All loadings exceed 0.578, indicating strong associations between items and their respective factors.

The two extracted factors reflect distinct dimensions of ad processing. The first factor (*Narrative Transportation and Presence*) includes items from narrative presence and transportation and seems to capture the immersive aspects of narrative engagement. The second factor (*Narrative Understanding*) is composed exclusively of narrative understanding items and seems to portray more reflective processes related to finding meaning in what is seen in the ad narrative.

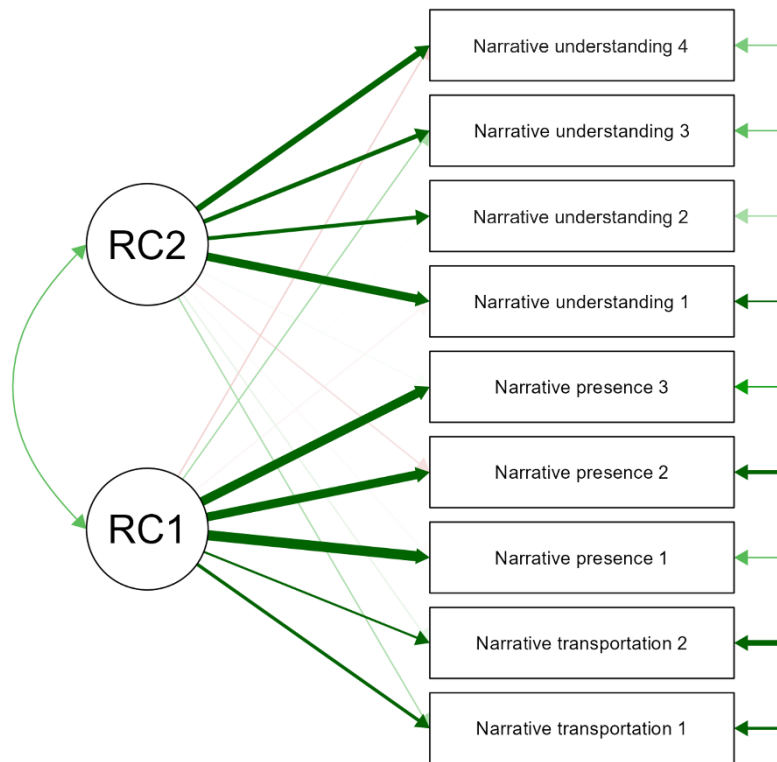


Figure 3.6: Path diagram of the two-factor solution. The path diagram illustrates a clear two-factor structure, with Factor 1 loading on items related to narrative presence and transportation, and Factor 2 loading on items from narrative understanding. Note that “RC1” = Rotated Component 1; “RC2” = Rotated Component 2.

The **multilevel mediation model** (Figure 3.7) posited that NS predicts three mediators (Narrative Transport/Presence, Narrative Understanding, and Mentalizing), which in turn predict four dependent outcomes: Liking, Sharing, Purchase Intention, and Recommendation Intention.

The independent variable (NS) significantly influenced the three mediators: Narrative Transport/Presence ($\beta = 0.637$, $SE = 0.071$, $p < .001$, $Std.all^7 = 0.319$), Narrative Understanding ($\beta = 0.636$, $SE = 0.076$, $p < .001$, $Std.all = 0.313$), and Mentalizing ($\beta = 2.338$, $SE = 0.154$, $p < .001$, $Std.all = 0.577$). The largest standardized effect was thus observed on Mentalizing, followed by Narrative Transport/Presence and Narrative Understanding.

The mediators significantly predicted all four outcome variables (Liking, Sharing, Purchase, and Recommendation). Ad Liking was significantly predicted by Narrative Transport/Presence ($\beta = 0.572$, $SE = 0.101$, $p < .001$, $Std.all = 0.343$), Narrative Understanding ($\beta = 0.551$, $SE = 0.072$, $p < .001$, $Std.all = 0.330$), and Mentalizing ($\beta = 0.196$, $SE = 0.050$, $p < .001$, $Std.all = 0.239$), Sharing Intent was significantly predicted by Narrative Transport/Presence ($\beta = 0.608$, $SE = 0.112$, $p < .001$, $Std.all = 0.360$), Narrative Understanding ($\beta = 0.371$, $SE = 0.070$, $p < .001$, $Std.all = 0.220$), and Mentalizing ($\beta = 0.122$, $SE = 0.056$, $p = .028$, $Std.all = 0.147$), Purchase Intent was significantly predicted by Narrative Transport/Presence ($\beta = 0.390$, $SE = 0.107$, $p < .001$, $Std.all = 0.213$), Narrative Understanding ($\beta = 0.513$, $SE = 0.082$, $p < .001$, $Std.all = 0.121$), and Mentalizing ($\beta = 0.109$, $SE = 0.054$, $p = .042$, $Std.all = 0.121$), and Recommendation Intent was significantly predicted by Narrative Transport/Presence

⁷ Std.all = Standardized estimate. These coefficients reflect the strength of associations when all variables are standardized, allowing for direct comparison across paths regardless of the original measurement scale.

($\beta = 0.410$, $SE = 0.117$, $p < .001$, $Std.all = 0.232$), Narrative Understanding ($\beta = 0.490$, $SE = 0.088$, $p < .001$, $Std.all = 0.278$), and Mentalizing ($\beta = 0.108$, $SE = 0.054$, $p = .044$, $Std.all = 0.125$).

Regarding the direct effects of NS on the ad effectiveness outcome variables, NS significantly predicted Ad Liking ($\beta = -0.357$, $SE = 0.148$, $p = .016$, $Std.all = -0.107$), Purchase Intent ($\beta = -0.495$, $SE = 0.133$, $p < .001$, $Std.all = -0.136$), and Recommendation Intent ($\beta = -0.448$, $SE = 0.129$, $p < .001$, $Std.all = -0.127$), but had no significant effect on Sharing Intent ($\beta = -0.193$, $SE = 0.155$, $p = .214$, $Std.all = -0.057$).

The indirect effects of NS through the three latent mediators were found to be highly significant for all the final dependent variables: Ad Liking ($\beta = 1.169$, $SE = 0.130$, $p < .001$, $Std.all = 0.350$) Sharing Intent ($\beta = 0.905$, $SE = 0.142$, $p < .001$, $Std.all = 0.268$), Purchase Intent ($\beta = 0.825$, $SE = 0.116$, $p < .001$, $Std.all = 0.226$), and Recommendation Intent ($\beta = 0.820$, $SE = 0.120$, $p < .001$, $Std.all = 0.233$).

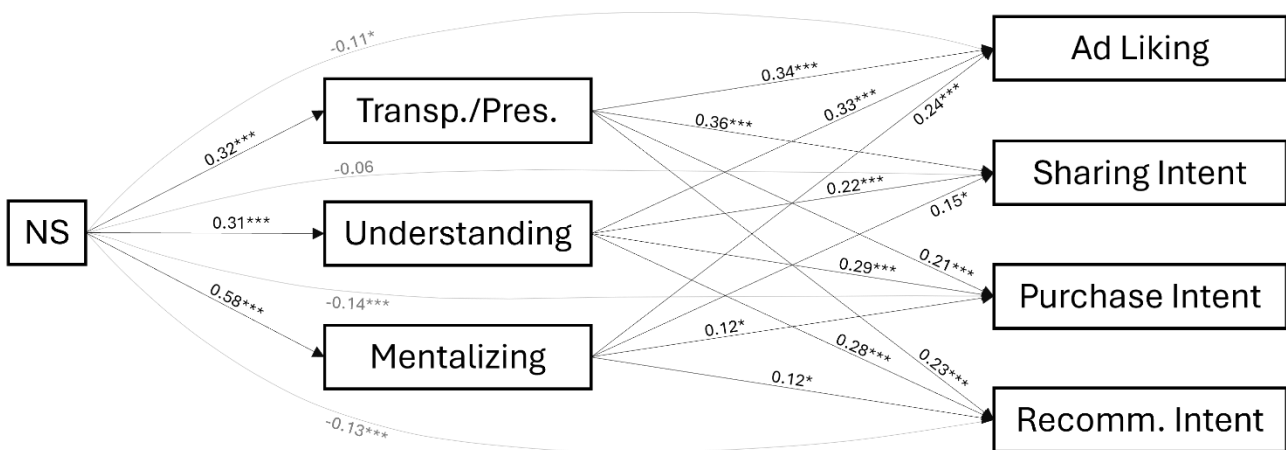


Figure 3.7. Behavioral model based on self-report data. Multilevel mediation model examining the indirect effects of NS on four outcome variables (Ad Liking, Sharing Intent, Purchase Intent, and Recommendation Intent) through three mediators (Narrative Transport/Presence, Narrative Understanding, Mentalizing). Standardized path coefficients (Std.all) are reported. Asterisks indicate significance levels: *** = $p < .001$, ** $p < .01$, * $p < .05$.

4.2. EEG Results

4.2.1. Mentalizing correlates

Following the procedure outlined in Section 3.5.1 (a) Mentalizing EEG Localizer estimation), the contrasts (LMMs) between GD and ToM stimuli revealed a series of main activation patterns across the main frequency bands (only 10% with the largest estimated difference were selected and are presented here).

The results ($N = 790$ contrasts) are presented in tables in the following pages, organized by frequency band: Delta: 1–4 Hz (**Table 3.6**), Theta: 5–7 Hz (**Table 3.7**), Alpha: 8–13 Hz (**Table 3.8**), Beta: 14–29 Hz (**Table 3.9**), and Gamma: 30–125 Hz (**Table 3.10**). **Figure 3.8**, instead, shows topographical representations, again divided by frequency band (five subfigures corresponding to Delta, Theta, Alpha, Beta, and Gamma bands) for the retained “Mentalizing” EEG correlates.

Delta band (1-4 Hz)

	Ch	Fr	Est.	t ratio	P Holm
1	AF8	1	-1.0040	-2.200	0.0332
2	F8	1	-0.7147	-3.701	0.0006
3	F7	1	-0.6531	-2.857	0.0066
4	FT7	1	-0.3740	-2.686	0.0102
5	AF7	1	-0.3510	-1.478	0.1468
6	P10	1	-0.2711	-0.834	0.4089
7	FT8	1	-0.2615	-1.639	0.1088
8	Fp2	1	-0.2593	-2.185	0.0344
9	F6	1	-0.2546	-2.375	0.0221
10	F8	2	-0.2285	-3.295	0.0020
11	AF8	2	-0.2284	-2.607	0.0125
12	FC6	1	-0.2256	-2.793	0.0078
13	PO3	1	0.2097	1.512	0.1379
14	Fp1	1	-0.1888	-1.822	0.0755
15	F5	1	-0.1827	-2.207	0.0327
16	F7	2	-0.1754	-2.075	0.0440
17	FC5	1	-0.1518	-1.982	0.0539
18	PO3	2	0.1433	2	0.0518
19	CP2	1	-0.1268	-1.365	0.1794
20	T8	1	-0.0985	-0.687	0.4959
21	CP6	1	-0.0981	-1.017	0.3150
22	P7	1	-0.0938	-1.158	0.2533
23	FT7	2	-0.0911	-1.845	0.0719
24	C6	1	-0.0846	-1.744	0.0884
25	CP2	2	-0.0845	-1.158	0.2533
26	C5	1	-0.0844	-1.250	0.2180
27	PO7	1	-0.0837	-1.542	0.1304
28	F6	2	-0.0826	-1.854	0.0706
29	T7	1	-0.0802	-0.766	0.4477
30	TP8	1	-0.0790	-1.109	0.2735
31	P3	1	-0.0786	-1.446	0.1557
32	P7	2	-0.0780	-2.362	0.0228
33	P4	1	0.0754	0.839	0.4061
34	P1	2	0.0698	1.482	0.1456
35	Fpz	1	-0.0688	-0.681	0.4997
36	Iz	2	0.0678	1.067	0.2921
37	C4	1	-0.0678	-1.059	0.2954
38	Iz	1	0.0654	0.444	0.6590
39	FC6	2	-0.0648	-2.132	0.0388
40	AF7	2	-0.0597	-0.544	0.5890
41	F8	3	-0.0587	-2.652	0.0112
42	POz	1	0.0583	0.761	0.4507
43	P9	2	0.0583	0.839	0.4062
44	P6	1	0.0578	0.905	0.3706
45	O1	2	0.0573	1.218	0.2298
46	AF8	3	-0.0566	-1.814	0.0766
47	P4	2	0.0542	1.577	0.1221
48	PO8	2	0.0535	0.576	0.5673
49	FC2	1	0.0514	0.833	0.4092
50	F2	1	0.0502	0.778	0.4411
51	F2	2	0.0500	1.357	0.1817
52	P2	2	0.0487	0.857	0.3962
53	POz	2	0.0468	1.149	0.2569
54	PO3	3	0.0458	1.444	0.1560
55	C2	1	0.0457	0.697	0.4894
56	TP7	1	-0.0452	-0.688	0.4950
57	F5	2	-0.0451	-0.939	0.3530
58	F1	1	0.0444	0.571	0.5711
59	CP2	3	-0.0442	-1.481	0.1458
60	F7	3	-0.0432	-1.543	0.1301
61	Pz	1	-0.0421	-0.962	0.3414
62	FC2	2	0.0421	1.077	0.2874
63	O2	1	-0.0408	-0.900	0.3731
64	AF3	2	0.0388	0.665	0.5096

Delta band (1-4 Hz)

	Ch	Fr	Est.	t ratio	P Holm
65	FCz	1	0.0383	0.526	0.6016
66	AF3	3	0.0380	1.120	0.2690
67	CP3	1	0.0375	0.572	0.5703
68	T7	2	-0.0367	-0.869	0.3896
69	FC1	1	0.0367	0.664	0.5104
70	CP1	2	0.0364	0.749	0.4577
71	P7	3	-0.0334	-2.230	0.0310
72	PO4	1	-0.0328	-0.241	0.8110
73	F6	3	-0.0328	-2.070	0.0444
74	PO8	3	0.0319	0.638	0.5270
75	FC4	1	-0.0306	-0.667	0.5085
76	P6	2	0.0305	0.823	0.4149
77	AF8	4	-0.0299	-1.513	0.1375
78	Fz	2	0.0288	0.737	0.4649
79	FC3	2	0.0285	0.855	0.3971
80	CP5	1	0.0273	0.417	0.6789
81	F7	4	-0.0272	-1.407	0.1666
82	FC5	2	-0.0270	-0.687	0.4955
83	O2	2	-0.0270	-1.402	0.1683
84	F3	2	0.0269	0.609	0.5458
85	FT7	3	-0.0263	-1.412	0.1651
86	F1	2	0.0262	0.605	0.5482
87	FC1	2	0.0260	0.793	0.4319
88	Fp2	2	-0.0255	-0.425	0.6730
89	AF3	4	0.0247	1.123	0.2676
90	CP3	2	0.0247	0.694	0.4916
91	Iz	3	0.0246	0.681	0.4997
92	AF4	1	-0.0244	-0.242	0.8102
93	C6	2	-0.0234	-0.854	0.3981
94	Fz	1	0.0232	0.356	0.7235
95	F8	4	-0.0231	-1.574	0.1228
96	F3	3	0.0228	1.107	0.2746
97	Cz	2	0.0226	0.688	0.4954
98	PO3	4	0.0222	1.158	0.2533
99	FCz	2	0.0218	0.575	0.5682
100	AFz	2	0.0215	0.481	0.6329
101	FC3	3	0.0213	1.275	0.2091
102	P2	3	0.0212	0.701	0.4869
103	Fp1	2	-0.0210	-0.445	0.6584
104	F4	2	0.0207	0.473	0.6385
105	F4	1	-0.0206	-0.219	0.8277
106	F2	3	0.0202	1.023	0.3121
107	P2	1	0.0201	0.171	0.8654
108	O2	3	-0.0195	-1.563	0.1255
109	CP5	2	0.0192	0.532	0.5974
110	PO8	4	0.0189	0.572	0.5706
111	Oz	1	0.0188	0.203	0.8399
112	C1	2	0.0186	0.535	0.5952
113	F3	1	0.0182	0.264	0.7933
114	P7	4	-0.0180	-1.773	0.0833
115	AF7	3	-0.0174	-0.598	0.5532
116	C2	2	0.0165	0.651	0.5184
117	TP8	3	-0.0164	-1.074	0.2888
118	FC2	3	0.0162	0.751	0.4566
119	PO7	2	-0.0162	-0.518	0.6071
120	P4	3	0.0161	1.181	0.2441
121	Cz	1	-0.0159	-0.278	0.7821
122	AFz	3	0.0159	0.767	0.4471
123	P1	3	0.0158	0.869	0.3898
124	AF4	2	0.0154	0.296	0.7683
125	O2	4	-0.0153	-1.381	0.1745
126	P8	2	0.0153	0.436	0.6652
127	FC1	3	0.0147	0.928	0.3584
128	Oz	3	-0.0145	-0.908	0.3690

Delta band (1-4 Hz)

	Ch	Fr	Est.	t ratio	P Holm
129	C3	1	0.0145	0.184	0.8545
130	AF3	1	0.0144	0.161	0.8729
131	Oz	4	-0.0142	-1.129	0.2654
132	CP4	2	0.0142	0.273	0.7863
133	T8	2	-0.0141	-0.245	0.8078
134	F1	3	0.0140	0.622	0.5373
135	C1	1	0.0140	0.210	0.8349
136	FT8	2	-0.0138	-0.140	0.8895
137	CP2	4	-0.0135	-2.703	0.0098
138	F5	3	-0.0131	-0.852	0.3990
139	TP8	4	-0.0130	-1.350	0.1840
140	AF7	4	-0.0130	-0.677	0.5017
141	T7	3	-0.0128	-0.848	0.4010
142	Fz	3	0.0127	0.597	0.5535
143	FC3	4	0.0127	0.943	0.3508
144	F3	4	0.0127	0.909	0.3685
145	Fpz	2	0.0127	0.264	0.7929
146	F6	4	-0.0125	-0.974	0.3355
147	AF4	3	0.0123	0.548	0.5866
148	T8	4	0.0118	0.614	0.5424
149	FC4	2	0.0115	0.389	0.6996
150	P10	4	-0.0113	-0.796	0.4302
151	CP1	3	0.0111	0.618	0.5401
152	FC6	3	-0.0110	-0.878	0.3847
153	Fpz	3	0.0109	0.552	0.5838
154	POz	3	0.0108	0.566	0.5743
155	P4	4	0.0103	1.074	0.2888
156	PO4	2	0.0102	0.186	0.8530
157	P9	3	0.0100	0.308	0.7594
158	AF4	4	0.0094	0.619	0.5392
159	FT8	4	0.0093	0.303	0.7637
160	P5	2	0.0093	0.240	0.8114
161	CP4	4	0.0089	0.882	0.3826
162	O1	1	0.0089	0.149	0.8822
163	P10	2	0.0089	0.191	0.8496
164	CP1	1	-0.0087	-0.097	0.9235
165	FC5	4	0.0087	0.592	0.5571
166	C2	4	-0.0086	-1.569	0.1241
167	Pz	4	-0.0083	-1.396	0.1702
168	PO8	1	0.0083	0.035	0.9724
169	P5	1	0.0081	0.130	0.8970
170	AFz	1	-0.0080	-0.085	0.9327
171	AFz	4	0.0079	0.538	0.5937
172	P3	2	-0.0077	-0.306	0.7608
173	Iz	4	0.0076	0.335	0.7391
174	P3	3	-0.0076	-0.591	0.5580
175	CP3	4	0.0076	0.699	0.4884
176	C3	3	-0.0075	-0.830	0.4114
177	PO7	4	0.0075	0.424	0.6735
178	CPz	4	-0.0074	-1.479	0.1466
179	CP5	4	0.0074	0.561	0.5776
180	PO4	3	-0.0073	-0.313	0.7560
181	F2	4	0.0069	0.517	0.6079
182	C2	3	-0.0067	-0.875	0.3866
183	P6	3	0.0067	0.492	0.6249
184	CPz	3	-0.0067	-0.832	0.4102
185	FCz	3	0.0067	0.374	0.7105
186	O1	3	0.0065	0.360	0.7208
187	P1	1	0.0065	0.115	0.9086
188	C5	2	-0.0062	-0.118	0.9064
189	CP3	3	0.0062	0.379	0.7068
190	Pz	3	-0.0062	-0.555	0.5816
191	PO7	3	-0.0061	-0.317	0.7531
192	F5	4	-0.0060	-0.628	0.5332

Table 3.6. Results of the LMMs (ToM vs GD), corresponding to Mentalizing elicitation in the Delta band.

A total of 192 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the t ratio, and the Holm-corrected p-value (p Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) (N = 17). The ones highlighted in red represent an estimated difference between conditions greater than $+0.1$ (N = 19).

Theta band (5-7 Hz)					Theta band (5-7 Hz)					Theta band (5-7 Hz)							
Ch	Fr	Est.	t ratio	p Holm	Ch	Fr	Est.	t ratio	p Holm	Ch	Fr	Est.	t ratio	p Holm			
1	AF8	6	-0.0246	-2.668	0.0107	27	FC3	6	0.0111	1.288	0.2046	54	P9	7	-0.0081	-0.573	0.5695
2	P7	5	-0.0224	-1.927	0.0607	28	F7	6	-0.0110	-1.564	0.1252	55	P3	7	-0.0079	-1.472	0.1484
3	AF8	5	-0.0223	-1.952	0.0575	29	P2	6	0.0107	0.807	0.4242	56	P5	7	-0.0079	-0.967	0.3389
4	P7	6	-0.0215	-1.812	0.0770	30	O1	5	-0.0106	-1.086	0.2837	57	P1	7	-0.0078	-1.890	0.0655
5	AF8	7	-0.0197	-3.125	0.0032	31	FT7	5	-0.0106	-1.241	0.2215	58	F7	7	-0.0078	-1.564	0.1251
6	F8	6	-0.0189	-3.513	0.0011	32	AFz	7	-0.0106	-0.854	0.3979	59	T7	5	-0.0078	-1.090	0.2817
7	F8	5	-0.0183	-2.111	0.0406	33	Oz	5	-0.0103	-1.180	0.2445	60	O1	6	-0.0077	-0.930	0.3574
8	AFz	6	-0.0182	-1.049	0.2999	34	CP2	6	-0.0100	-1.150	0.2566	61	PO8	7	0.0077	0.435	0.6660
9	F7	5	-0.0169	-1.952	0.0575	35	P10	6	-0.0100	-0.903	0.3715	62	AF7	6	-0.0077	-1.084	0.2844
10	O1	7	-0.0154	-1.341	0.1870	36	Oz	7	-0.0099	-0.993	0.3266	63	FC1	6	0.0074	0.720	0.4752
11	POz	7	-0.0151	-2.131	0.0388	37	F6	6	-0.0097	-2.278	0.0277	64	Fp2	6	-0.0073	-1.264	0.2130
12	P7	7	-0.0148	-1.572	0.1232	38	Oz	6	-0.0096	-1.133	0.2634	65	POz	6	-0.0072	-0.947	0.3490
13	PO3	7	-0.0142	-1.284	0.2060	39	AF7	7	-0.0096	-2.023	0.0493	66	CP4	5	0.0072	1.286	0.2052
14	PO7	7	-0.0139	-0.819	0.4176	40	P8	7	-0.0095	-0.992	0.3266	67	P6	5	0.0072	1.086	0.2834
15	P10	5	-0.0137	-1.172	0.2476	41	CP2	7	-0.0095	-1.894	0.0650	68	Pz	5	-0.0071	-1.834	0.0738
16	Fpz	7	-0.0136	-2.344	0.0238	42	FC3	5	0.0095	1.175	0.2463	69	F2	6	-0.0069	-0.622	0.5373
17	PO4	7	-0.0136	-1.433	0.1590	43	O2	6	-0.0093	-1.160	0.2527	70	CPz	7	-0.0067	-1.711	0.0944
18	AF3	5	0.0131	1.181	0.2442	44	CP2	5	-0.0093	-1.575	0.1225	71	F1	6	-0.0066	-0.552	0.5840
19	Fz	6	-0.0127	-0.755	0.4542	45	F8	7	-0.0092	-2.239	0.0304	72	FCz	5	-0.0066	-1.002	0.3221
20	P10	7	-0.0126	-1.140	0.2608	46	AF7	5	-0.0092	-1.074	0.2890	73	FC3	7	0.0066	0.801	0.4276
21	Fp2	7	-0.0125	-2.288	0.0271	47	O2	7	-0.0091	-1.082	0.2854	74	TP8	7	-0.0064	-1.480	0.1461
22	TP8	6	-0.0120	-2.642	0.0114	48	O2	5	-0.0090	-1.086	0.2835	75	CP4	6	0.0064	1.194	0.2389
23	Pz	7	-0.0116	-2.799	0.0077	49	Pz	6	-0.0084	-2.114	0.0405	76	PO4	6	-0.0064	-0.65	0.5192
24	F3	5	0.0113	1.054	0.2978	50	Cz	5	-0.0083	-1.306	0.1985	77	Fz	7	-0.0064	-0.442	0.6604
25	Fp1	7	-0.0112	-1.712	0.0941	51	TP8	5	-0.0083	-1.420	0.1628	78	FC2	6	-0.0063	-1.376	0.1759
26	Fpz	6	-0.0111	-1.288	0.2048	52	F3	6	0.0083	0.793	0.4322	79	F4	6	-0.0062	-1.008	0.3189
						53	F6	5	-0.0083	-1.513	0.1375						

Table 3.7. Results of the LMMs (ToM vs GD), corresponding to Mentalizing elicitation in the Theta band.

A total of 79 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Chan) and frequency (Freq), the table reports the estimated value (Est.), the t ratio, and the Holm-corrected p-value (p Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) (N = 13).

Alpha band (8-13 Hz)

Alpha band (8-13 Hz)

Alpha band (8-13 Hz)

Alpha band (8-13 Hz)					Alpha band (8-13 Hz)					Alpha band (8-13 Hz)							
Chan	Freq	Est.	t ratio	p Holm	Chan	Freq	Est.	t ratio	p Holm	Chan	Freq	Est.	t ratio	p Holm			
1	O1	10	-0.1457	-1.926	0.0607	106	F2	11	-0.0283	-1.430	0.1599	211	C2	10	-0.0127	-1.816	0.0763
2	PO8	10	-0.1253	-1.567	0.1244	107	P7	11	-0.0281	-1.449	0.1546	212	F4	12	-0.0127	-1.962	0.0563
3	PO7	10	-0.1249	-1.842	0.0723	108	P10	12	-0.028	-2.257	0.0291	213	F8	12	-0.0127	-1.784	0.0815
4	PO7	9	-0.1163	-1.728	0.0912	109	F7	11	-0.0279	-1.975	0.0547	214	AFz	8	-0.0126	-1.878	0.0672
5	PO3	10	-0.1162	-1.564	0.1252	110	P9	11	-0.0277	-1.519	0.1361	215	C2	11	-0.0126	-1.695	0.0974
6	PO8	11	-0.1124	-1.571	0.1234	111	F1	10	-0.0269	-1.352	0.1834	216	Iz	8	-0.0125	-1.126	0.2663
7	POz	10	-0.1118	-1.739	0.0893	112	Fz	10	-0.0266	-1.299	0.2010	217	P6	13	-0.0124	-1.040	0.3044
8	PO4	10	-0.1088	-1.510	0.1383	113	AF8	9	-0.0264	-2.141	0.0380	218	CP2	12	-0.0124	-1.830	0.0742
9	PO4	11	-0.1085	-1.657	0.1049	114	Pz	11	-0.0263	-1.245	0.2199	219	Fp2	13	-0.0123	-1.812	0.0770
10	O1	9	-0.1081	-2.051	0.0464	115	POz	8	-0.026	-2.634	0.0117	220	F6	12	-0.0121	-1.734	0.0901
11	O2	11	-0.1030	-2.145	0.0378	116	O1	13	-0.0259	-1.586	0.1200	221	F1	12	-0.0120	-1.481	0.1458
12	O1	11	-0.1029	-1.802	0.0786	117	F2	10	-0.0257	-1.324	0.1925	222	AF3	12	-0.0120	-1.539	0.1311
13	O2	10	-0.1015	-1.900	0.0644	118	PO4	8	-0.0254	-2.546	0.0146	223	P4	13	-0.0119	-1.753	0.0867
14	Oz	10	-0.0904	-1.966	0.0559	119	Fp1	9	-0.0254	-2.153	0.0370	224	CPz	8	-0.0118	-2.306	0.0261
15	POz	11	-0.0868	-1.659	0.1045	120	Fp2	9	-0.0252	-2.041	0.0474	225	Fz	8	-0.0118	-1.457	0.1523
16	PO7	11	-0.0836	-1.707	0.0949	121	FT8	9	-0.0252	-2.165	0.0361	226	P3	12	-0.0117	-1.166	0.2501
17	PO3	11	-0.0822	-1.331	0.1901	122	F3	10	-0.0251	-1.335	0.1888	227	P7	13	-0.0117	-1.775	0.0831
18	PO3	9	-0.0799	-1.689	0.0984	123	P10	8	-0.0251	-1.863	0.0693	228	AF4	12	-0.0115	-1.408	0.1662
19	P8	10	-0.0785	-1.334	0.1892	124	P9	12	-0.0250	-1.883	0.0665	229	FCz	8	-0.0114	-1.762	0.0851
20	Oz	11	-0.0773	-2.219	0.0319	125	TP8	9	-0.0250	-2.187	0.0342	230	Fp1	13	-0.0113	-1.616	0.1133
21	P6	11	-0.0727	-1.367	0.1788	126	Fpz	9	-0.0249	-2.078	0.0438	231	P6	8	-0.0112	-1.552	0.1281
22	P9	9	-0.0705	-2.532	0.0151	127	O2	13	-0.0241	-2.211	0.0325	232	T8	8	-0.0111	-1.380	0.1748
23	P8	11	-0.0678	-1.410	0.1658	128	P4	12	-0.0237	-2.107	0.0410	233	TP7	10	-0.0110	-0.974	0.3356
24	PO8	9	-0.0669	-1.683	0.0997	129	FC6	10	-0.0236	-2.170	0.0356	234	F8	8	-0.0110	-2.066	0.0449
25	Iz	10	-0.0656	-2.003	0.0515	130	F4	9	-0.0233	-2.034	0.0482	235	P1	12	-0.0109	-1.309	0.1974
26	P4	11	-0.0628	-1.525	0.1346	131	C6	11	-0.0228	-1.268	0.2115	236	C6	12	-0.0109	-2.022	0.0494
27	POz	9	-0.0597	-2.253	0.0294	132	P8	12	-0.0228	-0.970	0.3376	237	CP6	9	-0.0109	-0.999	0.3234
28	P6	10	-0.0596	-1.093	0.2805	133	Oz	8	-0.0227	-2.119	0.0400	238	FC5	9	-0.0109	-1.645	0.1072
29	Oz	9	-0.0579	-2.337	0.0243	134	Iz	13	-0.0227	-3.374	0.0016	239	FT7	11	-0.0108	-1.086	0.2834
30	O1	12	-0.0551	-1.827	0.0746	135	AFz	9	-0.0223	-1.737	0.0895	240	POz	13	-0.0107	-0.672	0.5053
31	O2	9	-0.0549	-2.275	0.0281	136	CP3	11	-0.0223	-1.111	0.2729	241	TP8	12	-0.0107	-1.593	0.1185
32	PO4	9	-0.0542	-2.093	0.0423	137	FC5	10	-0.0223	-1.831	0.0741	242	F7	12	-0.0106	-1.761	0.0853
33	P8	9	-0.0532	-1.613	0.1142	138	F8	9	-0.0221	-2.037	0.0479	243	FC6	12	-0.0105	-2.421	0.0198
34	P4	10	-0.0528	-1.424	0.1617	139	CP2	9	-0.0221	-1.256	0.2160	244	Fz	12	-0.0104	-1.403	0.1679
35	PO8	12	-0.0525	-1.779	0.0823	140	PO4	13	-0.0221	-1.093	0.2807	245	AF7	8	-0.0104	-2.355	0.0232
36	P9	10	-0.0522	-2.082	0.0434	141	P4	9	-0.0221	-1.655	0.1052	246	CP1	11	-0.0104	-1.133	0.2636
37	P10	9	-0.0521	-2.186	0.0343	142	PO8	13	-0.0219	-1.158	0.2534	247	CPz	9	-0.0103	-1.117	0.2706
38	PO7	8	-0.0516	-1.546	0.1295	143	F6	9	-0.0218	-2.008	0.0510	248	PO3	13	-0.0101	-0.437	0.6639
39	Iz	11	-0.0507	-1.811	0.0772	144	FC5	11	-0.0217	-1.998	0.0521	249	T7	10	-0.0101	-1.146	0.2583
40	P7	9	-0.0497	-1.851	0.0710	145	Fz	9	-0.0214	-1.658	0.1045	250	P4	8	-0.0100	-2.323	0.0250
41	Iz	9	-0.0495	-2.276	0.0279	146	C5	11	-0.0214	-1.328	0.1913	251	Pz	12	-0.0100	-1.352	0.1837
42	CP4	11	-0.0485	-1.127	0.2662	147	FC3	11	-0.0213	-1.880	0.0668	252	CP5	9	-0.0099	-1.086	0.2835
43	PO7	12	-0.0474	-1.621	0.1123	148	P7	12	-0.0208	-1.815	0.0765	253	C6	9	-0.0099	-1.290	0.2039
44	O2	12	-0.0472	-2.566	0.0139	149	P5	8	-0.0208	-1.561	0.1259	254	F7	8	-0.0099	-2.188	0.0342
45	P7	10	-0.0459	-1.827	0.0746	150	AF8	12	-0.0206	-2.200	0.0332	255	T8	10	-0.0099	-0.718	0.4767
46	P5	9	-0.0458	-1.699	0.0966	151	AF3	9	-0.0206	-1.797	0.0793	256	C5	10	-0.0098	-0.854	0.3978
47	Fp1	10	-0.0457	-2.012	0.0505	152	P8	8	-0.0205	-1.580	0.1215	257	F1	8	-0.0098	-1.282	0.2066
48	P5	10	-0.0454	-1.498	0.1414	153	Fp2	12	-0.0204	-2.109	0.0408	258	F3	12	-0.0097	-1.453	0.1536
49	AF8	10	-0.0444	-1.981	0.0540	154	F2	9	-0.0204	-1.617	0.1133	259	FC2	8	-0.0097	-1.894	0.0650
50	P1	10	-0.0438	-1.626	0.1112	155	FT8	11	-0.0203	-1.599	0.1172	260	FC5	12	-0.0096	-2.147	0.0375
51	Fp1	11	-0.0438	-1.978	0.0543	156	Fpz	12	-0.0202	-2.083	0.0432	261	F8	13	-0.0094	-2.367	0.0225
52	Fpz	10	-0.0436	-1.787	0.0810	157	FC6	11	-0.0202	-2.236	0.0306	262	FC1	10	-0.0093	-0.581	0.5643
53	Fpz	11	-0.0433	-1.783	0.0816	158	Pz	8	-0.0198	-3.156	0.003	263	Cz	8	-0.0093	-1.694	0.0975
54	P3	10	-0.043	-1.598	0.1176	159	AF7	9	-0.0198	-1.956	0.0570	264	FC1	9	-0.0093	-0.909	0.3683
55	P10	10	-0.0429	-1.554	0.1274	160	P10	13	-0.0194	-2.087	0.0429	265	TP7	8	-0.0092	-0.963	0.3407
56	PO4	12	-0.0426	-1.662	0.1037	161	FC6	9	-0.0193	-2.468	0.0177	266	AF3	8	-0.0092	-1.517	0.1367
57	O1	8	-0.0423	-2.022	0.0494	162	F7	9	-0.0192	-2.415	0.0201	267	F7	13	-0.0091	-2.564	0.0139
58	Fp2	10	-0.0423	-1.834	0.0735	163	FC2	9	-0.0188	-1.908	0.0631	268	CP3	10	-0.0091	-0.579	0.5655
59	Fp2	11	-0.0405	-1.792	0.0802	164	CP6	10	-0.0188	-0.745	0.4601	269	PO8	8	-0.0091	-0.474	0.6379
60	AF8	11	-0.0403	-1.958	0.0567	165	CP4	10	-0.0187	-0.662	0.5112	270	Cz	9	-0.0090	-1.065	0.2930
61	Pz	10	-0.0399	-1.610	0.1150	166	F1	9	-0.0186	-1.523	0.1351	271	C2	9	-0.0090	-1.184	0.2430
62	CP6	11	-0.0396	-1.161	0.2522	167	CP5	11	-0.0186	-1.059	0.2956	272	CP3	9	-0.0089	-1.013	0.3167
63	C4	11	-0.0392	-1.526	0.1342	168	AF4	9	-0.0186	-1.483	0.1454	273	FC3	12	-0.0088	-1.693	0.0977
64	F8	10	-0.0390	-2.056	0.0459	169	P5	12	-0.0185	-1.484	0.1452	274	CP1	9	-0.0088	-1.244	0.2201
65	P9	8	-0.0379	-1.926	0.0608	170	FT7	10	-0.0178	-1.642	0.1078	275	FT8	8	-0.0087	-1.066	0.2927
66	AF7	10	-0.0378	-1.991	0.0529	171	FC4	10	-0.0177	-1.856	0.0703	276	C3	12	-0.0086	-1.839	0.0728

67	AFz	11	-0.0374	-1.719	0.0928	172	FCz	9	-0.0176	-1.579	0.1216	277	AF4	8	-0.0083	-1.333	0.1896
68	AF3	11	-0.0368	-1.768	0.0842	173	P9	13	-0.0176	-2.177	0.0350	278	F2	12	-0.0083	-1.236	0.2233
69	AF3	10	-0.0365	-1.710	0.0945	174	F5	9	-0.0174	-1.917	0.0619	279	C5	12	-0.0082	-1.959	0.0566
70	C3	11	-0.0365	-1.575	0.1226	175	O2	8	-0.0174	-1.953	0.0576	280	CP1	8	-0.0082	-2.024	0.0492
71	Iz	12	-0.0355	-2.857	0.0066	176	FC4	11	-0.0173	-1.836	0.0733	281	FC1	12	-0.0081	-1.260	0.2143
72	AFz	10	-0.0351	-1.598	0.1174	177	C4	10	-0.0172	-1.069	0.2911	282	F2	8	-0.0078	-1.088	0.2829
73	Oz	12	-0.0350	-2.325	0.0250	178	TP8	11	-0.0172	-1.353	0.1833	283	F4	8	-0.0078	-1.188	0.2412
74	P2	11	-0.0347	-1.269	0.2114	179	Fp1	12	-0.0169	-1.839	0.0728	284	P2	12	-0.0077	-0.69	0.4941
75	P3	9	-0.0345	-1.943	0.0588	180	FCz	11	-0.0167	-1.099	0.2777	285	CPz	10	-0.0077	-0.774	0.4434
76	F6	10	-0.0343	-1.961	0.0564	181	PO7	13	-0.0166	-1.024	0.3115	286	CP5	10	-0.0077	-0.613	0.5429
77	P2	10	-0.0342	-1.213	0.2319	182	T8	9	-0.0165	-1.256	0.2157	287	CP5	12	-0.0076	-1.363	0.1800
78	P10	11	-0.0341	-1.685	0.0992	183	CP2	8	-0.0165	-2.329	0.0246	288	CP1	10	-0.0075	-0.853	0.3983
79	F7	10	-0.0340	-2.126	0.0392	184	AF8	8	-0.0163	-2.775	0.0081	289	TP7	11	-0.0075	-0.575	0.5685
80	PO3	12	-0.0337	-0.909	0.3684	185	FC1	11	-0.0161	-1.228	0.2260	290	FC3	10	-0.0074	-0.462	0.6466
81	CP2	11	-0.0335	-1.524	0.1348	186	TP7	9	-0.0161	-1.404	0.1675	291	FC6	8	-0.0073	-1.813	0.0768
82	P5	11	-0.0332	-1.467	0.1495	187	FC4	9	-0.0159	-2.127	0.0392	292	FC2	12	-0.0073	-1.252	0.2175
83	F4	10	-0.0331	-1.858	0.0700	188	P2	9	-0.0158	-1.282	0.2067	293	AF7	12	-0.0073	-0.905	0.3704
84	AF4	11	-0.0330	-1.497	0.1418	189	TP8	10	-0.0156	-1.032	0.3078	294	F6	13	-0.0071	-1.67	0.1021
85	F8	11	-0.0325	-2.110	0.0407	190	FCz	10	-0.0155	-1.007	0.3193	295	F6	8	-0.0071	-1.29	0.2039
86	AF4	10	-0.0325	-1.463	0.1508	191	FC2	10	-0.0155	-1.303	0.1994	296	FT8	12	-0.0071	-1.145	0.2588
87	Fz	11	-0.0324	-1.514	0.1374	192	Fp1	8	-0.0154	-2.545	0.0146	297	P5	13	-0.0070	-0.863	0.3927
88	F5	10	-0.0319	-1.869	0.0685	193	Fpz	8	-0.0153	-3.137	0.0031	298	T7	9	-0.0070	-1.127	0.2662
89	P3	11	-0.0316	-1.534	0.1326	194	AF8	13	-0.0153	-2.012	0.0505	299	F5	13	-0.0069	-1.539	0.1311
90	AF7	11	-0.0312	-1.734	0.0901	195	Fp2	8	-0.0152	-2.833	0.0070	300	FT7	9	-0.0069	-1.024	0.3118
91	PO3	8	-0.0307	-1.567	0.1244	196	C4	12	-0.0146	-1.797	0.0794	301	C1	8	-0.0069	-1.641	0.1082
92	F6	11	-0.0307	-1.963	0.0561	197	P3	8	-0.0146	-1.726	0.0918	302	FCz	12	-0.0068	-1.086	0.2836
93	F4	11	-0.0306	-1.833	0.0737	198	CP4	12	-0.0145	-1.918	0.0618	303	FC5	13	-0.0068	-2.35	0.0234
94	P6	12	-0.0306	-1.652	0.1058	199	FC2	11	-0.0145	-1.304	0.1992	304	P2	8	-0.0067	-0.823	0.4148
95	P6	9	-0.0304	-1.485	0.1448	200	P1	8	-0.0141	-2.079	0.0437	305	AF7	13	-0.0066	-1.157	0.2538
96	F1	11	-0.0304	-1.574	0.1229	201	CP6	12	-0.0141	-2.191	0.0339	306	C2	8	-0.0065	-1.645	0.1073
97	POz	12	-0.0303	-1.374	0.1765	202	C1	11	-0.0138	-1.398	0.1693	307	AFz	13	-0.0065	-1.31	0.1973
98	FT8	10	-0.0303	-1.831	0.0742	203	TP8	8	-0.0135	-2.114	0.0404	308	CP2	13	-0.0065	-1.961	0.0564
99	F5	11	-0.0301	-2.112	0.0405	204	Oz	13	-0.0135	-1.106	0.2751	309	F5	8	-0.0065	-1.296	0.2019
100	P1	11	-0.0298	-1.511	0.1381	205	AFz	12	-0.0133	-1.626	0.1113	310	TP8	13	-0.0064	-1.223	0.2281
101	Pz	9	-0.0298	-2.334	0.0245	206	Fpz	13	-0.0132	-1.908	0.0630	311	T7	11	-0.0064	-0.566	0.5742
102	P1	9	-0.0291	-1.999	0.0520	207	F5	12	-0.0130	-2.201	0.0332	312	FC4	13	-0.0064	-1.412	0.1652
103	P7	8	-0.0291	-1.824	0.0751	208	FC4	12	-0.0129	-1.634	0.1096	313	F4	13	-0.0063	-1.587	0.1197
104	CP2	10	-0.0290	-1.487	0.1443	209	F3	9	-0.0129	-1.164	0.2509	314	C2	12	-0.0062	-1.260	0.2146
105	F3	11	-0.0284	-1.682	0.0998	210	C6	10	-0.0129	-0.981	0.3321	315	Pz	13	-0.0061	-1.133	0.2635

Table 3.8. Results of the LMMs (ToM vs GD), corresponding to Mentalizing elicitation in the Alpha band.

A total of 315 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the *t* ratio, and the Holm-corrected *p*-value (*p* Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) ($N = 65$). The ones highlighted in red represent an estimated difference between conditions greater than $+/-0.1$ ($N = 13$).

Beta band (14-29 Hz)						Beta band (14-29 Hz)						Beta band (14-29 Hz)					
	Ch	Fr	Est.	t ratio	p Holm		Ch	Fr	Est.	t ratio	p Holm		Ch	Fr	Est.	t ratio	p Holm
1	PO4	14	-0.0173	-1.702	0.0960	51	Fpz	21	-0.0087	-1.492	0.1429	102	O2	17	-0.0069	-2.383	0.0218
2	AF8	18	-0.0169	-1.411	0.1655	52	F7	14	-0.0086	-2.925	0.0055	103	FT7	14	-0.0069	-2.236	0.0306
3	O2	14	-0.0160	-2.826	0.0072	53	AF7	16	-0.0086	-1.882	0.0667	104	F8	15	-0.0069	-1.204	0.2352
4	PO8	14	-0.0152	-1.343	0.1864	54	O1	18	-0.0086	-1.241	0.2215	105	PO3	22	-0.0069	-2.145	0.0377
5	AF8	17	-0.0151	-1.484	0.1452	55	Fp2	21	-0.0085	-0.957	0.3439	106	Fp2	29	-0.0069	-1.074	0.2888
6	O1	14	-0.0150	-1.509	0.1386	56	Fp1	15	-0.0084	-1.697	0.0969	107	FT7	17	-0.0068	-1.910	0.0628
7	AF8	19	-0.0150	-1.408	0.1663	57	Fp2	16	-0.0084	-1.242	0.2211	108	PO4	21	-0.0068	-2.618	0.0122
8	AF8	14	-0.0148	-1.887	0.0659	58	PO3	14	-0.0084	-0.679	0.5010	109	T7	27	0.0068	1.141	0.2601
9	P10	14	-0.0143	-1.858	0.0701	59	Fpz	23	-0.0084	-1.882	0.0666	110	F6	17	-0.0068	-1.068	0.2916
10	P9	14	-0.0143	-1.505	0.1396	60	Fpz	29	-0.0083	-1.382	0.1742	111	F8	18	-0.0068	-1.017	0.3151
11	AF8	15	-0.0138	-1.490	0.1436	61	Fp1	21	-0.0083	-1.254	0.2168	112	T8	26	0.0068	2.009	0.0508
12	T8	22	0.0132	2.795	0.0077	62	P7	14	-0.0083	-1.503	0.1402	113	T7	23	0.0068	1.166	0.2499
13	Fpz	18	-0.0130	-1.726	0.0916	63	FT7	19	-0.0082	-1.800	0.0789	114	P9	18	-0.0067	-1.387	0.1724
14	T8	21	0.0126	2.474	0.0174	64	Fp2	22	-0.0082	-1.036	0.3060	115	T8	28	0.0067	2.119	0.0399
15	Fpz	14	-0.0125	-2.074	0.0441	65	Fp2	15	-0.0081	-1.238	0.2223	116	PO8	20	-0.0067	-1.624	0.1118
16	AF8	16	-0.0120	-1.257	0.2154	66	O1	20	-0.0081	-2.557	0.0142	117	T8	27	0.0067	2.136	0.0385
17	Fp2	18	-0.0119	-1.206	0.2343	67	Fp1	22	-0.0081	-1.348	0.1846	118	P4	14	-0.0067	-1.761	0.0853
18	T8	19	0.0118	2.061	0.0454	68	Fpz	15	-0.0080	-1.403	0.1678	119	F6	18	-0.0067	-0.956	0.3445
19	AF8	20	-0.0118	-1.273	0.2099	69	FT8	23	0.0080	1.250	0.2181	120	Fp1	24	-0.0067	-1.105	0.2754
20	Fpz	17	-0.0117	-1.705	0.0954	70	F8	17	-0.0080	-1.339	0.1876	121	PO7	21	-0.0066	-1.964	0.0560
21	Fp2	14	-0.0116	-1.905	0.0635	71	FT7	18	-0.0080	-2.031	0.0485	122	TP8	14	-0.0066	-2.486	0.0169
22	T8	20	0.0116	2.239	0.0304	72	T8	23	0.0079	2.131	0.0388	123	F8	19	-0.0066	-1.044	0.3025
23	Fp1	14	-0.0116	-2.121	0.0397	73	T8	29	0.0078	2.602	0.0127	124	Fp1	26	-0.0066	-1.259	0.2150
24	Fpz	19	-0.0113	-1.791	0.0804	74	O1	21	-0.0078	-2.396	0.0210	125	P10	15	-0.0066	-0.882	0.3827
25	Fp1	18	-0.0111	-2.057	0.0458	75	Fp1	23	-0.0078	-1.304	0.1990	126	T7	26	0.0065	1.135	0.2625
26	Fp2	17	-0.0111	-1.367	0.1787	76	FT7	16	-0.0078	-1.966	0.0557	127	PO7	19	-0.0065	-1.206	0.2344
27	P6	14	-0.0111	-1.914	0.0623	77	FT7	21	-0.0077	-1.527	0.1341	128	CP2	14	-0.0065	-1.587	0.1198
28	PO4	15	-0.0110	-1.655	0.1052	78	T8	25	0.0077	2.307	0.0259	129	PO4	17	-0.0065	-2.478	0.0172
29	PO7	14	-0.0109	-0.860	0.3947	79	FT8	24	0.0075	1.297	0.2017	130	FT8	26	0.0065	1.270	0.2110
30	AF7	17	-0.0107	-2.138	0.0383	80	PO4	20	-0.0075	-2.776	0.0081	131	PO4	16	-0.0064	-1.344	0.1859
31	Fp2	19	-0.0105	-1.286	0.2054	81	P5	14	-0.0075	-1.477	0.1469	132	AF8	21	-0.0064	-0.722	0.4741
32	Iz	14	-0.0105	-2.530	0.0151	82	P8	14	-0.0075	-0.840	0.4053	133	P9	17	-0.0064	-1.216	0.2307
33	Fpz	22	-0.0103	-2.137	0.0383	83	F6	14	-0.0074	-1.631	0.1102	134	P9	15	-0.0064	-1.017	0.3148
34	Fpz	20	-0.0102	-1.749	0.0874	84	FT7	20	-0.0074	-1.570	0.1238	135	Fp1	27	-0.0064	-1.151	0.2559
35	Fp1	17	-0.0101	-1.935	0.0596	85	AF7	29	-0.0074	-1.101	0.2771	136	PO3	19	-0.0064	-1.137	0.2619
36	Oz	14	-0.0098	-1.594	0.1184	86	FT8	21	0.0074	0.955	0.3448	137	Oz	19	-0.0063	-2.097	0.0421
37	T8	18	0.0097	1.819	0.0759	87	F7	17	-0.0074	-2.240	0.0303	138	O2	20	-0.0063	-2.945	0.0052
38	AF7	18	-0.0096	-2.029	0.0487	88	T8	24	0.0074	2.142	0.0379	139	F8	16	-0.0063	-1.036	0.3059
39	FT8	22	0.0096	1.471	0.1486	89	F7	19	-0.0073	-1.957	0.0569	140	FT7	22	-0.0063	-1.253	0.2171
40	Fp1	19	-0.0095	-1.632	0.1100	90	T7	24	0.0073	1.288	0.2045	141	AF8	22	-0.0062	-0.644	0.5232
41	Fp1	20	-0.0094	-1.553	0.1278	91	AF7	15	-0.0073	-1.761	0.0854	142	F7	16	-0.0062	-1.967	0.0557
42	O1	19	-0.0093	-1.773	0.0832	92	Fp1	28	-0.0072	-1.335	0.1889	143	PO7	22	-0.0062	-2.491	0.0167
43	F8	14	-0.0092	-2.156	0.0367	93	FT7	15	-0.0072	-2.114	0.0403	144	Fpz	26	-0.0062	-1.390	0.1717
44	Fp2	20	-0.0091	-1.137	0.2617	94	AF7	14	-0.0071	-1.706	0.0953	145	Fpz	24	-0.0062	-1.555	0.1272
45	F7	18	-0.0091	-2.411	0.0203	95	O1	23	-0.0071	-2.821	0.0072	146	P8	16	0.0062	0.460	0.6480
46	Fp1	16	-0.0091	-1.752	0.0869	96	F7	15	-0.0070	-2.328	0.0247	147	T7	28	0.0061	0.982	0.3317
47	Fp1	29	-0.0090	-1.532	0.1328	97	T7	25	0.0070	1.135	0.2626	148	AFz	14	-0.0061	-1.726	0.0915
48	O1	22	-0.0089	-3.126	0.0032	98	Oz	18	-0.0070	-1.922	0.0614	149	Fp1	25	-0.0060	-1.113	0.2717
49	Fpz	16	-0.0089	-1.408	0.1664	99	O1	17	-0.0070	-0.957	0.3440	150	O2	15	-0.0060	-1.686	0.0991
50	Oz	17	-0.0088	-2.646	0.0114	100	PO7	20	-0.0070	-1.993	0.0526	151	PO4	19	-0.0060	-2.006	0.0512
						101	AF8	29	-0.0069	-0.818	0.4177						

Table 3.9. Results of the LMMs (ToM vs GD), corresponding to Mentalizing elicitation in the Beta band. A total of 151 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the t ratio, and the Holm-corrected p-value (p Holm) (N = 39).

Gamma band (30-125 Hz)

Gamma band (30-125 Hz)

Gamma band (30-125 Hz)

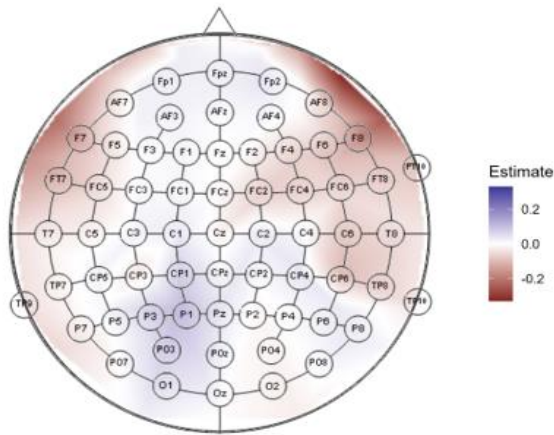
	Ch	Fr	Est.	t ratio	<i>p</i> Holm		Ch	Fr	Est.	t ratio	<i>p</i> Holm		Ch	Fr	Est.	t ratio	<i>p</i> Holm
1	Fp1	31	-0.0096	-1.573	0.1229	19	Fpz	34	-0.0072	-1.659	0.1043	37	Fpz	35	-0.0066	-1.819	0.0759
2	AF8	34	-0.0094	-1.191	0.2402	20	T8	32	0.0071	2.428	0.0194	38	T8	37	0.0066	1.756	0.0862
3	AF8	35	-0.0094	-1.216	0.2306	21	Fp1	34	-0.0071	-1.496	0.1419	39	Fpz	31	-0.0066	-1.217	0.2304
4	AF8	32	-0.0093	-1.026	0.3105	22	Fp1	38	-0.0071	-1.677	0.1008	40	Fp1	37	-0.0065	-1.586	0.1201
5	AF8	33	-0.0089	-1.073	0.2894	23	AF8	37	-0.0071	-1.040	0.3042	41	AF7	39	-0.0064	-1.498	0.1415
6	AF8	38	-0.0089	-1.170	0.2486	24	AF8	31	-0.0070	-0.726	0.4718	42	AF8	41	-0.0063	-0.974	0.3354
7	Fp1	30	-0.0087	-1.429	0.1602	25	AF7	35	-0.0070	-1.617	0.1132	43	AF8	42	-0.0063	-0.970	0.3376
8	Fp1	32	-0.0085	-1.624	0.1117	26	AF7	33	-0.0070	-1.342	0.1867	44	Fp1	35	-0.0063	-1.502	0.1404
9	AF7	32	-0.0082	-1.427	0.1609	27	F7	39	-0.0069	-2.551	0.0144	45	Fp1	44	-0.0063	-1.877	0.0673
10	Fp1	33	-0.0081	-1.668	0.1026	28	Fpz	30	-0.0069	-1.197	0.2377	46	Fp1	36	-0.0063	-1.612	0.1143
11	AF8	36	-0.0080	-1.085	0.2839	29	T8	38	0.0069	1.946	0.0582	47	AF7	38	-0.0063	-1.414	0.1645
12	CP2	100	-0.0079	-1.147	0.2577	30	F7	38	-0.0068	-2.55	0.0144	48	AF8	30	-0.0062	-0.717	0.4771
13	AF7	31	-0.0078	-1.096	0.2791	31	AF8	39	-0.0068	-1.029	0.3094	49	Fpz	38	-0.0062	-1.573	0.1231
14	AF7	34	-0.0077	-1.473	0.1481	32	T8	56	0.0067	2.097	0.0419	50	AF8	43	-0.0061	-0.978	0.3336
15	Fpz	33	-0.0075	-1.524	0.1349	33	Fp1	39	-0.0067	-1.727	0.0914	51	Fp1	40	-0.0061	-1.701	0.0962
16	AF8	40	-0.0075	-1.187	0.2419	34	F7	35	-0.0067	-2.511	0.0159	52	F7	36	-0.0061	-2.424	0.0196
17	AF7	30	-0.0074	-1.027	0.3103	35	AF7	37	-0.0067	-1.603	0.1163	53	F7	37	-0.0060	-2.339	0.0240
18	Fpz	32	-0.0073	-1.462	0.1509	36	T8	36	0.0066	1.791	0.0804						

Table 3.10. Results of the LMMs (ToM vs GD), corresponding to Mentalizing elicitation in the Gamma band. A total of 53 contrasts were retained for this frequency band. Across 3 columns, for each electrode (*Ch*) and frequency (*Fr*), the table reports the estimated value (*Est.*), the *t* ratio, and the Holm-corrected *p*-value (*p* Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) ($N = 7$).

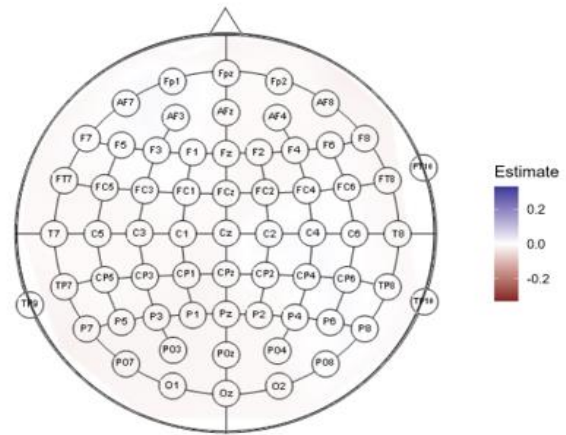
To further refine the analysis and identify the most meaningful contrasts to define the *Mentalizing EEG correlate*, only results that were statistically significant ($p_{Holm} < .05$) and showed an estimated difference greater than 0.1 between the ToM and GD conditions were retained. This selection revealed:

- A **decrease in frontal delta activity**, specifically at 1 Hz (Af8, F8, F7, FT7, Fp2, F6, FC6, and F5), and at 2 Hz (F8, Af8, and F7).
- A **decrease in occipital alpha activity**, specifically at 9 Hz (O1) and 11 Hz (O2).

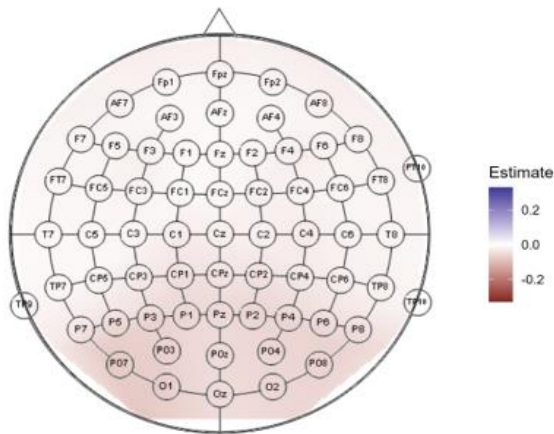
Estimate ToM vs. GD - Delta band (1-4 Hz)



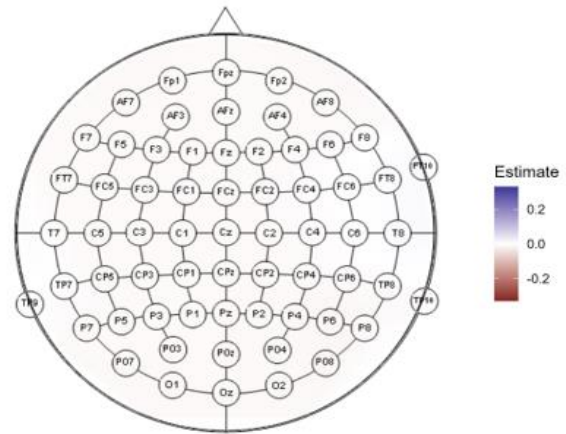
Estimate ToM vs. GD - Theta band (5-7 Hz)



Estimate ToM vs. GD - Alpha band (8-13 Hz)



Estimate ToM vs. GD - Beta band (14-29 Hz)



Estimate ToM vs. GD - Gamma band (30-125 Hz)

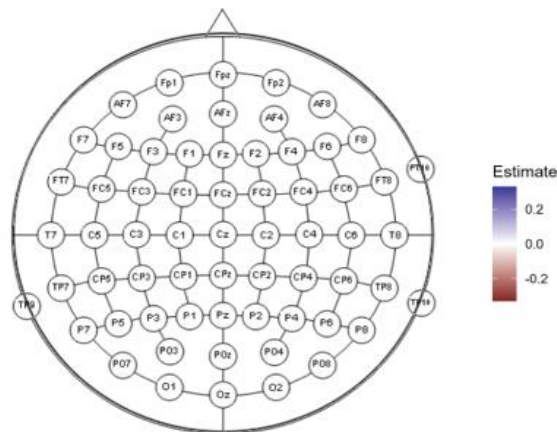


Figure 3.8. Mentalizing EEG activity topoplots. Topographical maps of EEG activity showing the contrast (ToM vs. GD) across Delta, Theta, Alpha, Beta and Gamma frequency bands. Colors and their intensity represent the estimated difference (Estimate) between conditions, with red indicating reduced activity in ToM relative to GD and blue indicating greater activity in ToM relative to GD. Electrode positions (10-20 system, Biosemi) are present. Note that the Gamma band appears nearly white due to the very small number of estimated contrasts and the correspondingly low effects, which remain negligible when plotted on the same global color scale. Topographies were generated in R using the packages ggplot2 (v. 3.5.2; Wickham, 2016), akima (v. 0.6-3.6; Akima & Gebhardt, 2025), and dplyr/tidyr (v. 1.1.4; Wickham et al., 2025).

4.2.2. Narrative perception correlates

Following the procedure outlined in Section 3.5.1 (b) Narrative EEG Localizer estimation), the contrasts (LMs) between Narrative and Control stimuli revealed a series of main activation patterns, across the main frequency bands (only 10% with the largest estimated difference were selected). The results (N = 791 contrasts) are presented via Tables form in the following pages, organized by frequency band: Delta: 1–4 Hz (**Table 3.11**), Theta: 5–7 Hz (**Table 3.12**), Alpha: 8–13 Hz (**Table 3.13**), and Beta: 14–29 Hz (**Table 3.14**). No relevant contrast was found between the Narrative and Control stimuli for the frequencies in the Gamma band (>30 Hz).

Figure 3.9, instead, shows topographical representations, again divided by frequency band (4 subfigures corresponding to Delta, Theta, Alpha, and Beta bands) for the retained “Narrative perception” EEG correlates.

Delta band (1-4 Hz)					Delta band (1-4 Hz)					Delta band (1-4 Hz)							
Ch	Fr	Est.	t ratio	P Holm	Ch	Fr	Est.	t ratio	P Holm	Ch	Fr	Est.	t ratio	P Holm			
1	Fpz	1	-0.5577	-1.3817	0.1742	69	AF8	2	-0.1127	-1.6376	0.1088	137	Fz	3	-0.0224	-1.2306	0.2252
2	Fp1	1	-0.5250	-1.4631	0.1507	70	P10	2	-0.1105	-1.9729	0.0550	138	Oz	3	-0.0219	-1.7868	0.0812
3	Fp2	1	-0.4589	-1.2782	0.2080	71	AFz	2	-0.1079	-1.2220	0.2284	139	Fp2	3	-0.0219	-1.0861	0.2835
4	AF3	1	-0.3859	-1.6344	0.1095	72	PO4	2	-0.1041	-2.1977	0.0334	140	P10	3	-0.0215	-1.3556	0.1823
5	CP6	1	-0.3591	-1.7693	0.0839	73	PO8	2	-0.1019	-1.9629	0.0561	141	FC2	3	-0.0214	-1.4734	0.1479
6	AF7	1	-0.3340	-1.4472	0.1551	74	POz	2	-0.0947	-1.8631	0.0693	142	AF8	3	-0.0202	-1.3657	0.1791
7	AFz	1	-0.3190	-1.4065	0.1668	75	Iz	2	-0.0874	-1.5074	0.1390	143	AFz	3	-0.0202	-1.0494	0.2999
8	Cz	1	-0.3034	-1.5261	0.1343	76	P1	2	-0.0846	-2.0052	0.0513	144	F1	3	-0.0201	-1.2565	0.2157
9	FC2	1	-0.2979	-1.9315	0.0600	77	P9	2	-0.0785	-1.8613	0.0696	145	CP1	3	-0.0193	-1.4618	0.1511
10	FCz	1	-0.2970	-1.5204	0.1357	78	Fz	2	-0.0771	-1.4429	0.1563	146	F2	3	-0.0186	-1.1293	0.2650
11	CP4	1	-0.2921	-2.2179	0.0319	79	P6	2	-0.0763	-1.8360	0.0733	147	CP3	3	-0.0181	-1.5264	0.1342
12	PO4	1	-0.2892	-2.5524	0.0143	80	AF4	2	-0.0747	-1.0102	0.3180	148	TP8	3	-0.0179	-1.4119	0.1652
13	PO8	1	-0.2767	-2.5777	0.0135	81	F3	2	-0.0724	-1.5394	0.1310	149	FC1	3	-0.0176	-1.272	0.2102
14	CP2	1	-0.2718	-1.5039	0.1399	82	TP8	2	-0.0722	-2.0981	0.0418	150	P4	3	-0.0166	-1.3324	0.1898
15	P1	1	-0.2625	-2.6762	0.0105	83	FC2	2	-0.0716	-1.7858	0.0812	151	P6	3	-0.016	-1.3399	0.1873
16	F2	1	-0.2535	-1.8732	0.0679	84	P4	2	-0.0694	-1.8030	0.0784	152	CP4	3	-0.0156	-1.1245	0.2670
17	Iz	1	-0.2459	-1.7068	0.0951	85	P2	2	-0.0687	-1.0975	0.2785	153	P9	3	-0.0153	-0.827	0.4128
18	AF8	1	-0.2453	-1.1674	0.2495	86	F2	2	-0.0652	-1.4632	0.1507	154	C4	3	-0.0147	-1.4278	0.1606
19	AF4	1	-0.2436	-1.2759	0.2088	87	F1	2	-0.0652	-1.2905	0.2038	155	FCz	3	-0.0147	-1.0701	0.2906
20	Fz	1	-0.2376	-1.8289	0.0744	88	CP1	2	-0.0651	-1.6974	0.0968	156	AF4	3	-0.0139	-0.8447	0.4029
21	P2	1	-0.2242	-1.8152	0.0765	89	CP4	2	-0.0604	-1.6797	0.1003	157	PO8	3	-0.0118	-0.8802	0.3836
22	TP8	1	-0.2214	-2.4485	0.0185	90	FC1	2	-0.058	-1.4312	0.1596	158	T8	3	0.0107	0.9700	0.3375
23	F3	1	-0.2181	-1.8452	0.0719	91	F5	2	-0.0573	-1.1062	0.2748	159	C2	3	-0.0106	-1.0712	0.2901
24	CP1	1	-0.2159	-2.1099	0.0407	92	FT8	2	-0.0535	-1.0146	0.3160	160	P7	3	0.0105	1.6019	0.1165
25	CP3	1	-0.2121	-1.8992	0.0643	93	C4	2	-0.0534	-1.8042	0.0782	161	F5	3	-0.0098	-0.642	0.5243
26	POz	1	-0.2027	-1.8112	0.0771	94	FC5	2	-0.0526	-1.8184	0.0760	162	CP5	3	-0.0096	-1.0828	0.2849
27	FT8	1	0.1970	0.6894	0.4943	95	FCz	2	-0.0512	-1.1894	0.2408	163	CPz	3	0.0094	1.2363	0.2232
28	C4	1	-0.1954	-2.0623	0.0453	96	F8	2	-0.0501	-1.0154	0.3156	164	F4	3	0.0094	0.5840	0.5623
29	P4	1	-0.1943	-2.1491	0.0373	97	P5	2	-0.0498	-1.5282	0.1338	165	FC3	3	-0.0092	-1.0313	0.3082
30	FC5	1	-0.1910	-2.2152	0.0321	98	PO3	2	-0.0494	-0.9313	0.3569	166	AF7	3	-0.0091	-0.4996	0.6199
31	F1	1	-0.1906	-1.7638	0.0849	99	CP3	2	-0.0482	-1.4587	0.1519	167	P8	3	0.0086	0.3547	0.7246
32	P6	1	-0.1850	-2.0018	0.0516	100	Oz	2	-0.0482	-1.1834	0.2433	168	P5	3	-0.0082	-1.0095	0.3184
33	PO3	1	-0.1795	-1.4540	0.1532	101	O2	2	-0.0442	-1.1740	0.2470	169	PO3	3	-0.008	-0.5321	0.5974
34	F5	1	-0.1733	-1.3804	0.1746	102	PO7	2	-0.0436	-1.4316	0.1595	170	O2	3	-0.0078	-0.6781	0.5014
35	C2	1	-0.1721	-1.9082	0.0630	103	FC3	2	-0.0425	-1.4485	0.1547	171	CP2	3	0.0071	0.3157	0.7537
36	C1	1	-0.1652	-1.7889	0.0807	104	C1	2	-0.0414	-1.0221	0.3124	172	F8	3	-0.0069	-0.5452	0.5884
37	P5	1	-0.1589	-2.3727	0.0222	105	C6	2	-0.041	-1.5790	0.1217	173	C3	3	-0.0065	-1.2561	0.2159
38	FC1	1	-0.1589	-1.9654	0.0558	106	F6	2	-0.0406	-0.9986	0.3236	174	P2	4	-0.0205	-0.8415	0.4047
39	Pz	1	-0.1580	-2.1873	0.0343	107	C2	2	-0.0402	-1.3737	0.1766	175	POz	4	-0.0196	-2.5147	0.0157
40	O1	1	-0.1434	-1.2927	0.2030	108	TP7	2	-0.0389	-1.7108	0.0943	176	CP6	4	-0.0166	-1.200	0.2367
41	PO7	1	-0.1386	-1.6778	0.1006	109	O1	2	-0.0355	-0.7818	0.4386	177	P8	4	0.0164	0.9892	0.3281
42	P8	1	-0.1259	-0.9718	0.3366	110	CP5	2	-0.0349	-1.2622	0.2137	178	Oz	4	-0.0158	-2.0187	0.0499
43	FC3	1	-0.1059	-1.8269	0.0747	111	Pz	2	-0.0334	-1.2327	0.2245	179	AF3	4	-0.0153	-1.4140	0.1646
44	C5	1	-0.1019	-2.2158	0.0320	112	FC4	2	-0.0332	-0.9601	0.3424	180	Fpz	4	-0.0148	-0.9805	0.3323
45	P9	1	-0.1012	-0.9410	0.3519	113	Cz	2	-0.0326	-0.8499	0.4001	181	CP1	4	-0.0146	-1.5961	0.1178
46	F6	1	-0.1006	-1.0105	0.3179	114	P8	2	-0.0324	-0.5302	0.5987	182	P1	4	-0.0144	-1.8911	0.0654

47	O2	1	-0.0991	-1.1419	0.2599	115	C5	2	-0.0299	-1.6227	0.1120	183	F3	4	-0.0143	-1.2906	0.2037
48	CP5	1	-0.0933	-1.6203	0.1125	116	FC6	2	-0.023	-1.3081	0.1978	184	F1	4	-0.0137	-1.4374	0.1578
49	T7	1	-0.0908	-1.5734	0.1230	117	F4	2	-0.0226	-0.5512	0.5844	185	T8	4	0.0125	1.6058	0.1156
50	TP7	1	-0.0887	-1.7556	0.0863	118	P3	2	-0.0211	-1.1726	0.2475	186	Iz	4	-0.0122	-1.6217	0.1122
51	Oz	1	-0.0823	-0.7171	0.4773	119	P7	2	-0.0209	-0.9179	0.3638	187	FC2	4	-0.0122	-1.3466	0.1852
52	C6	1	-0.0814	-1.6400	0.1083	120	T7	2	-0.0202	-1.1629	0.2513	188	Fz	4	-0.0119	-1.1777	0.2454
53	P3	1	-0.0798	-2.1814	0.0348	121	C3	2	-0.0138	-0.9316	0.3567	189	Fp1	4	-0.0115	-0.7972	0.4297
54	P10	1	0.0782	0.1859	0.8534	122	T8	2	-0.0128	-0.6651	0.5095	190	CP3	4	-0.0097	-1.2888	0.2043
55	C3	1	-0.0746	-1.6172	0.1132	123	CP2	2	-0.012	-0.3615	0.7195	191	PO7	4	-0.0095	-1.208	0.2336
56	P7	1	-0.0726	-1.3192	0.1941	124	CPz	2	-0.0096	-0.3224	0.7487	192	F2	4	-0.0089	-0.9469	0.3490
57	CPz	1	-0.0643	-1.1797	0.2447	125	F7	2	-0.0087	-0.1688	0.8667	193	C2	4	-0.0086	-1.3673	0.1786
58	FT7	1	-0.0627	-0.5439	0.5893	126	Fpz	3	-0.0421	-1.2090	0.2333	194	P10	4	-0.0086	-0.8566	0.3964
59	T8	1	-0.0592	-1.0982	0.2782	127	CP6	3	-0.0372	-1.5778	0.122	195	AFz	4	-0.0082	-1.0262	0.3105
60	F4	1	-0.0533	-0.5513	0.5843	128	Fp1	3	-0.0359	-1.0921	0.2809	196	PO3	4	-0.008	-1.1222	0.268
61	FC4	1	-0.0498	-0.6850	0.4970	129	AF3	3	-0.0309	-1.2624	0.2136	197	FC1	4	-0.0076	-0.8745	0.3867
62	FC6	1	-0.0381	-0.8545	0.3976	130	Iz	3	-0.0293	-1.8135	0.0767	198	C4	4	-0.0075	-1.5283	0.1338
63	Fpz	2	-0.1835	-1.3024	0.1997	131	PO4	3	-0.029	-1.7430	0.0885	199	AF4	4	-0.0074	-0.9709	0.3370
64	Fp2	2	-0.1708	-1.4463	0.1553	132	P2	3	-0.0269	-0.8094	0.4227	200	FCz	4	-0.0073	-0.9579	0.3435
65	Fp1	2	-0.1636	-1.2322	0.2246	133	POz	3	-0.0268	-1.8844	0.0663	201	PO4	4	-0.0071	-0.8304	0.4109
66	CP6	2	-0.1612	-1.6523	0.1058	134	FT8	3	-0.0251	-0.8649	0.3919	202	CP4	4	-0.007	-0.8013	0.4274
67	AF3	2	-0.1326	-1.4551	0.1529	135	F3	3	-0.0231	-1.3312	0.1901	203	F5	4	-0.0069	-0.8606	0.3942
68	AF7	2	-0.1207	-1.2283	0.2260	136	P1	3	-0.0225	-1.5325	0.1327	204	P9	4	-0.0069	-0.6657	0.5091

Table 3.11. Results of the LMMs (Narrative vs Control), corresponding to Narrative perception processes in the Delta band. A total of 204 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the t ratio, and the p-value (p Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) ($N = 17$). The ones highlighted in red represent an estimated difference between conditions greater than ± 0.1 ($N = 46$).

Theta band (5-7 Hz)					Theta band (5-7 Hz)					Theta band (5-7 Hz)							
Ch	Fr	Est.	t ratio	p Holm	Ch	Fr	Est.	t ratio	p Holm	Ch	Fr	Est.	t ratio	p Holm			
1	P2	5	-0.0265	-0.9615	0.3417	39	CP5	7	-0.0126	-1.9685	0.0555	77	AF4	5	-0.0094	-1.6317	0.1101
2	P7	6	-0.0234	-1.5975	0.1175	40	T7	7	-0.0124	-1.9276	0.0605	78	C4	7	-0.0093	-2.0929	0.0423
3	PO7	7	-0.0231	-2.5699	0.0137	41	Fpz	5	-0.0123	-1.252	0.2173	79	TP8	7	-0.0093	-1.5086	0.1387
4	P9	7	-0.0224	-3.0452	0.0040	42	Oz	7	-0.0123	-2.2623	0.0289	80	F3	7	-0.0092	-1.2724	0.2101
5	P7	5	-0.0213	-1.5833	0.1207	43	Oz	6	-0.0121	-2.3211	0.0252	81	T8	5	0.0091	1.3140	0.1958
6	AFz	6	-0.0204	-1.9150	0.0622	44	PO8	7	-0.0119	-1.5985	0.1173	82	AF3	7	-0.0091	-1.5600	0.1261
7	P2	6	-0.0202	-1.0081	0.3190	45	POz	7	-0.0117	-2.0347	0.0481	83	F4	7	-0.0091	-1.4421	0.1565
8	P2	7	-0.0196	-1.7270	0.0914	46	P10	5	-0.0115	-1.6813	0.1000	84	C5	7	-0.0089	-1.7946	0.0797
9	PO7	6	-0.0187	-2.3892	0.0213	47	P5	7	-0.0115	-1.9807	0.0540	85	CP1	5	-0.0088	-1.4953	0.1421
10	PO7	5	-0.0184	-2.162	0.0362	48	PO8	5	-0.0114	-0.8684	0.3900	86	AF4	7	-0.0086	-1.7313	0.0906
11	Oz	5	-0.0182	-3.1636	0.0029	49	P3	7	-0.0113	-2.3793	0.0220	87	F1	5	-0.0085	-1.4498	0.1544
12	AFz	7	-0.0178	-1.4726	0.1482	50	FC1	7	-0.0111	-2.1119	0.0405	88	C6	6	-0.0082	-2.1677	0.0358
13	P9	6	-0.0173	-2.2418	0.0302	51	P8	5	0.011	1.1152	0.2709	89	C2	5	-0.0081	-1.6898	0.0983
14	P10	7	-0.0172	-2.1065	0.0410	52	AF4	6	-0.011	-2.1594	0.0364	90	F3	5	-0.0081	-1.3827	0.1739
15	O1	5	-0.0166	-2.2595	0.0290	53	F2	6	-0.011	-1.7736	0.0832	91	FC2	7	-0.0081	-2.1124	0.0405
16	F1	7	-0.0162	-1.5530	0.1277	54	FCz	7	-0.0109	-2.1081	0.0409	92	CP4	7	-0.0081	-1.4581	0.1521
17	O1	6	-0.0161	-2.6848	0.0103	55	TP7	6	-0.0108	-1.3005	0.2004	93	P5	6	-0.008	-1.2314	0.2249
18	Iz	5	-0.0157	-2.5632	0.0140	56	Fpz	7	-0.0108	-1.9438	0.0585	94	F3	6	-0.0079	-1.5605	0.1260
19	Fz	7	-0.0157	-1.3984	0.1692	57	P8	7	-0.0108	-1.5595	0.1262	95	Cz	7	-0.0079	-1.9650	0.0559
20	P7	7	-0.0156	-2.5947	0.0129	58	F2	5	-0.0107	-1.6311	0.1102	96	FC2	5	-0.0078	-1.7465	0.0879
21	AFz	5	-0.0155	-1.3295	0.1907	59	AF8	6	-0.0105	-1.5579	0.1266	97	Iz	7	-0.0078	-1.3514	0.1836
22	CP6	6	-0.0152	-1.7802	0.0821	60	Fz	6	-0.0105	-1.3221	0.1931	98	T7	6	-0.0076	-0.9599	0.3425
23	TP7	7	-0.0147	-2.0992	0.0417	61	Fp1	7	-0.0104	-1.9607	0.0564	99	O2	7	-0.0072	-1.2737	0.2098
24	O1	7	-0.0145	-2.4946	0.0165	62	PO4	7	-0.0104	-1.5894	0.1193	100	CP3	5	-0.0071	-1.5349	0.1321
25	PO3	7	-0.0141	-2.6843	0.0103	63	AF3	6	-0.0103	-1.8294	0.0743	101	C6	5	-0.007	-2.1477	0.0374
26	CP6	5	-0.014	-1.3355	0.1887	64	CP5	6	-0.0103	-1.6251	0.1115	102	F8	5	-0.007	-1.5231	0.1351
27	P1	7	-0.0139	-2.5951	0.0129	65	CP1	7	-0.0103	-2.1858	0.0343	103	Fp2	5	-0.007	-1.1701	0.2484
28	Pz	7	-0.0139	-1.8484	0.0716	66	P1	5	-0.0102	-1.9038	0.0636	104	C6	7	-0.007	-1.7803	0.0821
29	CP6	7	-0.0137	-1.9464	0.0582	67	P4	7	-0.0101	-1.6606	0.1041	105	FC3	7	-0.007	-1.7025	0.0959
30	POz	5	-0.0134	-2.4527	0.0183	68	FT7	6	-0.01	-1.0869	0.2831	106	P1	6	-0.0069	-1.9086	0.0630
31	CPz	7	-0.0134	-1.9311	0.0602	69	PO3	5	-0.0097	-1.6686	0.1025	107	Fz	5	-0.0068	-0.9234	0.3610
32	P9	5	-0.0133	-1.8733	0.0678	70	Fp1	6	-0.0097	-1.7648	0.0847	108	F7	6	-0.0068	-1.0882	0.2826

33	P10	6	-0.0133	-1.9062	0.0633	71	Fpz	6	-0.0097	-1.3919	0.1711	109	CP3	6	-0.0067	-1.5811	0.1212
34	F2	7	-0.0133	-1.7046	0.0955	72	AF8	5	-0.0096	-1.4977	0.1415	110	FC4	7	-0.0066	-2.1903	0.0340
35	PO8	6	-0.0132	-1.4828	0.1454	73	Fp1	5	-0.0096	-1.0814	0.2856	111	PO4	5	-0.0065	-0.9966	0.3245
36	Iz	6	-0.0131	-2.0711	0.0444	74	PO3	6	-0.0095	-1.7533	0.0867	112	F8	6	-0.0065	-2.0017	0.0516
37	AF3	5	-0.013	-1.6098	0.1148	75	CP3	7	-0.0095	-2.0602	0.0455	113	P3	6	-0.0065	-1.9361	0.0596
38	F1	6	-0.0126	-1.7822	0.0818	76	FT7	7	-0.0095	-1.61	0.1147	114	POz	6	-0.0064	-1.7188	0.0928

Table 3.12. Results of the LMMs (Narrative vs Control), corresponding to Narrative perception processes in the Theta band. A total of 114 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the t ratio, and the Holm-corrected pvalue (p Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) ($N = 30$).

Alpha band (8-13 Hz)					Alpha band (8-13 Hz)					Alpha band (8-13 Hz)							
Ch	Fr	Est.	t ratio	p Holm	Ch	Fr	Est.	t ratio	p Holm	Ch	Fr	Est.	t ratio	p Holm			
1	PO8	10	-0.1047	-4.2745	0.0001	109	F3	9	-0.0300	-3.3853	0.0015	218	Fp1	8	-0.0163	-2.4875	0.0168
2	PO8	11	-0.1027	-4.2584	0.0001	110	AFz	10	-0.0299	-2.7504	0.0087	219	F3	11	-0.0163	-1.821	0.0756
3	PO7	9	-0.0903	-3.5482	0.0010	111	P9	12	-0.0298	-2.8615	0.0065	220	TP8	12	-0.0163	-1.7694	0.0839
4	PO7	10	-0.0885	-2.7387	0.0089	112	AF4	9	-0.0292	-3.9413	0.0003	221	F5	11	-0.0161	-2.2224	0.0316
5	PO4	11	-0.0866	-2.8024	0.0076	113	TP7	9	-0.0288	-2.636	0.0116	222	P3	13	-0.0161	-1.6859	0.0992
6	O1	10	-0.0847	-2.8171	0.0073	114	P9	13	-0.0283	-2.6974	0.0099	223	C4	8	-0.0159	-2.9564	0.0050
7	O1	11	-0.0835	-2.5861	0.0132	115	CP4	9	-0.0280	-3.0849	0.0036	224	F4	11	-0.0159	-1.9069	0.0632
8	PO8	9	-0.0785	-4.0460	0.0002	116	AF7	11	-0.0280	-2.9834	0.0047	225	P7	11	-0.0157	-1.1678	0.2493
9	PO4	10	-0.0785	-2.9935	0.0046	117	P10	13	-0.0279	-2.2113	0.0324	226	F7	11	-0.0156	-2.6008	0.0127
10	PO8	12	-0.0753	-2.8030	0.0076	118	PO8	8	-0.0278	-3.0109	0.0043	227	F4	8	-0.0155	-2.3703	0.0223
11	PO7	11	-0.0752	-2.5222	0.0154	119	F4	9	-0.0277	-3.1076	0.0033	228	FCz	11	-0.0155	-2.2449	0.0300
12	PO4	12	-0.0752	-2.4533	0.0183	120	AF8	9	-0.0276	-3.9533	0.0003	229	AF7	8	-0.0154	-2.5588	0.0180
13	P8	11	-0.0748	-3.1708	0.0028	121	P5	10	-0.0274	-1.7683	0.0841	230	C6	8	-0.0151	-2.9270	0.0055
14	O1	12	-0.0744	-2.7335	0.0091	122	P1	11	-0.0274	-2.1454	0.0376	231	T8	9	-0.015	-2.6628	0.0109
15	O2	11	-0.0729	-3.8896	0.0004	123	P2	12	-0.0274	-2.458	0.0181	232	F6	11	-0.0149	-2.1318	0.0388
16	O2	10	-0.0724	-3.5742	0.0009	124	Iz	8	-0.0273	-3.7893	0.0005	233	C3	11	0.0149	1.2145	0.2312
17	O1	9	-0.0714	-3.6550	0.0007	125	P5	8	-0.0262	-2.9801	0.0047	234	Fpz	8	-0.0148	-2.4211	0.0198
18	PO3	9	-0.0710	-3.6990	0.0006	126	CP2	10	-0.0262	-1.982	0.0539	235	CP2	11	-0.0148	-1.4020	0.1681
19	PO3	10	-0.0707	-2.3948	0.0211	127	PO4	8	-0.0261	-2.3978	0.0209	236	F2	12	-0.0148	-2.3082	0.0259
20	P8	10	-0.0700	-3.2964	0.0020	128	POz	8	-0.0257	-2.4905	0.0167	237	C6	9	-0.0147	-2.7195	0.0094
21	P10	10	-0.0697	-4.1866	0.0001	129	CP3	9	-0.0256	-2.1956	0.0336	238	C2	8	-0.0146	-2.5037	0.0162
22	P10	11	-0.0676	-4.2114	0.0001	130	P3	8	-0.0252	-2.4883	0.0169	239	AF8	12	-0.0146	-2.6916	0.0101
23	PO3	11	-0.0662	-1.9200	0.0615	131	F7	10	-0.0251	-3.3403	0.0017	240	FC6	9	-0.0145	-2.7725	0.0082
24	P6	11	-0.0657	-2.7125	0.0096	132	AF4	10	-0.0251	-3.1392	0.0031	241	P1	13	-0.0144	-1.8830	0.0665
25	P2	9	-0.0652	-2.9655	0.0049	133	P3	10	-0.0249	-1.851	0.0712	242	F5	8	-0.0142	-2.6662	0.0108
26	PO3	12	-0.0644	-2.0236	0.0493	134	Pz	11	-0.0246	-1.8858	0.0662	243	AF4	8	-0.014	-2.6561	0.0110
27	PO8	13	-0.0640	-2.1571	0.0366	135	TP7	8	-0.0244	-3.2880	0.0020	244	FT7	8	-0.014	-1.9761	0.0546
28	PO7	12	-0.0638	-2.5204	0.0155	136	CP5	9	-0.0243	-1.7739	0.0832	245	FC2	10	-0.0139	-2.1321	0.0388
29	P10	9	-0.0635	-4.5825	0.0000	137	Fz	10	-0.0243	-2.2089	0.0326	246	Fp2	12	-0.0139	-2.1169	0.0401
30	PO4	9	-0.0629	-3.6940	0.0006	138	AF8	10	-0.0241	-3.2663	0.0021	247	FC1	10	-0.0136	-1.8198	0.0758
31	P6	10	-0.0626	-2.8708	0.0063	139	P6	8	-0.0239	-2.7917	0.0078	248	AFz	12	-0.0135	-2.0382	0.0477
32	P8	9	-0.0607	-3.5375	0.0010	140	CP1	8	-0.0239	-2.5505	0.0144	249	AF4	12	-0.0134	-2.2630	0.0287
33	POz	10	-0.0593	-2.7770	0.0081	141	TP8	10	-0.0239	-2.1721	0.0354	250	AF3	12	-0.0132	-1.9166	0.0620
34	O2	9	-0.0587	-3.9586	0.0003	142	FCz	9	-0.0238	-3.2014	0.0026	251	FC4	8	-0.0131	-3.0526	0.0039
35	POz	11	-0.0568	-2.1321	0.0388	143	F3	10	-0.0238	-2.1532	0.0370	252	C5	8	-0.013	-2.1437	0.0378
36	Pz	9	-0.0567	-3.0333	0.0041	144	F5	9	-0.0237	-3.4089	0.0014	253	F8	11	-0.013	-1.9108	0.0627
37	P8	12	-0.0567	-1.8922	0.0652	145	F5	10	-0.0236	-2.5676	0.0138	254	FCz	12	-0.013	-2.0866	0.0429
38	POz	9	-0.0553	-3.4784	0.0012	146	Oz	8	-0.0235	-3.608	0.0008	255	C1	8	-0.0129	-3.3328	0.0018
39	P2	10	-0.0553	-2.6017	0.0127	147	F6	9	-0.0234	-3.2218	0.0024	256	TP8	13	-0.0129	-1.2908	0.2037
40	P6	12	-0.0546	-1.9667	0.0557	148	TP8	11	-0.0234	-2.2837	0.0274	257	T7	10	-0.0128	-1.5067	0.1392
41	O1	13	-0.0545	-2.2555	0.0292	149	F2	10	-0.0232	-2.4153	0.0200	258	TP7	10	-0.0128	-1.0141	0.3162
42	P6	9	-0.0542	-3.624	0.0008	150	P4	8	-0.023	-2.6104	0.0124	259	FC2	11	-0.0127	-2.1261	0.0393
43	P8	13	-0.0535	-1.322	0.1931	151	AFz	11	-0.023	-2.3882	0.0214	260	F6	12	-0.0126	-2.5824	0.0133
44	PO7	8	-0.0534	-3.2638	0.0022	152	Fz	8	-0.0228	-2.7339	0.0091	261	Cz	10	-0.0124	-2.7297	0.0092
45	P9	9	-0.0532	-3.5638	0.0009	153	AF3	11	-0.0228	-2.4475	0.0185	262	F4	12	-0.0124	-2.2327	0.0308
46	Iz	10	-0.0527	-3.5848	0.0009	154	O2	8	-0.0226	-3.0537	0.0039	263	C5	9	-0.0122	-1.4653	0.1501
47	Oz	10	-0.0525	-3.4846	0.0012	155	F8	9	-0.0226	-3.5209	0.0010	264	FC5	10	-0.0122	-1.4150	0.1643
48	P1	9	-0.0520	-3.1863	0.0027	156	TP8	8	-0.0224	-3.0682	0.0037	265	Fz	12	-0.0122	-1.9088	0.0630
49	O2	12	-0.0520	-3.0156	0.0043	157	F1	8	-0.0224	-2.8805	0.0062	266	CP6	12	-0.012	-1.2699	0.2109
50	Oz	11	-0.0519	-2.8043	0.0076	158	CPz	10	-0.0224	-2.183	0.0347	267	FC3	8	-0.0119	-2.6152	0.0122

51	PO7	13	-0.0511	-1.8385	0.0729	159	P1	12	-0.0223	-2.5755	0.0135	268	FC2	12	-0.0119	-2.0311	0.0485
52	P7	9	-0.0510	-2.7732	0.0082	160	P5	12	-0.0220	-2.1985	0.0333	269	Pz	13	-0.0119	-1.7691	0.0841
53	PO4	13	-0.0507	-2.0204	0.0496	161	F2	8	-0.0218	-3.0367	0.0041	270	C2	10	-0.0113	-1.7749	0.0830
54	PO3	13	-0.0503	-1.5645	0.1250	162	FC2	9	-0.0217	-3.0794	0.0036	271	Fp2	8	-0.0112	-1.8325	0.0738
55	Iz	11	-0.0502	-3.4716	0.0012	163	F1	10	-0.0217	-1.9273	0.0606	272	F8	12	-0.0112	-2.2394	0.0304
56	POz	12	-0.0497	-2.1811	0.0347	164	F7	9	-0.0216	-2.9285	0.0054	273	TP7	13	-0.011	-1.5421	0.1304
57	P4	10	-0.0488	-2.6904	0.0101	165	T7	9	-0.0214	-2.7676	0.0083	274	F6	8	-0.0109	-1.9472	0.0581
58	Iz	9	-0.0484	-4.3805	0.0001	166	CP6	8	-0.0213	-3.0006	0.0045	275	AF8	8	-0.0109	-1.6843	0.0994
59	Oz	9	-0.0473	-4.1989	0.0001	167	Fp2	11	-0.0211	-2.3877	0.0214	276	FC5	8	-0.0107	-2.4788	0.0172
60	Oz	12	-0.0469	-2.5795	0.0135	168	FC1	9	-0.0207	-3.2653	0.0022	277	F2	13	-0.0107	-2.7408	0.0089
61	P4	9	-0.0459	-3.559	0.0009	169	P5	13	-0.0207	-1.8423	0.0723	278	FT8	8	-0.0106	-1.5849	0.1203
62	P5	9	-0.0441	-2.9269	0.0055	170	P7	13	-0.0206	-1.7534	0.0867	279	F7	8	-0.0106	-1.5656	0.1248
63	P6	13	-0.0434	-1.5078	0.1389	171	Iz	13	-0.0205	-3.1083	0.0033	280	CPz	11	-0.0106	-1.6303	0.1105
64	P4	11	-0.0428	-2.4775	0.0172	172	CP5	8	-0.0199	-2.1633	0.0361	281	TP7	12	-0.0106	-1.2618	0.2138
65	P9	8	-0.0426	-4.3366	0.0001	173	FT7	9	-0.0199	-2.2853	0.0273	282	FC6	8	-0.0105	-2.5308	0.0151
66	P9	10	-0.0412	-2.5685	0.0138	174	F4	10	-0.0196	-2.2916	0.0269	283	F1	12	-0.0104	-1.6144	0.1138
67	P3	9	-0.0410	-2.8348	0.0070	175	CP3	8	-0.0195	-2.3934	0.0211	284	CP6	13	-0.0103	-1.3367	0.1883
68	P10	12	-0.0407	-3.5336	0.0010	176	FCz	8	-0.0194	-3.3915	0.0015	285	C3	8	-0.0101	-2.4521	0.0183
69	Pz	10	-0.0400	-2.5836	0.0133	177	CP6	10	-0.0194	-1.4045	0.1673	286	T8	8	-0.0101	-1.8576	0.0701
70	P1	10	-0.0394	-2.7563	0.0085	178	F2	11	-0.0194	-2.1472	0.0375	287	FT8	10	-0.0098	-1.4076	0.1664
71	P2	11	-0.0394	-2.3334	0.0244	179	AFz	8	-0.0192	-2.541	0.0147	288	C5	10	0.0097	0.5911	0.5575
72	CPz	9	-0.0390	-2.6878	0.0102	180	Cz	9	-0.0191	-2.6338	0.0117	289	CP1	11	-0.0097	-1.4024	0.1680
73	Fp1	10	-0.0389	-2.9469	0.0052	181	C3	10	0.0191	1.0974	0.2786	290	C1	10	-0.0096	-1.6358	0.1092
74	Pz	8	-0.0384	-2.2241	0.0315	182	P7	12	-0.0191	-1.659	0.1044	291	FC1	11	-0.0096	-1.3124	0.1963
75	AF7	10	-0.0376	-3.3423	0.0017	183	P4	13	-0.0190	-1.800	0.0789	292	AFz	13	-0.0096	-2.1706	0.0355
76	P2	8	-0.0368	-2.4300	0.0193	184	Pz	12	-0.0186	-2.3575	0.0231	293	F7	12	-0.0095	-2.5112	0.0159
77	Fpz	10	-0.0368	-2.9996	0.0045	185	F3	8	-0.0185	-2.6134	0.0123	294	F8	8	-0.0094	-1.5893	0.1193
78	P7	8	-0.0366	-3.4554	0.0012	186	FC4	9	-0.0185	-2.9116	0.0057	295	C3	9	-0.0094	-1.2122	0.2320
79	P10	8	-0.0357	-3.7918	0.0005	187	AF8	11	-0.0185	-2.4255	0.0196	296	Fz	13	-0.0094	-2.4000	0.0208
80	O2	13	-0.0356	-2.3879	0.0215	188	Fpz	12	-0.0185	-2.5625	0.0140	297	FC3	10	-0.0093	-1.0316	0.3080
81	Oz	13	-0.0347	-2.3369	0.0243	189	CP2	8	-0.0184	-1.8658	0.0689	298	Fp1	13	-0.0093	-1.6666	0.1029
82	Iz	12	-0.0343	-4.2883	0.0001	190	FT7	10	-0.0184	-1.8493	0.0713	299	FC4	10	-0.0092	-1.2868	0.2050
83	PO3	8	-0.0341	-3.2422	0.0023	191	P5	11	-0.0184	-1.5471	0.1292	300	F3	12	-0.0092	-1.4175	0.1635
84	TP8	9	-0.0337	-3.5148	0.0011	192	Fp1	12	-0.0184	-2.4568	0.0181	301	FCz	13	-0.0091	-2.3981	0.0209
85	P9	11	-0.0337	-2.8049	0.0075	193	P3	12	-0.0184	-1.9589	0.0568	302	Cz	11	-0.0088	-2.4090	0.0204
86	P1	8	-0.0335	-2.2978	0.0265	194	C4	9	-0.0183	-2.5017	0.0162	303	FT8	11	-0.0086	-1.5314	0.1330
87	CPz	8	-0.0333	-2.3994	0.0209	195	C2	9	-0.0183	-2.3935	0.0211	304	FT7	11	-0.0086	-1.1307	0.2644
88	Fp1	9	-0.0333	-3.5309	0.0010	196	AF4	11	-0.0183	-2.1608	0.0363	305	Fpz	13	-0.0086	-1.4986	0.1413
89	Fz	9	-0.0333	-3.0557	0.0038	197	Fz	11	-0.0183	-1.931	0.0601	306	F5	12	-0.0084	-1.6973	0.0969
90	AFz	9	-0.0330	-3.4790	0.0012	198	Cz	8	-0.0181	-2.9046	0.0058	307	C3	12	0.0084	0.7271	0.4711
91	Fpz	9	-0.0329	-3.7140	0.0006	199	P2	13	-0.0180	-2.1581	0.0366	308	FC2	13	-0.0084	-2.3466	0.0236
92	AF3	9	-0.0326	-3.7262	0.0006	200	AF3	8	-0.0179	-2.8321	0.0070	309	FT8	12	-0.0083	-1.9790	0.0542
93	Fp2	9	-0.0323	-4.0750	0.0002	201	F6	10	-0.0179	-2.6147	0.0123	310	F1	13	-0.0083	-1.9305	0.0602
94	P7	10	-0.0321	-1.7957	0.0796	202	C1	9	-0.0175	-3.3808	0.0015	311	AF7	13	-0.0083	-1.4256	0.1612
95	POz	13	-0.0321	-1.6363	0.1091	203	FT8	9	-0.0175	-2.6963	0.0100	312	T8	10	-0.0082	-1.2259	0.2269
96	AF7	9	-0.032	-3.5997	0.0008	204	FC5	9	-0.0172	-2.9709	0.0048	313	CP2	12	-0.0082	-1.3223	0.1931
97	F2	9	-0.032	-3.1911	0.0026	205	FC3	9	-0.0171	-2.9053	0.0058	314	FC6	12	-0.0081	-2.0595	0.0455
98	CP2	9	-0.0318	-2.5052	0.0161	206	F8	10	-0.0171	-2.5689	0.0138	315	FC5	11	-0.0078	-1.4111	0.1654
99	O1	8	-0.0316	-3.648	0.0007	207	CP4	10	-0.0170	-1.1354	0.2625	316	AF4	13	-0.0077	-1.9216	0.0613
100	AF3	10	-0.0316	-2.8552	0.0066	208	T7	8	-0.0169	-2.4011	0.0207	317	CPz	12	-0.0075	-2.0932	0.0424
101	Fp1	11	-0.0315	-2.7594	0.0085	209	P3	11	-0.0169	-1.4824	0.1457	318	AF3	13	-0.0074	-1.3874	0.1725
102	Fp2	10	-0.0312	-3.296	0.0020	210	FC1	8	-0.0168	-3.4013	0.0015	319	Cz	12	-0.0073	-1.9839	0.0537
103	F1	9	-0.0311	-3.1123	0.0033	211	AF7	12	-0.0168	-2.5772	0.0135	320	C5	11	0.0072	0.7608	0.4509
104	CP6	9	-0.0308	-3.1446	0.0030	212	FC2	8	-0.0166	-3.4314	0.0013	321	TP7	11	-0.0069	-0.7005	0.4874
105	CP1	9	-0.0306	-2.871	0.0063	213	CP1	10	-0.0165	-1.7146	0.0936	322	F4	13	-0.0068	-2.0634	0.0451
106	Fpz	11	-0.0305	-2.7397	0.0089	214	F1	11	-0.0165	-1.7712	0.0836	323	FC6	10	-0.0066	-1.1247	0.2669
107	P4	12	-0.0303	-2.1045	0.0412	215	CP4	8	-0.0164	-2.5756	0.0135	324	CP1	12	-0.0064	-1.6812	0.1000
108	P8	8	-0.0302	-2.5553	0.0142	216	FCz	10	-0.0164	-2.1898	0.0340	325	CP2	13	-0.0064	-1.5720	0.1233
						217	CP6	11	-0.0164	-1.5382	0.1313						

Table 3.13. Results of the LMMs (Narrative vs Control), corresponding to Narrative perception processes in the Alpha band. A total of 325 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the *t* ratio, and the Holm-corrected *p*-value (p_{Holm}). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) ($N = 231$). The ones highlighted in red represent an estimated difference between conditions greater than $+0.1$ ($N = 2$).

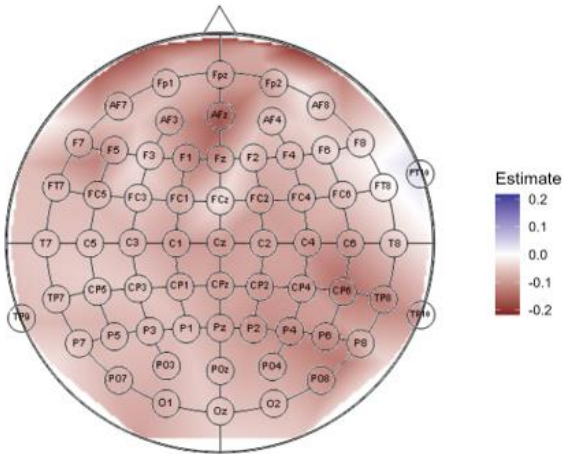
Beta band (14-29 Hz)						Beta band (14-29 Hz)						Beta band (14-29 Hz)					
Ch	Fr	Est.	t ratio	p		Ch	Fr	Est.	t ratio	p		Ch	Fr	Est.	t ratio	p	
				Holm						Holm						Holm	
1	P8	14	-0.0482	-1.3354	0.1888	50	P10	18	-0.0125	-3.2013	0.0026	100	P5	17	-0.0078	-2.1604	0.0364
2	PO8	14	-0.0471	-1.7832	0.0816	51	P6	17	-0.0124	-1.5716	0.1234	101	P3	17	-0.0078	-2.1167	0.0402
3	PO3	14	-0.0454	-1.2962	0.2018	52	Iz	14	-0.0123	-2.2078	0.0326	102	O2	18	-0.0078	-2.7487	0.0088
4	PO7	14	-0.0435	-1.5187	0.1362	53	O2	16	-0.0116	-2.0544	0.0462	103	Fpz	14	-0.0077	-1.2382	0.2224
5	O1	14	-0.0397	-1.7471	0.0878	54	P1	14	-0.0115	-1.6549	0.1052	104	F4	16	-0.0077	-2.1669	0.0358
6	P8	15	-0.0358	-1.3381	0.1879	55	P7	15	-0.0115	-1.5050	0.1396	105	PO7	19	-0.0077	-2.7341	0.0090
7	P6	14	-0.0339	-1.4279	0.1605	56	PO3	18	-0.0111	-2.0156	0.0501	106	AF7	22	0.0077	1.6396	0.1084
8	PO4	14	-0.0324	-1.7037	0.0957	57	PO4	17	-0.0110	-1.7807	0.0820	107	F3	14	-0.0076	-1.4933	0.1427
9	PO8	15	-0.0314	-1.6284	0.1108	58	P2	17	-0.0110	-1.7007	0.0962	108	FCz	15	-0.0076	-3.0643	0.0038
10	PO7	15	-0.0303	-1.6800	0.1002	59	P4	15	-0.0109	-1.9090	0.0630	109	AF4	15	-0.0075	-1.6627	0.1036
11	PO3	15	-0.0275	-1.2933	0.2028	60	P3	15	-0.0109	-1.6164	0.1135	110	AF7	24	0.0075	1.5660	0.1247
12	P10	14	-0.0268	-2.4559	0.0182	61	CP6	14	-0.0105	-1.7011	0.0961	111	AF4	14	-0.0074	-1.3615	0.1804
13	O1	15	-0.0246	-1.7668	0.0844	62	O2	17	-0.0105	-2.4717	0.0176	112	P4	16	-0.0074	-1.9944	0.0525
14	P6	15	-0.0244	-1.3758	0.1760	63	PO8	18	-0.0105	-2.2911	0.0269	113	F2	17	-0.0074	-3.2143	0.0025
15	O2	14	-0.0243	-1.9337	0.0599	64	POz	15	-0.0104	-1.3372	0.1882	114	PO8	21	-0.0074	-2.1185	0.0399
16	P10	15	-0.0237	-3.1269	0.0032	65	Pz	14	-0.0103	-1.8169	0.0764	115	F4	14	-0.0073	-1.5155	0.1370
17	P9	14	-0.0227	-2.6759	0.0105	66	P5	16	-0.0102	-1.8686	0.0685	116	Pz	15	-0.0073	-2.1762	0.0352
18	PO7	16	-0.0224	-2.0996	0.0417	67	P2	16	-0.0100	-1.6413	0.1080	117	PO3	19	-0.0073	-2.519	0.0156
19	P8	16	-0.0221	-1.4898	0.1436	68	F2	14	-0.0096	-2.1180	0.0400	118	Iz	15	-0.0072	-1.8946	0.0649
20	Oz	14	-0.0217	-1.8790	0.0672	69	Oz	16	-0.0096	-2.0981	0.0419	119	Oz	19	-0.0072	-2.6867	0.0103
21	PO4	15	-0.0216	-1.7716	0.0835	70	Fz	14	-0.0095	-2.0677	0.0447	120	PO7	20	-0.0072	-2.3907	0.0213
22	PO8	16	-0.0215	-1.7710	0.0837	71	TP8	15	-0.0094	-1.6405	0.1082	121	FC1	15	-0.0071	-2.9475	0.0052
23	POz	14	-0.0194	-1.3561	0.1821	72	Oz	17	-0.0094	-2.6502	0.0113	122	FC2	15	-0.0071	-2.8868	0.0061
24	O1	16	-0.0194	-2.0801	0.0435	73	P9	18	-0.0094	-3.2203	0.0024	123	F2	16	-0.0071	-2.4661	0.0177
25	P5	14	-0.0188	-1.6302	0.1104	74	P2	18	-0.0094	-1.9583	0.0567	124	PO4	20	-0.0071	-2.3388	0.0241
26	PO3	16	-0.0188	-1.4281	0.1605	75	TP7	14	-0.0093	-1.8567	0.0702	125	AF3	14	-0.007	-1.1917	0.2399
27	PO7	17	-0.0187	-2.9985	0.0045	76	AFz	14	-0.0092	-1.6683	0.1025	126	O2	19	-0.0069	-2.7527	0.0087
28	O2	15	-0.0174	-2.0394	0.0477	77	Fz	15	-0.0092	-2.4260	0.0195	127	FC1	14	-0.0068	-2.3667	0.0225
29	PO8	17	-0.0174	-1.8666	0.0688	78	O1	19	-0.0092	-3.1291	0.0031	128	TP7	15	-0.0068	-2.0341	0.0481
30	P8	17	-0.0174	-1.7502	0.0872	79	FCz	14	-0.0091	-2.9862	0.0046	129	TP8	16	-0.0068	-2.1112	0.0406
31	P7	14	-0.0171	-1.6657	0.1030	80	F1	14	-0.0091	-1.8132	0.0768	130	P6	18	-0.0068	-2.1231	0.0395
32	O1	17	-0.0168	-2.9391	0.0053	81	P1	15	-0.0089	-2.0556	0.0459	131	F3	15	-0.0067	-1.7569	0.0861
33	P10	16	-0.0164	-3.2637	0.0022	82	P7	16	-0.0088	-1.4637	0.1506	132	FC2	16	-0.0067	-3.1541	0.0029
34	P9	15	-0.0161	-3.0284	0.0041	83	P10	19	-0.0088	-2.9008	0.0058	133	Fz	16	-0.0067	-2.4526	0.0183
35	P6	16	-0.0153	-1.5045	0.1398	84	TP8	17	-0.0087	-2.8258	0.0071	134	AF3	15	-0.0066	-1.5405	0.1308
36	P10	17	-0.0153	-2.8336	0.0070	85	PO8	20	-0.0087	-2.3438	0.0238	135	P1	17	-0.0066	-2.2684	0.0284
37	P3	14	-0.0152	-1.5199	0.1360	86	P8	18	-0.0086	-2.3234	0.0250	136	FC4	14	-0.0065	-2.0156	0.0501
38	Oz	15	-0.0152	-2.1375	0.0384	87	PO4	19	-0.0086	-2.7114	0.0096	137	F5	14	-0.0065	-1.6610	0.1040
39	PO3	17	-0.0152	-1.7593	0.0856	88	F2	15	-0.0085	-2.2608	0.0289	138	Fp2	14	-0.0065	-1.1161	0.2706
40	P2	14	-0.0151	-1.9683	0.0555	89	P3	16	-0.0085	-1.8101	0.0774	139	P1	16	-0.0065	-1.9986	0.0520
41	PO7	18	-0.0145	-3.0713	0.0037	90	Fp1	14	-0.0083	-1.3612	0.1805	140	F4	17	-0.0065	-2.4551	0.0182
42	P4	14	-0.0141	-1.8258	0.0748	91	F1	15	-0.0082	-2.1497	0.0372	141	P2	20	-0.0065	-1.6453	0.1072
43	TP8	14	-0.0136	-1.6962	0.0971	92	F4	15	-0.0082	-1.9867	0.0534	142	FC4	15	-0.0064	-2.3854	0.0215
44	P9	17	-0.0133	-3.1138	0.0033	93	P10	20	-0.0082	-3.2500	0.0022	143	Fz	17	-0.0064	-2.6645	0.0108
45	PO4	16	-0.0131	-1.7835	0.0816	94	FC2	14	-0.0081	-2.7088	0.0097	144	P2	19	-0.0064	-2.1358	0.0384
46	P9	16	-0.0128	-2.9870	0.0046	95	PO4	18	-0.0081	-2.1587	0.0365	145	O1	20	-0.0064	-1.9028	0.0638
47	P2	15	-0.0127	-1.8281	0.0745	96	CP6	15	-0.0080	-1.5382	0.1313	146	P10	21	-0.0064	-2.9063	0.0058
48	P5	15	-0.0127	-1.5330	0.1326	97	PO8	19	-0.0080	-2.0798	0.0435	147	AF7	23	0.0064	1.5832	0.1207
49	O1	18	-0.0125	-3.2409	0.0023	98	AFz	15	-0.0079	-1.9206	0.0614	148	AF7	26	0.0064	1.6096	0.1148
						99	Oz	18	-0.0079	-3.0297	0.0042						

Table 3.14. Results of the LMMs (Narrative vs Control), corresponding to Narrative perception processes in the Beta band. A total of 148 contrasts were retained for this frequency band. Across 3 columns, for each electrode (Ch) and frequency (Fr), the table reports the estimated value (Est.), the t ratio, and the p-value (p Holm). Rows highlighted in green indicate values reaching statistical significance ($p_{Holm} < .05$) ($N = 71$).

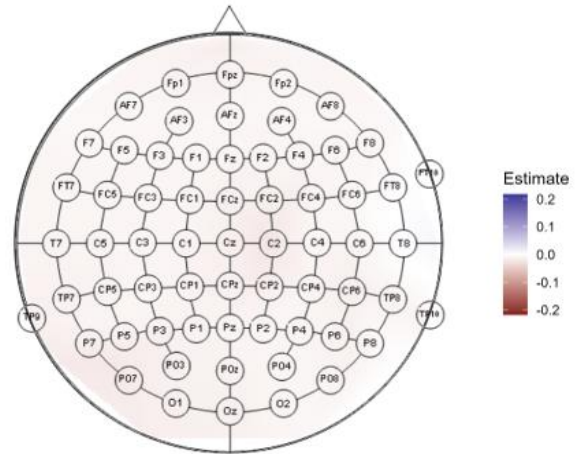
To further identify the most meaningful contrasts to define the EEG correlates of Narrative perception, only statistically significant results ($p_{Holm} < .05$) and with an estimated difference greater than 0.1 between the Narrative and control conditions were retained. This selection revealed:

- A **decrease in centro-parietal delta activity**, specifically at 1 Hz (CP4, CP1, P4, P5, P1, Pz, C4, C5, FC5, PO4, PO8, and TP8).
- A **decrease in parieto-occipital alpha activity**, specifically at PO8 at both 10-11 Hz.

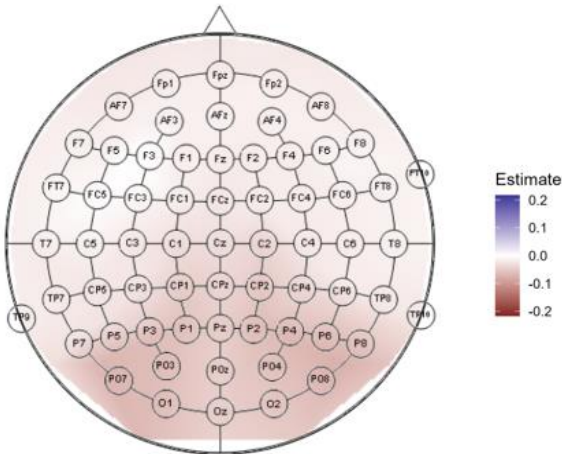
Estimate Narrative vs. Control - Delta band (1-4 Hz)



Estimate Narrative vs. Control - Theta band (5-7 Hz)



Estimate Narrative vs. Control - Alpha band (8-13 Hz)



Estimate Narrative vs. Control - Beta band (14-29 Hz)

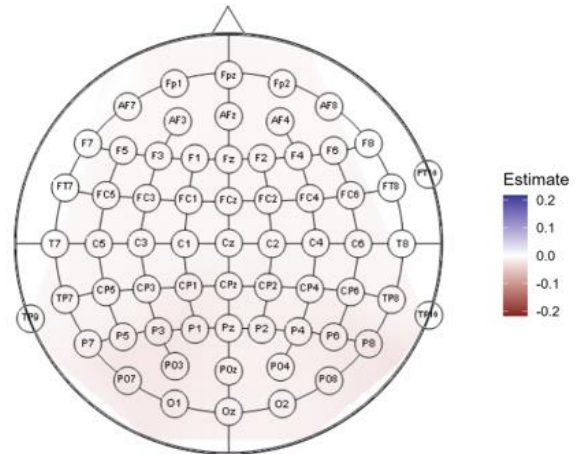


Figure 3.9. Narrative perception EEG activity topoplots. Topographical maps of EEG activity showing the contrast (Narrative vs. Control) across Delta, Theta, Alpha, and Beta bands. No results emerged within the Gamma frequency bands. Colors and their intensity represent the estimated difference (Estimate) between conditions, with red indicating reduced activity in the perception of Narrative compared to the Control condition, and blue indicating greater activity perception of Narrative compared to the Control condition. Electrode positions (10-20 system, Biosemi) are also present. Topographies were generated in R using the packages ggplot2 (v. 3.5.2; Wickham, 2016), akima (v. 0.6-3.6; Akima & Gebhardt, 2025), and dplyr/tidyr (v. 1.1.4; Wickham et al., 2025).

4.2.3. How do they relate to the pre-established ad-related EEG measures?

Following the procedures described in Section 3.5.1 on EEG data analyses, correlation analyses were conducted between the EEG measures related to Mentalizing, Narrative perception, and other education-relevant EEG metrics (van Diepen et al., 2024): centroparietal alpha (CP alpha -

attention/arousal), frontal beta (F beta - reward/liking), frontocentral gamma (FC gamma - understanding), and frontocentral theta (FC theta - memory/disliking). Given the nature of the variables (normally distributed continuous data), a series of Pearson's correlations was computed.

Overall, the results (**Figure 3.10** and **Table 3.15**) indicate that - except for a few cases - the variables were generally positively associated.

Mentalizing and Narrative perception showed the strongest correlation ($r = 0.718, p < .001$), suggesting a close relationship between these two higher-order cognitive processes. In addition, Mentalizing was positively correlated with centroparietal alpha ($r = 0.41, p < .001$), while frontal beta ($r = 0.112, p < .001$), frontocentral gamma ($r = 0.137, p < .001$), and frontocentral theta ($r = 0.341, p < .001$) also showed weaker but still significant positive correlation with Mentalizing.

Narrative perception was positively correlated with centroparietal alpha ($r = 0.394, p < .001$), frontal beta ($r = 0.104, p < .001$), frontocentral gamma ($r = 0.075, p < .01$), and frontocentral theta ($r = 0.42, p < .001$).

In addition, most of the other EEG measures were positively intercorrelated, except for a few small but significant negative correlations observed between frontocentral gamma and centroparietal alpha ($r = -0.057, p < .05$), and between frontocentral gamma and frontal beta ($r = -0.101, p < .001$). The correlation between frontocentral gamma and frontocentral theta was also slightly negative ($r = -0.033$) but not statistically significant.

Pearson's Correlations

			Pearson's r	p	Effect size (Fisher's z)	SE Effect size
Mentalizing	-	Narrative	0.718	< .001	0.904	0.028
Mentalizing	-	CP_alpha	0.410	< .001	0.436	0.028
Mentalizing	-	F_beta	0.112	< .001	0.113	0.028
Mentalizing	-	FC_gamma	0.137	< .001	0.138	0.028
Mentalizing	-	FC_theta	0.341	< .001	0.355	0.028
Narrative	-	CP_alpha	0.394	< .001	0.417	0.028
Narrative	-	F_beta	0.104	< .001	0.105	0.028
Narrative	-	FC_gamma	0.075	.007	0.075	0.028
Narrative	-	FC_theta	0.420	< .001	0.448	0.028
CP_alpha	-	F_beta	0.502	< .001	0.552	0.028
CP_alpha	-	FC_gamma	-0.057	.042	-0.057	0.028
CP_alpha	-	FC_theta	0.308	< .001	0.318	0.028
F_beta	-	FC_gamma	-0.101	< .001	-0.101	0.028
F_beta	-	FC_theta	0.483	< .001	0.526	0.028
FC_gamma	-	FC_theta	-0.033	.236	-0.033	0.028

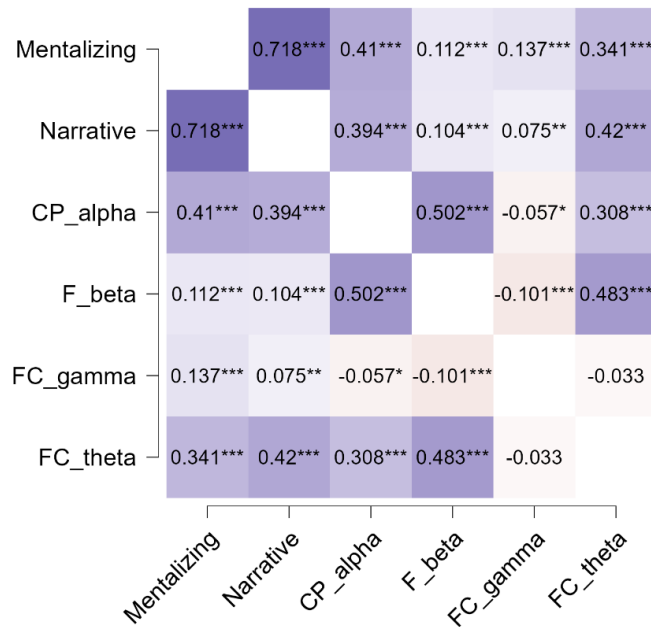


Figure 3.10; Table 3.15. Correlation Results (Table) and Heatmap (Figure) between the EEG measures of interest (Mentalizing, Narrative perception, centroparietal alpha, frontal beta, frontocentral gamma, and frontocentral theta). * $p < .05$, ** $p < .01$, *** $p < .001$.

4.2.4. NS effects on Mentalizing and Narrative perception correlates

The results of the LMM analysis on EEG data related to Mentalizing, which included narrative structure (NS) as a fixed effect and sbj (N = 44) as a random factor, showed *no* significant effect of NS ($p = .095$). So, different levels of narrative structure in the advertisements (high vs. low) did not produce significant changes in mentalizing-related EEG activity (**Table 3.16**).

The estimated marginal means revealed a slight decrease in EEG activity, specifically, a reduction in frontal delta and occipital alpha power, suggesting a trend consistent with the EEG correlates mentalizing: as frontal delta and occipital alpha power tend to decrease when participants are exposed to advertisements with higher narrative structure (**Figure 3.11a**), which means that mentalizing EEG activity slightly augments with high NS ads, and slightly diminishes with low NS ads.

Model Summary				Fit statistics				
Effect	df	F	<i>p</i>	Deviance (REML)	log Lik.	df	AIC	BIC
NS	1, 57.93	2.879	.095	3,400	-1,700	6	3,412	3,443

Fixed Effects Estimates

Term	Estimate	SE	df	t	<i>p</i>
Intercept	1.913	0.191	43.01	10.031	< .001
NS (1)	-0.053	0.031	57.93	-1.697	.095

Estimated Marginal Means

Row	NS	Estimate	SE	95% CI Lower	95% CI Upper
1	H	1.860	0.171	1.525	2.195
2	L	1.965	0.213	1.548	2.383

Table 3.16. Summary of the LMM testing the effect of NS (high vs. low) on EEG activity related to Mentalizing. The model included NS as a fixed effect and participant (N = 44) as a random intercept. Results indicated no significant main effect of NS ($p = .095$), suggesting that variations in NS did not produce statistically significant changes in Mentalizing-related EEG activity.

The results of the LMM analysis on EEG data related to Narrative perception, which included narrative structure (NS) as a fixed effect and sbj (N = 44) as a random factor, showed no significant effect of NS ($p = .695$). So, different levels of narrative structure in the advertisements (high vs. low) did not produce significant changes in mentalizing-related EEG activity (**Table 3.17**).

The estimated marginal means revealed a slight, non-significant decrease in the Narrative perception-related EEG activity for the advertisements with higher narrative structure (**Figure 3.11b**).

Model Summary				Fit statistics				
Effect	df	F	<i>p</i>	Deviance (REML)	log Lik.	df	AIC	BIC
NS	1, 184.80	0.154	.695	3,189	-1,595	6	3,201	3,232

Fixed Effects Estimates					
Term	Estimate	SE	df	t	<i>p</i>
Intercept	1.264	0.112	43.00	11.245	< .001
NS (1)	-0.009	0.022	184.80	-10.392	.695

Estimated Marginal Means					
Row	NS	Estimate	SE	95% CI Lower	95% CI Upper
1	H	1.255	0.107	1.045	1.465
2	L	1.272	0.121	1.035	1.510

Table 3.17. Summary of the LMM testing the effect of NS (high vs. low) on EEG activity related to Narrative perception. The model included NS as a fixed effect and participant (N = 44) as a random intercept. Results indicated no significant main effect of NS ($p = .695$), suggesting that variations in NS did not produce statistically significant changes in Narrative perception-related EEG activity.

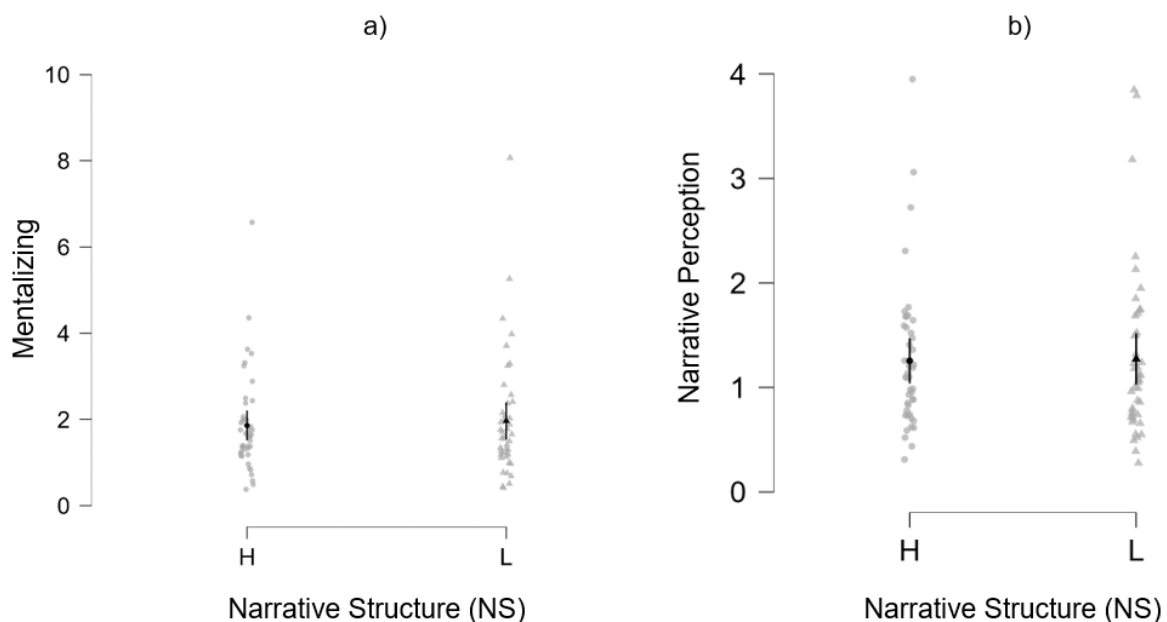


Figure 3.11. EMMs of Mentalizing (a) and Narrative Perception (b) as a function of NS (high vs. low).

4.2.5. Final EEG-based model

The EEG-based model aims to examine how the **EEG-derived correlates** of mentalizing and narrative perception might **mediate** the relationship between narrative structure and the final outcome variables of advertising effectiveness.

As a first step, Spearman's **correlation** analyses between the self-report variables (Mentalizing, Narrative Transportation/Presence, and Narrative Understanding) and the EEG measures (Mentalizing and Narrative Perception) were conducted to assess the degree of convergence vs divergence between self-report and EEG-based responses.

The results (**Table 3.18, Figure 3.12**) indicate that the two EEG indices correlated moderately with each other ($\rho = .557, p < .001$). The self-report variables were intercorrelated, with a strong association between SR Mentalizing and SR Narrative Transportation/Presence ($\rho = .673, p < .001$) and weaker correlations between SR Mentalizing and SR Narrative Understanding ($\rho = .183, p < .001$) and between SR Narrative Transportation/Presence and SR Narrative Understanding ($\rho = .157, p < .001$). Cross-domain associations (between self-report and EEG data) were generally negligible: SR Mentalizing showed no relation to EEG Mentalizing ($\rho = .001, p = .960$) or EEG Narrative ($\rho = -.032, p = .251$). Only SR Narrative Transportation/Presence related very weakly to EEG Mentalizing ($\rho = -.066, p = .014$) and weakly to EEG Narrative ($\rho = .126, p < .001$). SR Narrative Understanding showed no association with either EEG Mentalizing ($\rho = .007, p = .804$) or EEG Narrative ($\rho = .014, p = .602$).

Spearman's Correlations

			n	Spearman's rho		p	Effect size (Fisher's z)	SE Effect size
sr_mentalizing	-	sr_narr_tras_pres	1,320	0.673	***	< .001	0.816	0.029
sr_mentalizing	-	sr_narr_und	1,320	0.183	***	< .001	0.185	0.028
sr_mentalizing	-	mentalizing	1,320	0.001		.960	0.001	0.028
sr_mentalizing	-	narrative	1,320	-0.032		.251	-0.032	0.028
sr_narr_tras_pres	-	sr_narr_und	1,320	0.157	***	< .001	0.159	0.028
sr_narr_tras_pres	-	mentalizing	1,320	-0.066	*	.016	-0.067	0.028
sr_narr_tras_pres	-	narrative	1,320	-0.126	***	< .001	-0.127	0.028
sr_narr_und	-	mentalizing	1,320	0.007		.804	0.007	0.028
sr_narr_und	-	narrative	1,320	0.014		.602	0.014	0.028
mentalizing	-	narrative	1,320	0.557	***	< .001	0.628	0.029

* $p < .05$, ** $p < .01$, *** $p < .001$. all the variable names are abbreviated. sr = self-report.

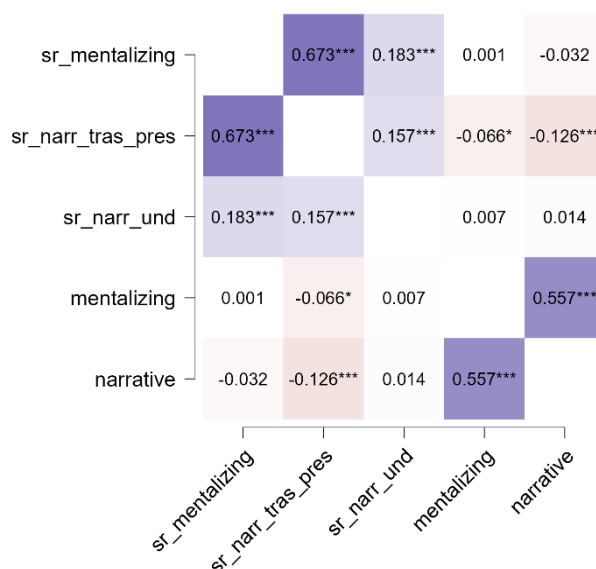


Table 3.18; Figure 3.12. Correlation Results (Table) and Heatmap (Figure) between the EEG measures of Mentalizing and Narrative perception and the self-report measures of Mentalizing, Narrative Transportation/Presence, and Narrative Understanding. * $p < .05$, ** $p < .01$, *** $p < .001$.

A multilevel structural equation model (SEM) was estimated to investigate whether the EEG-based indices of Mentalizing and Narrative Perception mediated the effect of the NS (coded as 0 = L, 1 = H) on the dependent variables of advertising effectiveness (ad liking, sharing intent, purchase intent, and recommendation intent) using robust maximum likelihood (MLR). It was estimated in the following way:

```

model <- '
# Mediation: NS → Mediators
Mentalizing ~ a1*NS
NarrativePerception ~ a2*NS

# Mediators → Dependent Variables
Liking ~ b1*Mentalizing + b2*NarrativePerception + c1*NS
Sharing ~ b4*Mentalizing + b5*NarrativePerception + c2*NS
Purchase ~ b7*Mentalizing + b8*NarrativePerception + c3*NS
Recommendation ~ b10*Mentalizing + b11*NarrativePerception + c4*NS
'

fit <- sem(model, data = data, cluster = "SBJ", estimator = "MLR")

```

Although the overall model fit (**Table 3.19 a.**) did not reach conventional standards ($\chi^2(16) = 709.52$, $p < .001$, CFI = .75, TLI = .43, RMSEA = .18 (90% CI [0.17, 0.19]), SRMR (within) = .10, and SRMR (between) = .55,), the estimates can still be theoretically interpreted.

Estimator	ML
Optimization method	NLMINB
Number of model parameters	38
Number of observations	1320
Number of clusters [SBJ]	44
Number of missing patterns - level 1	1

a - Model Test User Model		
	Standard	Scaled
Test Statistic	621.218	709.518
Degrees of freedom	16	16
p value	0.000	0.000
Scaling correction factor		0.876
Model Test Baseline Model		
Test Statistic	4878.643	2768.212
Degrees of freedom	36	36
p value	0.000	0.000
Scaling correction factor		1.762
User Model versus Baseline Model		
Comparative Fit Index (CFI)	0.875	0.746
Tucker-Lewis Index (TLI)	0.719	0.429
Loglikelihood and Information Criteria		
Loglikelihood user model (H0)	-12796.817	-12796.817

Scaling correction factor for the MLR correction		2.242
Loglikelihood unrestricted model (H1)	12486.208	-12486.208
Scaling correction factor for the MLR correction		1.837

Root Mean Square Error of Approximation

RMSEA	0.169	0.181
90% CI - lower	0.158	0.169
90% CI - upper	0.181	0.194
p value H ₀ : RMSEA ≤ 0.050	0.000	1.000
p value H ₀ : RMSEA ≥ 0.080	1.000	0.000

b- Regressions

	Estimate	SE	z-value	p	Std.lv	Std.all
Mentalizing ~						
NS (a1)	2.370	0.146	16.185	0.000	2.370	0.644
Narrative Perception ~						
NS (a2)	0.960	0.098	9.829	0.000	0.960	0.435
Liking ~						
Mentalizing (b1)	0.075	0.039	1.912	0.056	0.075	0.090
Narrative perception (b2)	0.809	0.065	12.382	0.000	0.809	0.582
NS (c1)	-0.157	0.130	-1.202	0.229	-0.157	-0.051
Sharing ~						
Mentalizing (b3)	0.029	0.047	0.604	0.546	0.029	0.034
Narrative perception (b4)	0.716	0.073	9.784	0.000	0.716	0.515
NS (c2)	-0.076	0.125	-0.609	0.542	-0.076	-0.025
Purchase ~						
Mentalizing (b5)	-0.058	0.041	-1.425	0.154	-0.058	-0.062
Narrative perception (b6)	0.626	0.063	9.995	0.000	0.626	0.403
NS (c3)	-0.141	0.146	-0.969	0.333	-0.141	-0.041
Recommendation ~						
Mentalizing (b7)	-0.033	0.043	-0.784	0.433	-0.033	-0.038
Narrative perception (b8)	0.578	0.076	7.590	0.000	0.578	0.400
NS (c4)	2.178	0.179	12.145	0.000	2.178	0.856

Table 3.19. Results of the multilevel SEM testing the mediating role of EEG-based indices of Mentalizing and Narrative Perception in the relationship between NS and advertising effectiveness outcomes. Panel **a** reports the overall model fit indices. Panel **b** reports the standardized regression coefficients for all structural paths.

At the within-person level, the experimental manipulation significantly increased both EEG-based mediators (**Table 13.19 b**). The effect of NS on *Mentalizing* was strong and positive ($\beta = 2.37$, $SE = 0.15$, $p < .001$, $Std.all = .64$), and on *Narrative Perception* was moderate but still significant ($\beta = 0.96$, $SE = 0.10$, $p < .001$, $Std.all = .44$). When predicting the outcome variables, *Narrative Perception* showed large and significant positive effects on all four dependent measures: it predicted higher ad liking ($\beta = 0.81$, $SE = 0.07$, $p < .001$, $Std.all = .58$), greater sharing intent ($\beta = 0.72$, $SE = 0.07$, $p < .001$, $Std.all = .52$), higher purchase intent ($\beta = 0.63$, $SE = 0.06$, $p < .001$, $Std.all = .40$), and stronger recommendation intent ($\beta = 0.58$, $SE = 0.08$, $p < .001$, $Std.all = .40$). On the other hand, *Mentalizing* as a mediator displayed only weak and nonsignificant effects on the outcome variables. Its association with ad liking was marginal ($\beta = 0.08$, $SE = 0.04$, $p = .056$, $Std.all = .09$) and nonsignificant for sharing intent ($\beta = 0.03$, $SE = .05$, $p = .55$, $Std.all = .04$), purchase intent ($\beta = -0.06$, $SE = .04$, $p = .15$, $Std.all = -0.06$), and recommendation intent ($\beta = -0.03$, $SE = -0.04$, $p = .43$, $Std.all = -0.04$).

The direct effects of NS on each outcome (paths c_1 – c_4) were generally small and nonsignificant (p values between .23 and .54), except for the Recommendation intent variable, for

which the NS displayed a strong and significant effect ($\beta = 2.18$, $SE = 0.18$, $p < .001$, $Std.all = .86$), indicating that the manipulation influenced the dependent variables primarily through the mediators rather than directly.

The model explained a substantial amount of variance in the mediators and outcomes. R^2 was .41 for *Mentalizing* and .19 for *Narrative Perception*, while the dependent variables showed R^2 values of .35 for ad liking, $R^2 = .26$ for sharing intent, $R^2 = .14$ for purchase intent, and $R^2 = .14$ for recommendation intent. All residual variances and random intercepts at the between-subject level were significant, confirming meaningful variability across individuals in baseline neural and behavioral responses.

So, the NS manipulation significantly increased both EEG indices, but only *Narrative Perception* consistently predicted ad effectiveness outcomes. The *Mentalizing* pathway showed limited predictive power, and no significant direct effects of the manipulation remained once the mediators were included, supporting a predominantly mediated pattern of influence.

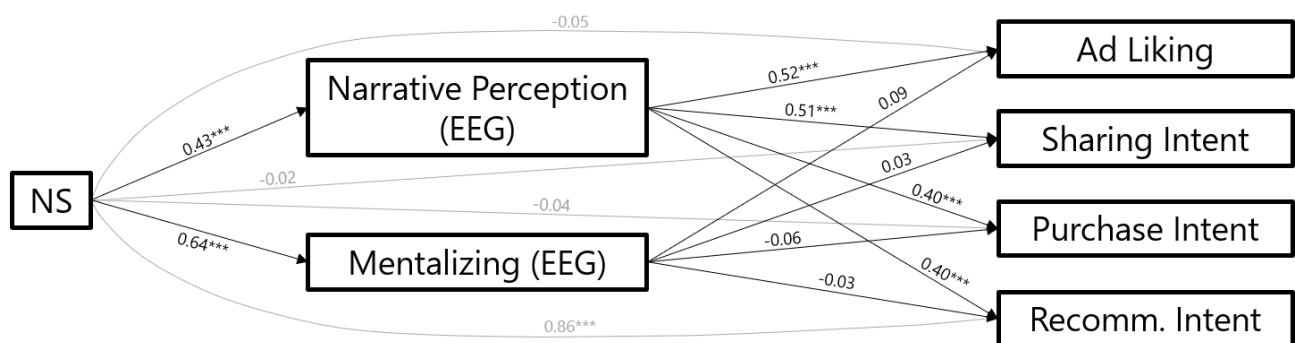


Figure 3.12. EEG-based model. Multilevel mediation model examining the indirect effects of NS on four outcome variables (Ad Liking, Sharing Intent, Purchase Intent, and Recommendation Intent) through two mediators (EEG measures of Narrative perception and Mentalizing). Standardized path coefficients (Std.all) are reported. Asterisks indicate significance levels: *** = $p < .001$, ** $p < .01$, * $p < .05$

5. Discussion

Over the past two decades, EEG has become a widely used method for investigating cognitive and emotional processes in response to advertising stimuli. Much of this research has examined relatively basic mechanisms, such as attention, arousal, memorization, and motivational tendencies. However, as the literature highlights, a considerable gap remains in capturing more complex, higher-order processes central to how viewers make sense of and respond to advertising. Processes such as *mentalizing* and *narrative perception* are increasingly recognized as central to understanding the persuasive power of storytelling in advertising. This study aimed to contribute to this line of research by identifying the EEG correlates of these processes and integrate them into a framework that considers them as key mechanisms linking narrative structure (NS) to advertising effectiveness.

To this end, a laboratory EEG experiment was conducted with a final sample of 44 participants. Each participant was exposed to a set of 30 advertisements, presented twice, as well as additional literature-based stimuli designed to elicit mentalizing- and narrative-related mental processes. This design enabled us to identify EEG features associated with these higher-order processes and test how they interact with NS to shape consumer responses (ad effectiveness measures). This

combination of self-report measures with EEG-based indices can provide a richer perspective on the role of narrative mechanisms in advertising, and positions mentalizing and narrative perception as central processes in the subjective experience of and response to ads.

The first objective of this study focused on **self-report data** to evaluate a model in which NS influences the effectiveness of advertisements through narrative perception and mentalizing assessed via questionnaire items (**Aim 1**).

In relation to this, a first research question (**RQ1.1**) asked whether a stronger narrative structure improves the dependent variables (ad effectiveness measures of ad liking, sharing intent, purchase intent, and recommendation intent). The results clearly support this: **advertisements with strong narrative structures were consistently evaluated more positively**. Participants reported greater liking of the ads, a stronger willingness to recommend them, a higher intention to share them, and increased purchase intentions in the high NS condition. These results are highly consistent with prior work on narratives and storytelling in advertising research. We know that narrative formats are capable of enhancing persuasiveness compared to non-narrative formats (Lien & Chen, 2013) and can generate stronger emotional responses and greater word-of-mouth intention (Kang et al., 2020), probably because they are more fluently processed than non-narrative formats (Bullock et al., 2021). In real-world advertising settings, ads with a NS have been shown to drive higher narrative transportation and more favorable attitudes toward the ad (Yıldız & Sever, 2021). Moreover, a recent systematic review (Oliveira Júnior et al., 2022) underscores that storytelling promotes engagement, emotional identification, and purchase intentions. These results confirm the importance of ad narration in shaping consumer responses: when there is a **story** that is easier to follow and better organized, it can lead to more favorable attitudes toward the ad and the brand and generally increase the likelihood of “desired” consumer behaviors.

A second research question investigated whether narrative-related and mentalizing variables mediate the effect of NS on advertising evaluation outcomes and, if so, to what extent (**RQ1.2**). According to the mediation analyses, **both narrative-related dimensions (transportation, presence, and understanding) and mentalizing all acted as significant mediators of the relationship between NS and advertising outcomes** (*ad effectiveness dimensions*). This means that the positive impact of NS does not work by itself, but it emerges through viewers’ transportation and immersion in the story, their sense of presence in the narrative world, their understanding of the story events, and their mentalizing with the characters of the story. These strongly interrelated processes significantly predict advertising effectiveness (ad liking, sharing intent, purchase intent, and recommendation intent measures), reinforcing the idea that, at least from a theoretical point of view, narrative persuasion is a “multilayered” phenomenon that integrates emotional and cognitive components. Here, the narrative-related variables (transportation & presence, and understanding) reflect more “surface-level” experiential engagement and comprehension of the story’s flow, events, and spatio-temporal context. Mentalizing, in contrast, refers to a more reflective, social-cognitive dimension: it is the ability to step into the characters’ minds, to infer intentions, emotions, and mental states beyond what is explicitly shown. This finding aligns well with prior work on narrative persuasion, which has shown that immersion, comprehension, and perspective-taking are the main mechanisms through which storytelling can be persuasive. For example, advertising research has shown that narrative transportation mediates the effect of storytelling on brand attitudes and recall (Brechman & Purvis, 2015). Similarly, Glaser et al. (2021) found evidence that the positive effect of a

story on brand attitude was mediated by narrative comprehension and transportation. Another way to contextualize these results is through conceptual models of narrative persuasion, which propose that narrative influence occurs through two interconnected processes: first, absorption into the story, then, reflective meaning-making, empathy, and integration with the self (Green & Brock, 2000; Hamby et al., 2016).

The third research question linked to the first aim (**RQ1.3**) asked which measures, mentalizing or narrative-related ones, would show a stronger indirect effect on the final ad effectiveness dependent variables. When the mediators were examined jointly (mentalizing vs understanding and presence & transportation), a distinction indeed emerged. **Mentalizing was the variable most strongly influenced by NS**, confirming that NS has a particularly strong impact on viewers' social-cognition processes, **but its predictive power on the dependent variables was comparatively weaker, though still statistically significant**. On the other hand, the narrative-related variables (presence and transportation & understanding) appeared slightly less affected by NS, but they exerted a stronger and more significant influence on the final advertising effectiveness measures. These results suggest that mentalizing is the process most directly influenced by the stimulus narration, while narrative perception better explains variance in consumers' evaluative and behavioral responses, such as ad liking, recommending, sharing, and purchase intentions. One possible explanation is that narrative perception reflects processes of immersion and comprehension, which are closely tied to the experience of the advertisement itself. In this sense, narrative structure can be seen as the primary trigger of mentalizing (as it is a higher-order process), but it is the broader set of narrative perception processes that actually drives advertising effectiveness.

The second research aim was to identify the **EEG correlates** of consumer *mentalizing* and *narrative perception* (**Aim 2**). To this end, we presented participants with a series of stimuli from the literature specifically designed to elicit these two processes: Frith-Happé triangle animations (Abell et al., 2000) for mentalizing and stimuli from Nguyen et al. (2019) for narrative processing.

The first research question within this second aim analyzed which EEG correlates were specifically related to the elicitation of mentalizing processes (**RQ2.1**). To address this question, I examined the 10% of contrasts with the largest estimated differences in EEG activity between the experimental conditions (Tom vs GD stimuli; N = 793), reflecting stronger mentalizing processing. The results showed differences across multiple frequency bands, with the most consistent effects observed in the delta (1–4 Hz) and alpha (8–13 Hz) ranges. Specifically, **mentalizing processes elicited a bilateral reduction in fronto-central delta activity and a concurrent increase in left parietal delta activity, while in the alpha band it was associated with a bilateral decrease in parieto-occipital alpha activity**. Smaller but still meaningful effects also emerged in the other frequency bands. Theta activity (4–7 Hz) exhibited a slight, widespread decrease in both frontal and parietal regions. Beta activity (14–29 Hz) decreased, especially at prefrontal and parietal sites. Effects in the Gamma range were minimal and nearly negligible.

Frontal Delta and Occipital Alpha decrease during Mentalizing. The reduction of frontal delta power during the elicitation of mentalizing processes can be interpreted as a shift toward a more alert and heightened cognitive processing mode as viewers infer characters' mental states. Delta power is indeed classically related to deep slow wave sleep (Anderson & Horne, 2003; Latreille et al., 2019), sleep deprivation (Münch et al., 2004), and states of drowsiness and low vigilance. Thus, a delta decrease over frontal sites during mentalizing is consistent with **heightened attention, control,**

vigilance, awareness, cognitive engagement, and working memory (Jaiswal et al., 2019). Thus, mentalizing during ad viewing appears to suppress low-frequency activity linked to low arousal, favoring an efficient allocation of executive resources to complete the social-cognition task. However, this interpretation should be considered with caution, as the role of delta oscillations in cognition is still not well understood. For instance, Harmony (2013) argues that sustained delta activity may reflect internal control mechanisms that suppress interference from irrelevant networks during cognitively demanding tasks rather than merely indicating low arousal or idling states. Indeed, several paradigms have reported frontal delta increases during working memory and semantic processing, suggesting a more active and regulatory role. Furthermore, delta-band oscillations have been shown to support connectivity between frontal and parietal regions during decision-making, suggesting that this rhythm may mediate integrative top-down processes (Nácher et al., 2013). Therefore, delta activity may be associated with different cognitive operations whose specific roles are difficult to define and seem to be task-dependent: while a reduction in frontal delta during mentalizing may indicate heightened alertness or suppression of low-frequency idling, it could also reflect a shift in slow-wave control dynamics.

The decrease of occipital alpha (8–13 Hz) fits the well-established signature of event-related desynchronization (ERD) that marks **active information processing** (Pfurtscheller et al., 1994). Indeed, alpha activity is widely interpreted as an inhibitory/suppressive rhythm: when cognitive processing (i.e., attention, semantic, and visual processing) intensifies, alpha power drops over task-relevant posterior regions (Klimesh, 2012). Moreover, literature shows that posterior alpha suppression implements a “gating by inhibition” mechanism: it disinhibits cortical populations representing task-relevant inputs while inhibiting distractors. Both correlational and causal studies link posterior alpha reductions to selective attention and preparatory processing in sensory visual and auditory tasks (e.g., Foxe & Snyder, 2011; Deng et al., 2019; Clements et al., 2023), and to successive memory formation (Woodman et al., 2021).

So, combining the two main findings: frontal delta activity decreases when a person is engaged and alert, indicating reduced “slow-wave” idling, while posterior alpha activity decreases when a person actively selects, processes, and integrates advertising content and its narrative cues. In the context of ad viewing, mentalizing appears to rely on the attentional processing of the unfolding story (alpha ERD) while reducing low-arousal dynamics (delta activity). This combination of neural activity seems to guide the inference of others’ intentions and emotions from dynamic visual scenes, an interpretation that is consistent with broader EEG research on social cognition, where, for example, 8–13 Hz activity suppression has often been linked to the processing and understanding of others’ intentional actions and social meaning (Genzer et al., 2022).

A second research question within this aim examined the EEG correlates of Narrative Perception (**RQ2.2**). From the EEG analysis of our narrative perception task, we could observe a **reduction in centro-parietal delta activity and a decrease in right parieto-occipital alpha activity at 10–11 Hz (PO8) when narrative stimuli were compared to non-narrative ones**. Smaller but still meaningful effects also emerged in the other frequency bands. Theta power activity (4–7 Hz) showed a slight, widespread decrease. Beta activity (14–29 Hz) decreased, especially at posterior sites. Nothing emerged in the Gamma range.

Centro-parietal Delta and Parieto-occipital Alpha decrease during Narrative perception. As previously discussed, the posterior alpha modulation is in line with well-documented evidence

linking alpha suppression to the selective attention of visual information and the sustained processing of task-relevant input. As we have seen with the result for the EEG correlates of Mentalizing, reduced alpha activity in the posterior cortex indicates diminished inhibition of visual areas and increased engagement with the ongoing content (Foxy & Snyder, 2011; Klimesch et al., 2012). The delta activity finding complements this account. Reviews suggest that higher delta activity during wakefulness is associated with inward-focused processing and interference control (Harmony et al., 1996), while reductions in slow activity over the centro-parietal regions are related to externally oriented attention (Güntekin & Başar, 2016; Harmony, 2013). This could be consistent with the demands of tracking the scene sequences during narrative perception. Moreover, these emerging EEG patterns found in the delta and alpha frequency bands can complement broader accounts of narrative comprehension found from other modalities (e.g., fMRI) that emphasize sustained attention and integrative mechanisms, and are also consistent with research demonstrating that naturalistic language and story processing modulate posterior alpha/beta rhythms (Song et al., 2021).

At this point, it should be discussed **whether and how these two EEG patterns converge and diverge**. First, both Narrative perception and Mentalizing appear to show posterior alpha suppression (PO8 at 10–11 Hz, O1 at 9 Hz, and O2 at 11 Hz). This indicates a strong component of attentional selection and sustained processing of task-relevant visual input in both cases, consistent with evidence linking posterior alpha decreases to the “prioritization” of relevant sensory information (Foxy & Snyder, 2011; Klimesch, 2012). In practical terms, **both tasks require participants to pay attention and carefully engage with the visual video material**, whether that be tracking and understanding what happens in the story (Narrative stimuli) or inferring characters’ states (Mentalizing stimuli). Secondly, both processes recruit delta-band activity, even though they diverge in topography. In the narrative contrast, we observe a centro-parietal delta decrease at 1 Hz, whereas in the mentalizing contrast, we see a frontal delta decrease at 1–2 Hz. We know that reductions in delta activity could be related to attentional and control mechanisms, so when the task is more related to event integration across scenes (Narrative stimuli), centro-parietal delta decreases are expected, while when the emphasis shifts to inferring characters’ intentions, feelings, and goals (Mentalizing stimuli), a frontal delta decrease reflects the additional control and inference processes on the recipient.

This high overlap emerged between the Mentalizing and Narrative EEG correlates corresponds to the framework introduced earlier (section 2.3.4 of this Chapter): narrative perception stems from the connections between stimulus features, such as narrative structure (Escalas, 2004; Dahlstrom, 2014; Van Laer et al., 2014), and recipient-side mechanisms of attention, comprehension, and mentalizing (Green & Brock, 2000; Busselle & Bilandzic, 2009; Green & Appel, 2024). Thus, it seems reasonable to treat narrative perception and mentalizing as closely linked processes, particularly in the context of advertising perception. Moreover, they also seem to share similar neural patterns (e.g., Mar, 2011). Our EEG data support this view: **mentalizing is not separated from narration perception, but rather, it often emerges along with it and within it**.

This view also supports the argument that effective advertising narratives need both narrative structure from the stimulus itself and mentalizing processes in the recipients, and that EEG is capable of providing sensitive indices to assess these strongly interrelated processes.

A third research question explored how the EEG correlates identified for the processes of Mentalizing and Narrative perception (**RQ2.3**) relate to the metrics previously reported as relevant for advertising perception (e.g., the ones analyzed in Van Diepen et al., 2024).

Regarding **Mentalizing EEG correlates**, our results indicate a decrease in frontal delta activity at 1–2 Hz (Af8, F8, F7, FT7, Fp2, F6, FC6, and F5) and a decrease in occipital alpha activity at 9–11 Hz (O1 and O2). Although the decrease in delta activity does not correspond directly to any EEG metrics typically reported in advertising research, the reduction in posterior alpha is partially related to the established measures of **arousal and attentional engagement**. As previously discussed, alpha suppression is a well-known marker of increased active information processing, attention, and engagement (Klimesh, 2012). However, due to the slightly different topographical distribution, this “alignment” is only partial: the alpha suppression we found in Mentalizing is merely occipital, a classic index of enhanced *sensory-related, visual* attention (Hohaia et al., 2022), rather than more general attention. In contrast, the alpha-related metric described by Van Diepen et al. (2024) refers to a centro-parietal cluster (CP1, CP2, Pz). These more central decreases in alpha power have been associated with greater perceived interest in advertising content and enhanced ad memorability, suggesting that it is more sensitive to the cognitive components of attentional focus, whereas the more posterior alpha activity that we found with our mentalizing-eliciting task reflects a more primary, sensory–visual form of perception (Smith & Gevins, 2004; Palva & Palva, 2007; Shestyuk et al., 2019). Thus, in our case, the observed alpha reduction likely reflects sensory-driven visual attention specific to stimulus perception (Frith-Happè triangles) rather than broader, domain-general attentional recruitment.

No other correspondence emerged at the “theoretical level” with the other EEG measures typically associated with advertising perception (Van Diepen et al., 2024), such as frontal beta activity (reward and ad liking), frontocentral gamma activity (higher-order cognitive processing), or frontocentral theta activity (memory encoding or negative evaluation). A “partial” link could be considered for frontal alpha asymmetry, which is related to approach motivation. Although from our results, alpha activity seems to be recruited in Mentalizing, our effects were posterior and bilaterally distributed without evidence of hemispheric asymmetry. Therefore, even if alpha engagement is present, its spatial distribution and lack of asymmetry imply that mentalizing does not relate to processes such as approach or withdrawal motivation.

Regarding the **EEG correlates of Narrative perception**, our data showed a decrease in centro-parietal delta activity at 1 Hz (CP4, CP1, P4, P5, P1, Pz, C4, C5, FC5, PO4, PO8, and TP8) and in parieto-occipital alpha activity at 10–11 Hz (PO8). Similarly to Mentalizing EEG correlates, the strongest overlap with established EEG metrics for advertising research (Van Diepen et al., 2024) regards centro-parietal alpha activity (8–12 Hz; CP1, CP2, and Pz), which is associated with attention and arousal. The effects emerged in our study within the alpha frequency range, also fell in a partially overlapping topographical region (posterior and slightly lateral, PO8). This pattern suggests that narrative perception engages attentional resources as well, most likely reflecting the sustained visual but also more cognitive and semantic processing required to follow the storyline (as they move to merely occipital positions to more parietal ones) - following the different processes related to the different localization of alpha suppression (as described in the work of Shestyuk and colleagues, 2019).

As with mentalizing, no “theoretical” correspondence was observed with the other ad-related EEG measures: frontal beta, frontocentral gamma, or frontocentral theta (Van Diepen et al., 2024).

This may indicate that narrative perception of our stimuli (Nguyen et al., 2019) may not involve reward-related beta activity. Similarly, the stimuli and their narratives were not particularly complex and did not elicit increased gamma activity in frontocentral areas, which are associated with higher-order cognitive processes. For a similar reason, substantial recruitment of memory-related processes was not expected, which is consistent with the absence of frontocentral theta activity. The presence of alpha modulation, but not in frontal regions or in terms of asymmetry between hemispheres, indicates that narrative perception itself is neutral with respect to motivational direction. In fact, any “emotional feature” related to specific scenes or characters would have been very difficult to evoke with our stimuli: the narratives were intentionally emotionally neutral, with simple successions of scenes rather than emotionally charged content. So, both mentalizing and narrative perception appear to be primarily associated with attentional processes, while showing little evidence of involvement in other specific cognitive or emotional subprocesses.

After the “theoretical comparison” between these EEG measures, the correlations conducted among these indices provide more specific insights into the relationships between *Narrative perception*, *Mentalizing*, and the other EEG measures commonly used in consumer neuroscience for advertising analysis. The consistent pattern of positive and significant correlations across all measures suggests a close relationship between mentalizing and narrative processes and other neural mechanisms typically associated with attention, arousal, reward, liking, memory, and understanding. The positive association between both Mentalizing and Narrative perception with centroparietal alpha activity indicates a connection with arousal (Johnston et al., 2022) and attentional regulation processes (Uusberg et al., 2013), completely supporting what has already been discussed in the previous paragraphs. The correlations with frontal beta activity further indicate a relationship with liking, reward-related, and motivational processes, suggesting that greater liking or motivation may support more effective narrative processing and mental state attribution. Similarly, the positive associations with frontocentral theta power highlight the involvement of memory-related mechanisms (Tan et al., 2024), suggesting that better activation of both Mentalizing and Narrative perception mechanisms may rely on the recruitment of memory resources to integrate social and story-related information, or that the more we perceive a narrative or the more we mentalize, the more it will be likely that we will remember that stimulus. Finally, the positive correlation with frontocentral gamma activity is consistent with the established role of gamma oscillations in semantic integration and high-level comprehension (Ueno et al., 2023), components at the basis of both mentalizing and narrative processing.

Finally, it is also worth noting that, although both mentalizing and Narrative perception processes involved reductions in delta activity, their spatial patterns differed: frontal for Mentalizing and centro-parietal for Narrative perception. Delta activity does not emerge within the commonly reported EEG metrics used in advertising research (Van Diepen et al., 2024), so this finding raises an interesting question for future studies: *what is the specific role of delta modulation (and suppression) in social cognition and narrative perception processes?*

Moving forward to analyze the results that emerged, the absence of significant effects of NS on the EEG measures related to Mentalizing and Narrative perception was in a certain sense unexpected. Previous research has often suggested that well-structured narratives enhance understanding of characters’ intentions and emotional engagement (e.g., Green & Brock, 2000; Green & Appel, 2024). However, in this study, variations in ads NS (high vs. low) did not produce statistically

significant differences in EEG activity associated with these processes. Although estimated marginal means indicated a slight reduction in the EEG activity of both *Mentalizing* and *Narrative* processing measures, patterns that emerged from our task-based “localizer” analysis as associated with increased mentalizing and narrative transportation, this effect did not reach the levels of statistical significance.

One possible explanation is that the manipulation of NS in the current stimuli, while being solid from a theoretical point of view, may not have been strong enough to elicit clear differences in the EEG activity. Another reason could be that mentalizing- and narrative-related processes depend more on other features, especially the more emotional ones such as character empathy, emotional tone, or presence, than on narrative structure alone (e.g., Bal & Veltkamp, 2013; Busselle & Bilandzic, 2009).

Thus, although NS may contribute to social cognition process and narrative engagement, its effects are not straightforward and do not result to be reflected in EEG measures of mentalizing and narrative perception. This discrepancy seems to be unique to the EEG data because the self-report results clearly showed that NS influenced both mentalizing- and narrative-related variables. So, the reason why this modulation emerges at the self-report level but is not mirrored in the corresponding EEG still remains to be fully understood.

Finally, the study aimed at developing an **EEG-based model** analogous to the self-report one, using the EEG correlates of *Mentalizing* and *Narrative Perception* as mediators of the effect of the experimental condition (NS) on the ad effectiveness variables (**Aim 3**).

The first research question (**RQ3.1**) asked whether EEG-derived indices explain additional variance in advertising effectiveness outcomes beyond that accounted for by self-report measures. The second question (**RQ3.2**) examined which model (self-report or EEG-based) explains advertising effectiveness better, thus assessing and comparing the explanatory value of the EEG-based measures relative to self-reports.

The results of the EEG-based model show that although the experimental manipulation (H vs. L condition) significantly increased both *Mentalizing* and *Narrative Perception* related brain activity, only the latter was systematically linked to advertising effectiveness measures. The consistent “paths” from *Narrative Perception* to ad liking, sharing, purchase, and recommendation intentions suggest that the extent to which viewers engage, even at the brain level, with the narrative aspects of the advertisement could be considered the key mechanism driving ad effectiveness variables and persuasive success. So, a higher narrative-related EEG response seems to be translated into stronger evaluative and behavioral intentions toward the ad. The results are different for the EEG measure of *Mentalizing*: despite being strongly modulated by the manipulation itself (NS), it showed no reliable relationship with the outcome measures. This suggests that, although the manipulation elicited enhanced EEG activity in regions associated with mentalizing processes, such activation did not contribute to advertising effectiveness. This means that it may instead reflect a broader engagement with social content that is not directly predictive of consumers’ attitudinal or behavioral responses.

The absence of significant direct effects of the manipulation on the dependent variables, after including the EEG mediators, means that the influence of the experimental condition (NS) on ad effectiveness thus appears to operate mostly through the EEG mechanisms of narrative perception rather than through other processes (i.e., *Mentalizing*) or self-reported processes.

In any case, the findings of the EEG-based model indicate that the ***Narrative perception EEG measure seems to be the main path through which the NS affects ad effectiveness responses***,

whereas mentalizing activity plays a limited and secondary role. The results support the interpretation that EEG-based measures of narrative processing capture the neural mechanisms most directly associated with persuasion. In this sense, the *Narrative Perception* EEG index emerges as a reliable and process-based predictor of advertising success, offering a more robust alternative to traditional self-report measures of narrative involvement

When it comes to comparing the self-report and EEG-based mediation models, a clear pattern emerges concerning both their explanatory power and the underlying psychological and neural mechanisms they capture. The self-report model provided strong and consistent evidence that NS enhances advertising effectiveness measures, operating through viewers' *subjective and reported experiences* of narrative perception and mentalizing. All narrative-related self-report measures (transportation & presence, and understanding) together with self-report mentalizing significantly mediated the effect of NS on the four ad effectiveness outcomes. In this framework, participants exposed to highly structured narratives reported presence, transportation, and comprehension of the narrative, which, in turn, led to higher liking, stronger sharing, purchase, and recommendation intentions. These results suggest that, at the psychological level, the perception of being absorbed in and understanding the ad story is a central mechanism of persuasion. Mentalizing also acted as a mediator, though its influence was smaller, indicating that reflective understanding of characters' intentions contributes modestly to persuasion compared with experiential narrative immersion.

The EEG-based model, which tested the same conceptual structure at the EEG level, revealed a more selective mediation pattern. The experimental manipulation (H vs. L NS) significantly increased both EEG-based indices of *Mentalizing* and *Narrative Perception*. However, only the EEG measure of *Narrative Perception* was systematically and robustly linked to ad effectiveness outcomes. EEG measures associated with narrative perception predicted higher ad liking, greater sharing and purchase intentions, and stronger recommendation intentions, closely following the pattern observed for the self-report narrative variables. The EEG *Mentalizing* index, while strongly influenced by the manipulation itself, did not significantly predict any of the outcome variables. This suggests that EEG signals reflecting social-cognition processing may capture general engagement with social content rather than processes directly responsible for persuasion. Moreover, the absence of significant direct effects of NS on ad effectiveness, once EEG mediators were included, indicates that the influence of the manipulation operates primarily through the EEG measures of narrative perception, rather than through other processes.

These results make it difficult to provide a clear answer to the two research questions. Regarding **RQ3.1** (i.e., whether EEG-derived indices explain additional variance in advertising effectiveness beyond self-reports) the findings suggest **partial but meaningful added value**. While the EEG model captures less overall variance than the self-report model, it isolates the *neural signature* of the narrative processes that, at the behavioral level, were already shown to be very meaningful. EEG measures confirm the mediating role of narrative processing without relying on self-reports. Thus, even if they do not explain more variance, they provide converging evidence of the same phenomenon observed behaviorally.

A similar answer can be given to **RQ3.2** (i.e., whether the self-report or EEG-based model better explains advertising effectiveness), as our results evidence a complementary rather than competitive relationship between the two models. While the self-report model better accounts for the subjective experience of narrative persuasion, capturing how individuals consciously feel transported, present, and understand the narrative, the EEG-based model, instead, identifies the EEG

mechanism underlying those experiences, showing that activity related to narrative perception is the key *physiological* path linking narrative structure to advertising effectiveness outcomes. We can say that the self-report model appears statistically stronger in explaining variance, while the EEG-based model is richer and the “theoretical level”, as it reveals the brain processes through which narrative persuasion operates. The answer to the research questions of Aim 3? *Integrating both levels of analysis* for the most comprehensive modeling: self-reports for what people experience and EEG measures for how those experiences are processed in our brain.

A few final remarks should discuss the role of mentalizing, especially the role of its EEG measure. Although the present findings provide clear evidence that narrative perception-related EEG measure is the main and stronger path linking the NS to advertising effectiveness, the role of *Mentalizing* within this framework appears to be more limited. Once narrative perception is included in the model, the contribution of mentalizing becomes substantially weaker, suggesting that much of its apparent relevance in “simpler” models may actually be absorbed by narrative-related processes. Thus, while mentalizing remains an important aspect of social-cognition mechanisms, its influence on persuasive outcomes (particularly in the domain of advertisement perception) seems secondary to the mechanisms captured by narrative perception. This implies that mentalizing, at least in the context of narrative advertising, does not seem to be the main driver of effectiveness or persuasive processes, but rather a mechanism reflecting general social understanding. Future research could therefore explore the role of mentalizing in non-narrative contexts, where its predictive value for communication and persuasion outcomes might emerge more clearly and independently from narrative-related dynamics.

5.1. Theoretical implications

This study advances the understanding of higher-order mechanisms in consumer neuroscience by introducing an EEG-based measure of mentalizing and empirically testing it in the context of advertising perception. The findings suggest that mentalizing plays a distinct, important, and measurable role in shaping how consumers engage with advertising narratives, offering a more complete account of advertising persuasion than models that only focus on “traditional” mental processes such as attention, approach/withdrawal, memory, or engagement.

First, the results in a sort of sense “**extend**” **narrative transportation theory** by identifying mentalizing as a complementary and potentially foundational process. The data show that, beyond the perception of the merely structural aspects of narratives, consumers engage in inference of characters’ mental states (i.e., mentalizing) while processing advertising content. This provides evidence that **the persuasive power of stories is** not only **driven by** emotional immersion but also by **social-cognitive processing of the characters’ mental states**. In this sense, mentalizing can be considered as a “connection” between narrative understanding and emotional involvement, helping to explain why well-structured stories elicit stronger (and better) responses.

Additionally, through the EEG-based model, this work highlighted the prevalence of *narrative perception* over *mentalizing* processes in explaining advertising effectiveness. They suggest that persuasion through storytelling and narratives may rely less on social-cognition mechanisms and more on immersive, perceptual integration processes that merge attention, emotion, and comprehension into a unified narrative experience.

Second, the study contributes to the **theoretical integration of mentalizing and narrative processing** within consumer neuroscience. Prior research often treated them separately: narrative

engagement was seen as an experiential process, while mentalizing was only a simple social cognition process, unrelated to persuasion. The present findings suggest that these two constructs overlap substantially, supporting the idea that narrative persuasion can be, at least partially, understood as an act of social cognition, where consumers mentalize with the intentions and emotions of characters, probably to then relate them to their own goals and values.

Third, the use of EEG provides not only the **neural correlates of Mentalizing and Narrative perception processes**, but also presents neurophysiological support for these theoretical claims. The observed suppression in posterior alpha bands and the delta suppression in frontal regions during mentalizing indicate that these processes involve sustained attention and cognitive processing. These measures are applied here within a consumer and advertising context, suggesting that they can also be used to assess the engagement of social-cognitive processes during naturalistic media exposure. Moreover, the EEG-based model highlights the specific potential of the EEG measures of narrative perception to provide direct insight into consumers' implicit processing of advertising narratives and offer a reliable indicator of advertising effectiveness than self-report data alone.

So, this work moves beyond "traditional" behavioral models of advertising effectiveness and proposes a novel framework that integrates narrative structure, mentalizing, and narrative perception with the final consumer response. In this sense, it can represent a contribution to a wider theoretical shift from models of passive information processing to models of active, socially grounded meaning construction in consumer experience.

5.2. Practical implications

These findings also carry several practical implications with them, primarily related to the domain of advertising research and "applied communication design".

For practitioners and creatives, the results highlight the importance of **designing and building ads that encourage viewers to infer characters' thoughts and emotions**, and connect with them. Moreover, ads with an identifiable narrative structure and identifiable characters (with identifiable cognitions and emotions) invite consumers to engage in mentalizing and narrative processing, which in turn could enhance ad liking, sharing intention, recommendation, and purchase intention. Rather than relying only on measures such as emotional valence and intensity or approach vs. withdrawal processes, or even just aesthetic evaluation and "appeal", advertisers should focus on ensuring that viewers can understand characters, why they act as they do, and what intentions and goals drive them.

Moreover, these findings can offer practical guidelines for the pre-testing of advertising content. EEG correlates that capture mentalizing-related activity can complement traditional self-report measures and assess whether a story truly elicits these processes. This could help identify which alternative narratives, or which specific narrative segments would fail to evoke such processes to then inform targeted adjustments before campaign approval and distribution. Particularly, between the different measures, our results highlight the performance of EEG-based measures of *narrative processing* as a valid and reliable indicator of advertising effectiveness. In an applied testing context, monitoring neural markers of narrative processing can help practitioners design campaigns that maximize narrative coherence, emotional resonance, and viewer immersion, all core elements of an ad's persuasive power. These measures can complement traditional self-reports to offer a fuller and richer set of insights into how consumers actually process and respond to advertising narratives.

Indeed, our evidence suggests that **mentalizing** is not merely an abstract social cognitive process, but an important **predictor of marketing-relevant outcomes** (when assessed via self-report measures). So, **integrating these EEG-based neurophysiological indices into standard measures for campaign evaluation** would help marketers to gain more comprehensive and reliable feedback on how viewers perceive the advertising content (particularly regarding how much the ad “can persuade”), rather than simply on how much they, for example, report liking it.

Finally, these insights may have implications **beyond advertising** for all those fields where both narrative persuasion and social processes matter a lot, such as health communication, education, political campaigns, etc... Understanding the importance of an audience that can first infer and then respond to others' mental states and intentions, can guide the creation of messages that foster deeper engagement, are better perceived and work more.

5.3. Limitations and future directions

Despite its important theoretical and practical insights, this study has some limitations that should nonetheless be considered a starting point for future research.

First, the nature of the localizer stimuli used should be taken into account. The experimental task materials consisted of neutral, purely geometrical stimuli adapted from prior literature (Abell et al., 2000; Nguyen et al., 2019). While this choice ensured standardization, control, and that the stimuli had already been used and validated in scientific literature, it may have reduced ecological validity and emotional as well as cognitive engagement compared to more naturalistic or commercial stimuli. We can all agree that the type of stimulus inevitably shapes the neural response: EEG activity always reflects an interaction between cognitive processing and the specific features of the stimulus being perceived. There is no “neutral” stimulus, as every input carries a certain level of social, affective, or narrative meaning. Thus, future research should test how different stimulus types, **not only simple abstract geometric animations**, influence the elicitation of mentalizing and narrative-related processes at the neural level. Such comparisons would also help distinguish which EEG patterns are actually associated with the process itself (mentalizing or narrative perception) and which depend on the perceptual “richness” of the material adopted in the task.

Second, while this approach provided evidence of consistent EEG signatures for both mentalizing and narrative processing, they were limited to the extraction of a limited number of more robust features from condition-level comparisons. In future analyses, **more advanced analytical approaches** could reveal more precise spatial and frequency-level dynamics of these processes. For instance, **cluster-based permutation analysis** could be employed to identify statistically significant clusters of activation across scalp regions, offering a more precise assessment of the neural topography associated with each construct. In this way, the EEG correlates corresponding to each process will be better mapped, as would also be the eventual overlap between mentalizing and narrative perception-related EEG measures.

Third, the laboratory setting chosen for this study oversimplifies **natural exposure to media and media content** (e.g., advertisements). On the other hand, this choice was motivated by several reasons. For example, it allowed for a high level of experimental control over lighting, sound, movement, and other factors that can easily introduce artifacts in EEG data, ensuring data reliability and internal validity. Furthermore, given the exploratory nature of this research, it was necessary to focus on control first rather than ecological validity in this initial stage, to identify consistent EEG signatures of mentalizing and narrative processing. Future studies can use this acknowledged

limitation as a starting point to test whether similar EEG patterns emerge in more natural settings and with more ecologically valid designs, where contextual and social factors may also influence audience response. Indeed, real-world advertising often involves other types of stimulation (even multisensory), contextual cues, interactive formats, and spontaneous social sharing, all of which may influence mentalizing processes as well as the perception of narratives.

Fourth, while EEG provides high temporal precision, its limited spatial resolution does not allow for a detailed identification of the cortical sources of this process. We observed posterior and frontal activations, but more spatially resolved methods such as fNIRS or fMRI would also be necessary, for example, to confirm the involvement of the already-established mentalizing regions, such as the medial prefrontal cortex or the temporo-parietal junction (Shurz et al., 2014). The combination of our data emerged with EEG and these techniques would provide complementary insights into both when and where mentalizing and narrative processes occur when we watch ads.

Another limitation concerns the composition of the participant sample. For our experimental control purposes, the group was fairly homogeneous: it consisted mainly of young adults with relatively high familiarity with media formats. A larger, more diverse sample could reveal how demographic factors influence EEG dynamics during the perception of advertising. Furthermore, the sample was highly diverse in terms of country of origin. What impact does this diversity have? Do EEG data, particularly those related to the constructs of mentalization and narrative perception on which we focused, change according to country of origin? Or according to culture?

Finally, future research should ***continue refining the operationalization of the mentalizing construct*** within consumer neuroscience, and specifically in the context of advertising research. This study combined a task-based approach and EEG “neurometrics”, but further validation across different stimulus contexts, stimulus types, and sensory modalities will be needed to reinforce the results and make these EEG correlates more generalizable. Moreover, the insights of this study can be, in a sort of sense, limited by the narrative nature of the stimuli. Since mentalizing and narrative perception strongly overlap, the specific contribution of mentalizing may have been overlooked due to its integration within narrative-related processing. Future research should test mentalizing in contexts beyond narrative communication, where it may operate more independently and its unique predictive role can better emerge.

This study thus provides initial evidence for distinct EEG correlates of mentalizing and narrative perception, but for sure it also opens new questions about the boundaries, context-dependence, and generalizability of this evidence, which must be met to obtain a better and more comprehensive framework on how consumers perceive and respond to communication messages they encounter in their everyday life.

6. Conclusion

This chapter started from the construct of *mentalizing* and applied it to the context of *narrative perception*, examining how these higher-order mechanisms operate when people process advertising messages. Using a repeated-measures EEG study (44 participants; 30 ads shown twice) and validated localizers (Frith–Happé triangles for mentalizing, Abell et al., 2000; Nguyen et al., 2019, for narrative perception), it attempted to link Narrative structure (NS) to the outcomes of ad liking,

sharing, purchase, and recommendation through both subjective reports and neural (EEG-based) measures.

On the behavioral side, the *self-report model* confirmed and extended prior work: stronger NS yielded better evaluations across all four ad effectiveness outcomes. Mediation analyses indicated that this effect proceeds through narrative perception (narrative transportation/presence and understanding) and, to a lesser extent, through self-reported mentalizing. When an ad has a coherent narrative story, viewers report greater presence, transport, and comprehension, which in turn supports more favorable attitudes and intentions. Mentalizing contributes, but its indirect effects were smaller than those of the narrative variables.

On the neural side, the “localizer” tasks identified consistent EEG patterns for both processes. Mentalizing was associated with frontal delta reductions (1–2 Hz) and posterior alpha suppression (9–11 Hz), a pattern consistent with heightened attention and active visual/semantic processing. Narrative perception showed centro-parietal delta reductions (~1 Hz) together with right parieto-occipital alpha suppression (10–11 Hz), in line with sustained attention and integration across scenes. Both processes shared posterior alpha suppression, but differed in delta topography (frontal for mentalizing; centro-parietal for narrative), suggesting overlapping attentional mechanisms (alpha activity) implemented through partially distinct control networks (delta activity). The EEG evidence supports the idea that mentalizing is not separated from narrative perception during ad viewing: it seems to co-occur with the attentional/perceptual work required to process unfolding stories.

Comparison analyses with the other EEG measures used in advertising research within the consumer neuroscience field (Van Diepen et al., 2024) positioned these two resulting neurometrics close to attentional/arousal mechanisms (centro-parietal alpha), with limited correspondence to reward-related beta, frontocentral gamma, or theta markers, which can be due to the neutral and highly controlled nature of the stimuli.

One surprising finding was the lack of significant NS effects on the EEG indices of Mentalizing and Narrative perception themselves, despite clear NS effects on self-reports. Several factors may explain this discrepancy: the high control of stimuli, the emotionally neutral localizers, and the possibility that NS primarily modulates neural mechanisms via processes that are not fully captured by the selected EEG features. These considerations suggest the need for more naturalistic designs and richer stimulus sets in future work.

Finally, the *EEG-based mediation model* showed similar results to the behavioral framework but with a more selective picture. The manipulation increased both EEG indices, yet only the Narrative-Perception measure showed to influence the ad effectiveness outcomes. The Mentalizing EEG measure, while sensitive to the NS manipulation, did not predict ad responses once narrative perception was in the model. Thus, at the neural (EEG) level, narrative processing appears to be the primary mechanism by which NS translates into persuasion, with mentalizing playing a secondary role. Between the self-report and the EEG-based model, the most informative approach seems to be integrative: **self-reports to assess what** participants experience, and **EEG to show how** (i.e., through which mechanisms) those “experiences” are represented in the brain.

Conceptually, this study makes two arguments: first, that narrative perception should play a central role in advertising research, and second, that mentalizing should be treated as a more context-dependent mechanism. Since within the context of narrations and narrative ads mentalizing seems to be “absorbed” by narrative processing, its predictive value may emerge more clearly outside narrative contexts, where it is less confounded with story comprehension and transportation. So, its role should be tested more in these other contexts.

Practically, the EEG correlates that emerged, particularly those related to narrative processing, may provide a reliable measure for pre-testing stimuli, helping to diagnose whether structures and cues elicit those higher-order processes that can predict successful ad responses.

In any case, the conclusions of this work are limited by the following factors: a controlled laboratory environment, too neutral localizers, and a relatively too simple set of (ad) stimuli. Addressing these limitations along with a more sophisticated analysis should help understand when narrative processing and mentalizing diverge, how delta/alpha dynamics relate to persuasive mechanisms, and under which conditions mentalizing becomes the main driver of communication dynamics and optimal consumer responses.

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CHAPTER 4

Final Remarks

This doctoral dissertation aimed to advance the methodological and theoretical foundations of consumer neuroscience and neuromarketing, with a specific focus on the measurement of social-cognition processes - specifically mentalizing - through electroencephalography (EEG). Across the different chapters, the work tried to address two main challenges that currently limit the development of the field: (1) the methodological inconsistencies in the use of EEG metrics in consumer research, and (2) the need to bridge the gap between scientific academic research and applied market research practice.

1. General discussion

The first chapter offered a systematic review of EEG-based measures commonly used in consumer research, providing an overview of how cognitive and affective processes have been operationalized and highlighting significant heterogeneity and inconsistencies both at the conceptual and methodological levels. This review highlights the limits that the consumer neuroscience discipline currently faces, emphasizes the need for a more standardized, theory-driven approach to EEG metrics, and called attention to social cognition processes as a promising yet underexplored area of investigation.

Building on this, the second chapter focused on the theoretical definition and conceptualization of *mentalizing* (we should know at this point that it is the ability to infer others' thoughts, intentions, and emotions) as a key but neglected component in understanding consumer behavior. Drawing from social and affective neuroscience, the chapter argued that mentalizing plays a fundamental role in how consumers interpret communication messages, particularly those that involve human interaction or narrative content. It concludes by proposing that the integration of mentalizing into consumer neuroscience frameworks, and particularly via EEG measurements, could enhance our understanding of several consumer mechanisms, such as persuasion, empathy, and social connection in marketing contexts.

The third, empirical chapter provided the first attempt to operationalize an EEG-based metric of mentalizing within the domain of advertising research. The study identified EEG correlates of the processes of mentalizing as well as narrative perception during ad exposure and examined how these processes were influenced by narrative structure (NS). While no statistically significant effects of NS were found on the EEG measures, the direction of the trends and the insights from self-report data analysis suggested that participants' subjective experiences of mentalizing and narrative transportation were indeed modulated by NS. Furthermore, when the EEG-based measures of mentalizing and narrative perception were used as predictors of ad effectiveness measures, only those related to narrative gave strong and significant results, while those related to mentalizing did not. On the contrary, in the results with self-report data, both measures had an impact on the final outcomes.

This discrepancy between self-report and EEG-based findings raises some theoretical and methodological questions: it may reflect the inherent complexity of capturing subtle, socially grounded processes through EEG, or it may suggest that these EEG correlates are mostly influenced by other factors. Moreover, these findings highlight the importance of a multimethod approach

combining neurophysiological and behavioral measures to achieve a fuller understanding of the consumer.

The findings of this dissertation can contribute to the following three main areas:

1. **Theoretical advancement.** Introducing mentalizing as a measurable, EEG-based construct within consumer neuroscience, the work expands the theoretical bases of the field beyond traditional metrics such as attention, emotions, memory, engagement or arousal. Moreover, it places the mentalizing process within the context of narrative and narrative perception research, between narrative engagement and persuasion, supporting the idea that effective communication is also deeply “social”.
2. **Methodological innovation.** The EEG-based measure computed and proposed in this dissertation represents an initial step toward operationalizing social-cognition constructs in consumer neuroscience. Of course, what has been presented so far represents only an initial attempt that requires further refinement and systematic testing before it can be considered a valid metric of mentalizing. Nevertheless, the study demonstrates the feasibility of assessing higher-order social-cognitive processes through EEG and reinforces the importance of methodological rigor, standardization, and construct validity in applied consumer neuroscience and neuromarketing research.
3. **Practical implications.** This research demonstrates how EEG and social cognition processes can meaningfully contribute to real-world advertising evaluation. Beyond its theoretical value, the developed approach provides both conceptual guidance and practical tools for creatives and market researchers to comprehensively and deeply test new products, messages, and communication materials, such as advertisements. Insights derived from the analyses of EEG “localizers” measures and their future refinements and systematic testing can be integrated into applied research contexts, such as A/B testing or post-production analysis. In these market research settings, EEG can offer an additional component for understanding consumer responses by revealing aspects often inaccessible through traditional self-report measures. In this sense, this work contributes to bridging the gap between academic research and applied everyday industry needs and practices, a central aim of this doctoral dissertation.

Nevertheless, several limitations must be acknowledged. EEG, while temporally precise, offers limited spatial resolution, and future studies should integrate it with complementary techniques such as fNIRS or fMRI to identify the cortical sources of mentalizing-related activity. Moreover, the sample was relatively homogeneous in terms of age, media literacy and experience, which could have potentially limited the generalizability of the findings. Expanding future research to more diverse populations and cultural contexts could help determine how narrative and social-cognitive processing vary across audiences.

Future research should also aim to refine the operationalization of mentalizing in consumer neuroscience, validating the current EEG-based approach across different stimulus types (e.g., social media content, interactive ads) and integrating behavioral, emotional, and physiological data. More ecologically valid designs that reflect real-world media consumption would also be particularly interesting in understanding how social cognition unfolds in other consumption contexts, such as dynamic, multi-sensory environments.

2. General conclusions

In conclusion, this dissertation aimed to contribute to a ***more socially grounded, methodologically rigorous, and practically relevant consumer neuroscience***. The overall purpose was not only to refine how we measure consumer responses, but also to deepen our understanding of the social and cognitive processes that shape them.

The findings presented here suggest that EEG can be used to explore not only basic affective and cognitive states but also more complex, socially embedded processes such as mentalizing. Even though these results remain preliminary, they show that it is possible to approach higher-order cognitive phenomena through neuroscientific tools, offering a path toward a more integrated understanding of how people interpret, relate to, and emotionally connect with communication messages. The progress made thus far is an important first step, even though it still requires further refinement, replication, and systematic validation before it can be considered a robust and reliable EEG measure for mentalizing.

More broadly, this work also promotes a “vision” of consumer neuroscience that embraces both rigor and relevance. Indeed, another significant aspect of the future of this discipline lies in the ability to integrate precise neuroscientific methods with behavioral and self-report approaches, combining quantitative depth with ecological validity. Rather than as a challenge, interdisciplinarity should thus be viewed as the real value of this discipline, which aims to connect psychological theory, neural measurement, and applied market research.

From a practical point of view, the proposed approach offers insights that can be extended beyond academic contexts. EEG-based measures of consumer processes, if carefully developed, tested, and validated, could be adopted by creatives and market researchers to complement traditional tools, enriching advertising and product evaluation processes, to reveal aspects of consumer experience that remain invisible to self-report, allowing for a more comprehensive, accurate, and authentic understanding of audience responses.

The ambition of this research goes beyond simply finding a single metric. It attempts to contribute to a broader transformation in how we think about consumer neuroscience as a discipline that can not only assess neural data but in general can capture the human dimensions of decision-making, such as empathy, understanding, and meaning-making. If this work has succeeded, even just a little, in helping move the field toward this vision by encouraging dialogue between scientific rigor and practical relevance, then it will have fulfilled its most important purpose.

Appendix

This *Appendix* provides supplementary material relevant to the study, intending to enhance methodological transparency and replicability. It includes additional detailed information on the measurement scales employed, on the stimuli used during the experimental procedures, and on the statistical analyses (e.g., extended results from exploratory analyses, supplementary figures, and further model specifications that support the main findings presented in the manuscript).




Section 1. Narrative Structure














Narrative Structure Scale (NSS) items (Escalas, 2004b), measured on a 5-point scale from 1 (Not at all) to 5 (Very much so).



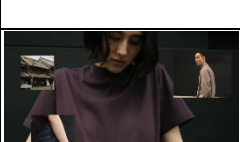

1. To what extent does this ad consist of actors engaged in actions to achieve goals?
2. To what extent does this ad let you know what the actors are thinking and feeling?
3. To what extent does this ad provide you with insights about the personal evolution or change in the life of a character?
4. To what extent does this ad explain why things happen, that is, what caused things to happen?
5. To what extent does this ad have a well-delineated beginning (initial event), middle (crisis or turning point), and ending (conclusion)?
6. To what extent does this ad focus on a specific, particular event rather than on generalizations or abstractions?



Section 2. Ad stimuli description

The following table presents the final set of advertisements selected according to the procedure described in Section 3.2.1. Each entry provides details on the Brand, Ad title, category and reference Product, as well as a Link to directly view the ad, its duration (Dur.), Year of release, and a representative Frame to illustrate the content. The table also reports the ratings on the Narrative Structure Scale (NSS) by Rater 1 and Rater 2, the averaged Narrative Structure score - NS (M), and the final categorization of the ad's narrative structure as high vs. low.

Brand	Ad Name	Product	Link	Dur.	Year	Frame	NSS Rat. 1	NSS Rat. 2	NS (M)	NS Cat.
Toyota	All-New Toyota Kluger Hybrid	Car	https://www.adsoft.heworld.com/campaigns/all-new-toyota-kluger-hybrid	30s	2021		20	25	22.5	high
	Clouds		https://www.adsoft.heworld.com/campaigns/tiene-un-no-se-que	30s	2024		7	10	8.5	low
Adidas	Free Throw	Shoes	https://www.youtube.com/watch?v=BrKAlfSoaew	30s	2024		24	24	24	high

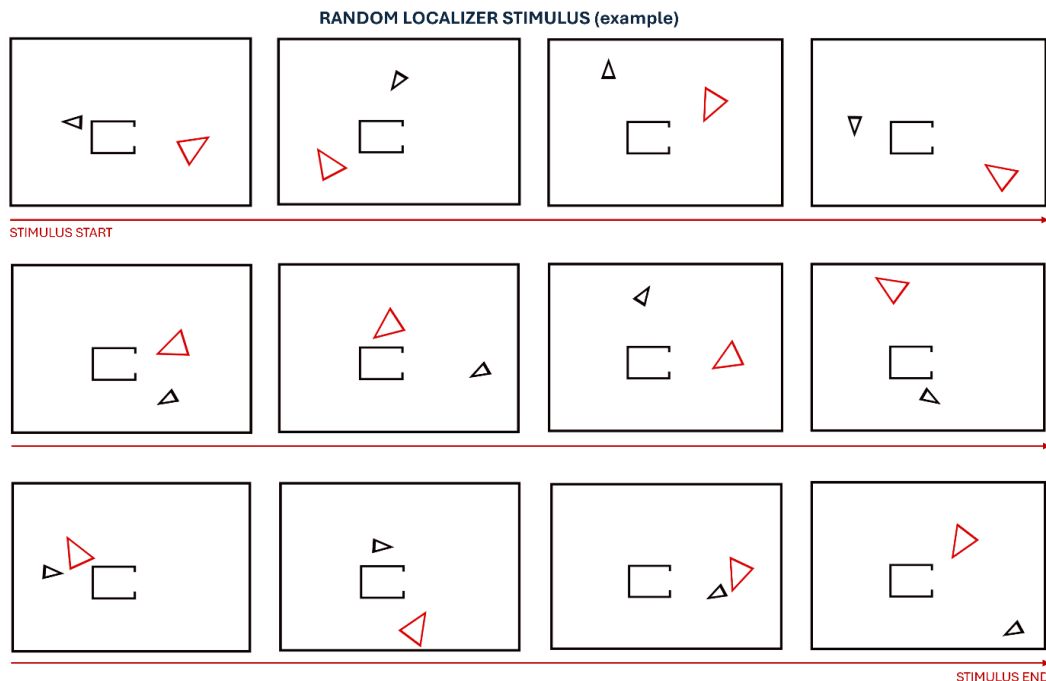
	Enter OzWorld		https://www.youtube.com/watch?v=kINoSs5osgg	30s	2022		6	8	7	low
Amazon	Rapunzel	Service – ECommerce	adsoftheworld.com/campaigns/rapunzel-cleopatra	30s	2021		27	25	26	high
	Binge Cheat		https://www.adsoftheworld.com/campaigns/binge-cheat	30s	2020		11	8	9.5	low
Heinz	The Heiress	Food	https://www.youtube.com/watch?v=YMvxC-KRBVE	30s	2024		21	21	21	high
	Heinz Ketch-Up & Down		https://www.adsoftheworld.com/campaigns/heinz-ketchup-amp-down	20s	2023		7	8	7.5	low
Ikea	It's the Little Things	Furniture	https://www.youtube.com/watch?v=bgpoOpNX5IY	30s	2022		23	23	23	high
	Sleek, modern built-in appliances		https://www.youtube.com/watch?v=R8A9cCWzBUY	30s	2021		6	6	6	low
Apple	New Driver	Tech	https://www.adsoftheworld.com/campaigns/iphone-15-check-in-new-driver	30s	2024		24	18	21	high
	Apple Watch Series 10		https://www.youtube.com/watch?v=e6T34u51MaA	30s	2024		6	8	7	low
Lego	Adults welcome	Toys	https://www.youtube.com/watch?v=iYbDrDlxVs	30s	2022		25	21	23	high
	#UKRAINE inLEGObricks		https://www.adsoftheworld.com/campaigns/ukraineinlegobricks	32s	2024		6	6	6	low
Uber	Froggy	Service - Transport	https://www.youtube.com/watch?v=tXka2ConDqc	30s	2024		23	18	20.5	high
	A clearer, bolder, more detailed navigation experience		https://www.youtube.com/watch?v=zm7q3JVCmdk	34s	2023		7	7	7	low

Aldi	Switch to Aldi for the Freshest Groceries	Supermarket	https://www.youtube.com/watch?v=fD6IS6B6ly8	30s	2020		26	19	22.5	high
	Mandarins		https://www.adsoftheworld.com/campaigns/mandarins	16s	2018		7	6	6.5	low
Levis	One Fair Exchange in the Greatest Story Ever Worn	Clothes	https://www.youtube.com/watch?v=vBaaajSrXq	30s	2023		24	17	20.5	high
	Made & Crafted in Japan Fall/Winter 2022		https://www.youtube.com/watch?v=bB2vvHogvsY	30s	2022		6	9	7.5	low
Pringles	Stuck In	Food	https://www.youtube.com/watch?v=aP2up9N6H-g	30s	2022		21	21	21	high
	#MultiGRANotGRAN		https://www.youtube.com/watch?v=lkkt4gQSF7w	20s	2022		6	8	7	low
Heineken	All the taste, no Bitter Ending	Beverage	https://www.youtube.com/watch?v=MnXJnZLi0GA	30s	2023		27	22	24.5	high
	Unique Balanced Taste		https://www.youtube.com/watch?v=i6MCNP8z6ng	30s	2024		6	7	6.5	low
Samsung	Join the Flip Side	Tech	https://www.youtube.com/watch?v=mqNWOrfID7I	30s	2022		24	19	21.5	high
	Unfold your story Galaxy AI		https://www.youtube.com/watch?v=KyqT3Vn4lik	30s	2024		8	7	7.5	low
Duracell	Dad Got Caught	Electronics	https://www.adsoftheworld.com/campaigns/dad-got-caught	30s	2024		24	21	22.5	high
	Keep Your Mobile Mobile		https://www.youtube.com/watch?v=eOLr65E3l8	30s	2019		8	7	7.5	low

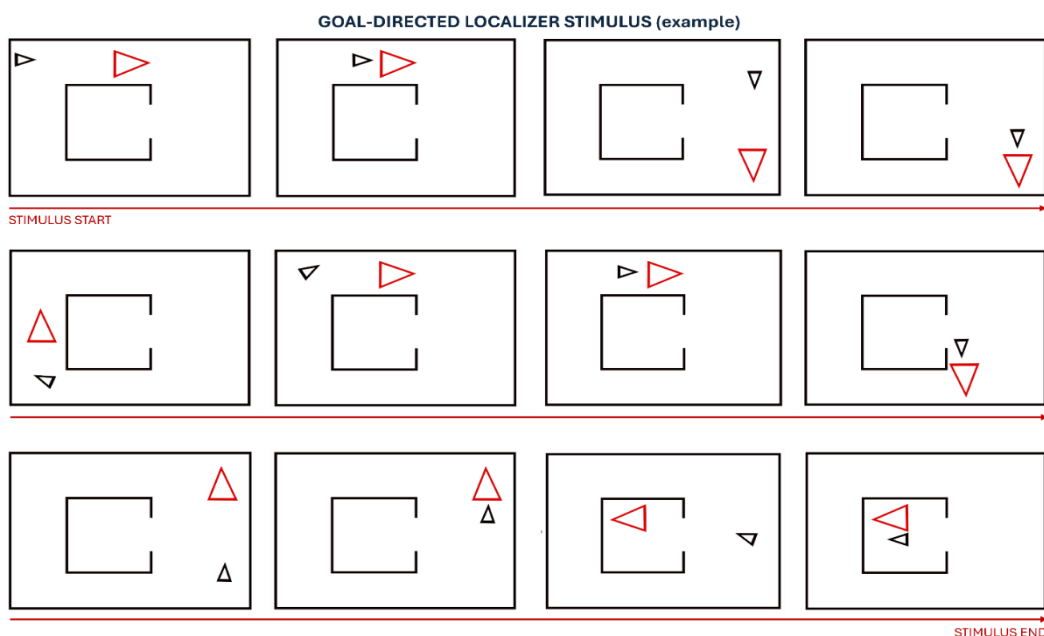
Domino's	Emergency Pizza - Jar	Food	https://www.youtube.com/watch?v=hgLSEIVENrU	30s	2024		25	24	24.5	high
	Domino's Meltzz		https://www.youtube.com/watch?v=4uwwlzhEb20&t=32s	30s	2023		7	13	10	low

Section 3. Mentalizing localizer task

The following images describe the Mentalizing task by providing an example of one stimulus from each of the three stimulus categories (Random – Goal-directed – ToM) used in the Frith-Happé Triangles task. The aim was to contrast EEG activity across these categories in order to identify the EEG correlates of mentalizing processes. The figure below schematically represents the **“Random” stimulus category**. In particular, the sequence of frames is taken from the stimulus titled “Drifting”, which shows two triangles moving in a completely random manner within the space.

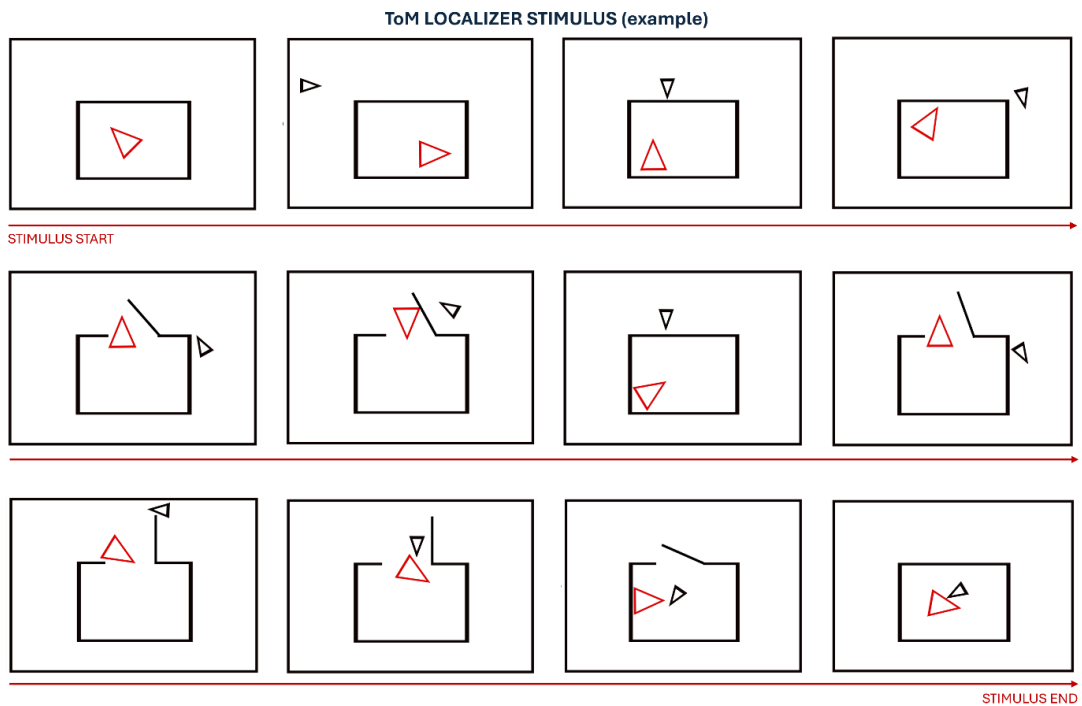


The figure below represents one of the stimuli from the **“Goal-Directed” category**. In this condition, the triangles exhibit purposeful behavior. For instance, in the stimulus shown (titled “Chasing”), the small black triangle is chasing the bigger red triangle until it reaches it inside the house. This type of stimulus involves goal-directed action, as the triangles appear to be engaged in a specific objective, even if their behavior does not imply any mental states or intentions beyond the observable goal.



The figure below schematically illustrates a stimulus from the **“Theory of Mind (ToM)” category**, specifically the animation titled “Surprise”. In the initial frames, there is only the big red triangle inside the house. The small black triangle then approaches and seems to knock on the door. Then, it quickly runs away to the right, so that when the red triangle opens the door, no one can be seen. Meanwhile, behind the door, the black triangle slightly moves in a way that resembles a giggle. The red triangle briefly looks around, sees no one, and returns inside, closing the door. The black triangle then comes back and knocks again, only to repeat the same trick. This time, as the red triangle opens the door and then goes back inside, the black triangle quickly enters behind it, seemingly to surprise it. The red triangle turns as if to face the black triangle, and the animation ends with both triangles approaching each other and remaining inside the house together.

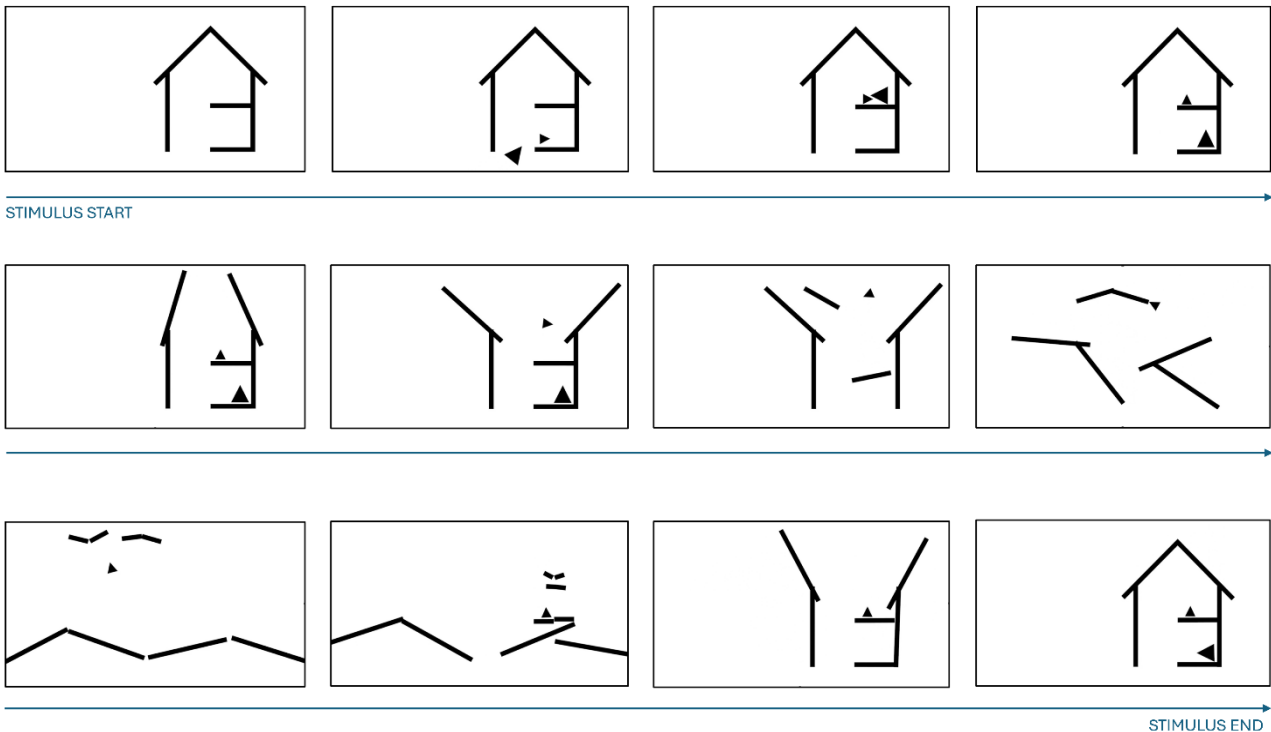
This type of stimulus clearly requires the viewer to infer the mental states of the two characters (triangles) to make sense of their actions. As such, it engages *mentalizing* processes, not elicited in the other conditions (particularly in the Goal-Directed one), where the triangles’ behavior is purposeful but does not imply underlying intentions or beliefs. This distinction is key in differentiating ToM stimuli from the other categories.



Section 4. Narrative localizer task

For the Narration Task, a total of 4 videos were presented, starting from the stimulus used in Nguyen et al. (2019). This video stimulus was selected specifically for its narrative and because it closely matches the type of stimuli used in the other mentalizing localizer tasks. Similar to ToM localizer videos, it features abstract triangle shapes that, despite lacking facial or emotional features, behave in a way that allows observers to infer intentions and construct a meaningful story based on their interactions. The original video was relatively long (7 minutes), so it was segmented into two key excerpts in which a coherent storyline could be clearly identified. Each lasted approximately 1.40 minutes, so that it corresponded in total duration to one of the conditions of the mentalizing localizer. A detailed description of one of the two **narrative** videos is provided below and in the figure. The video begins with a house simply constructed from basic geometric shapes and lines. Two triangular figures appear (one small and one bigger, interpretable as a child and a parent). They enter the house together and go upstairs. The big triangle kisses the smaller one, saying goodnight. Both figures remain still for a period, suggesting that they are sleeping. At a certain point, the roof of the house opens, and the small triangle rises, indicating that the child is dreaming. The house opens and transforms into a landscape with hills, and the small triangle begins to fly with birds. After a while, the dream ends, the house closes back up, and the video concludes with the child still asleep and the parent awake, suggesting it is now morning. The narrative is further reinforced by a piano-based soundtrack, which contributes to creating coherence and narrating the storyline.

NARRATIVE LOCALIZER STIMULUS (example)



In contrast, the control (non-narrative) stimuli lacked all the narrative features present in the original videos. To build it, short segments from the narrative videos were extracted and reassembled in a randomized order to eliminate any narrative structure (e.g., scenes such as the house rotating or opening appeared without context or continuity). Additionally, the music did not support or enhance any narrative flow. Although the soundtrack was also piano-based, it was not related to the events in the video and did not contribute to a sense of story, unlike the music in the narrative condition.

Section 5. Narrative Understanding

Narrative Understanding (Boksem et al., 2025) scale items, rated on a 7-point scale from 1 (Not at all) to 7 (Very much).

1. I found it easy to understand and comprehend what was going on in the ad.
2. The ad did not make sense.
3. The ad has a clear storyline.
4. It was difficult to understand how the events in the ad were related.

Section 6. Narrative Presence

Narrative Presence (Busselle & Bilandzic, 2009) scale items, rated on a 7-point scale from 1 (Not at all) to 7 (Very much).

1. During the ad, my body was in the room, but my mind was inside the world created by the story.
2. The ad created a new world, and then that world suddenly disappeared when the ad ended.
3. At times during the ad, the story world was closer to me than the real world.

Section 7. Mentalizing

Participant's mentalizing ability was measured through the Mentalization Scale – Brief Version (MENTS-12) (Stefana et al., 2024). It comprises 12 items divided in: (S) items assessing mentalizing about the Self, (O) items assessing mentalizing about Others, and (M) items assessing Motivation to mentalize. Responses are rated on a 5-point scale, from 1 ("Completely incorrect") to 5 ("Completely correct"). Intermediate ratings were 2 ("Mostly incorrect"), 3 ("Both correct and incorrect"), and 4 ("Mostly correct"). In line with the original paper, participants were instructed as follows: *"This questionnaire consists of 12 items. Please read each item carefully and select a number on the scale from 1 to 5, depending on how much the item is CORRECT FOR YOU PERSONALLY."*

1. Usually I can recognize what makes people feel uneasy. (O)
2. When I get upset I am not sure whether I am sad, afraid, or angry. (S)
3. I can make good predictions of other people's behavior when I know their beliefs and feelings. (O)
4. Often I cannot explain, even to myself, why I did something. (S)
5. Sometimes I can understand someone's feelings before s/he tells me anything. (O)
6. I find it important to understand what happens in my relationships with people close to me. (M)
7. To understand someone's behavior, we need to know her/his thoughts, wishes, and feelings. (M)
8. I often talk about emotions with people that I am close to. (M)
9. I find it difficult to admit to myself that I am sad, hurt, or afraid. (S)
10. I am often confused about my exact feelings. (S)
11. People tell me that I understand them and give them sound advice. (O)
12. I have always been interested in why people behave in certain ways. (M)

Section 8. Involvement with the product

To assess the involvement with the product, participants were instructed as follows: *"When you are involved with something, you personally consider it relevant, meaningful, and fundamental. Based on this description, rate your level of involvement with the following product categories, on a scale from 1 (Not at all) to 7 (Very much)."*

1. Cars
2. Sportswear
3. E-commerce
4. Sauces
5. Furniture
6. Electronics
7. Toys
8. Transportation Services
9. Supermarkets
10. Clothing
11. Snacks
12. Beverages
13. Batteries
14. Food

The categories listed above correspond to those of the products/services featured in the advertisements presented to participants.

Section 9. Involvement with the brand

To assess the involvement with the brand, participants were instructed as follows: *"When you are involved with something, you personally consider it relevant, meaningful, and fundamental. Based on this description, rate your level of involvement with the following brands, on a scale from 1 (Not at all) to 7 (Very much)."*

1. Toyota
2. Adidas
3. Amazon
4. Heinz
5. Ikea
6. Apple
7. Lego
8. Uber
9. Aldi
10. Levis
11. Pringles
12. Heineken
13. Samsung
14. Duracell
15. Domino's

The brands listed above correspond to those of the products/services featured in the advertisements presented to participants.

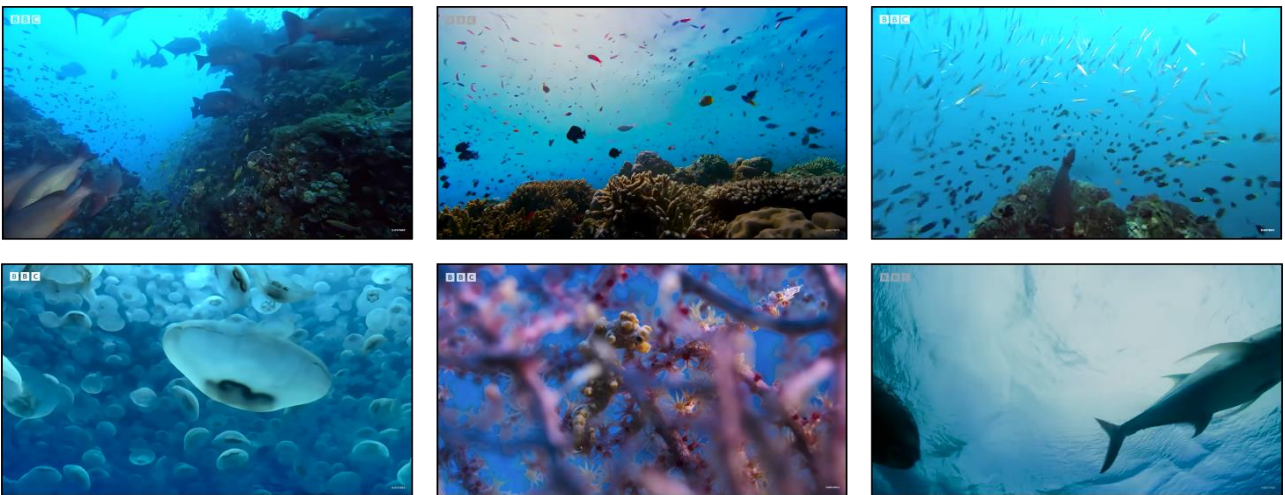
Section 10. Brand Familiarity

Items for Brand Familiarity assessment (adapted from the concepts by Machleit et al., 1993). Participants were instructed as follows: *"Thinking about the brand [brand picture], please answer the following questions from 1 (Not at all) to 7 (Very much)"*.

1. I am familiar with this brand.
2. I have had experiences with this brand.
3. I have knowledge about this brand.

Section 11. Documentaries

Frames from the marine documentaries that were presented between blocks of advertisements to simulate a typical commercial break, enhancing the ecological validity of the stimulus presentation and preventing excessive participant fatigue.



Section 12. Example of advertisements used: comparison between two spots from the same brand (Levi's), one featuring a Low narrative structure (a), and the other a High narrative structure (b)

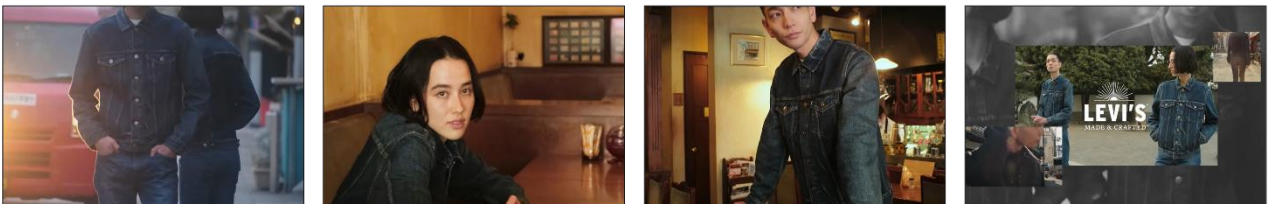
Version A (on the top) consists of a simple sequence of disconnected images, with no identifiable narrative. It just shows the two models wearing clothes from the advertised collection, which places it within the low narrative structure category.

In contrast, version B has a high narrative structure, as evidenced by the coherent and clearly defined storyline that unfolds throughout the spot. It opens with a spatiotemporal reference, "Tbilisi, Georgia, 1952", with a boy in his room reading a magazine. He stops, looking at an advertisement showing a man wearing Levi's jeans. The narrative continues as the boy leaves his house, opens the stable, and leads one of his cows to another farm. There, he meets a man wearing Levi's jeans and trades the cow for the jeans. The commercial ends with the boy, visibly happy, walking away wearing his newly acquired Levi's jeans.

a) Levi's ad "Made & Crafted in Japan | Fall/ Winter 2022", Low Narrative Structure

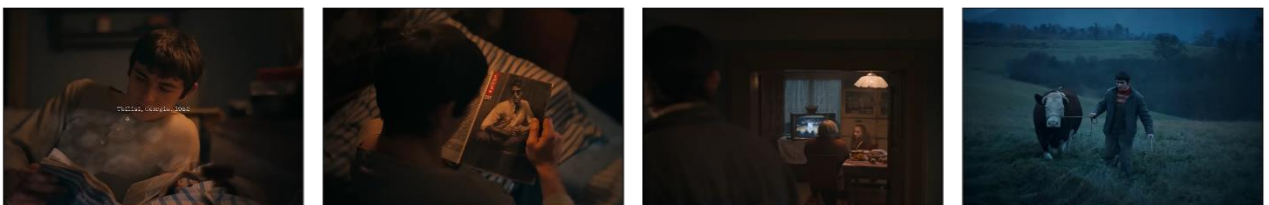


AD START



AD END

b) Levi's ad "One Fair Exchange in the Greatest Story Ever Worn", High Narrative Structure



AD START



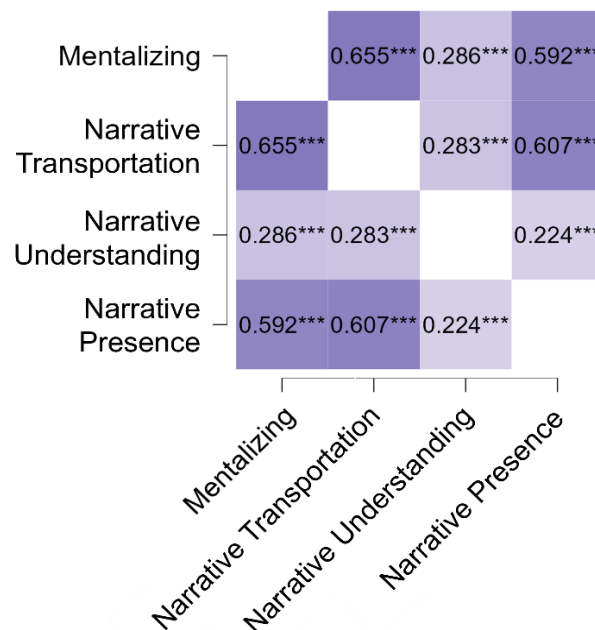
AD END

Section 13: Correlation analyses – self report variables

Correlation analyses were conducted between the self-report dimensions (mentalizing, narrative transportation, narrative understanding, and narrative presence - A) and the dependent variables (ad liking, sharing intent, recommendation intent, and purchase intent - B). Given the nature of the variables (categorical Likert-type scales and not consistently normally distributed), Spearman’s rank-order correlations were used. The results show that all scales are highly intercorrelated, with all correlation p-values < .001. This pattern suggests that the constructs may share underlying variance, indicating the possible presence of a common latent factor influencing both narrative engagement and perceived ad effectiveness. So, we should interpret each variable independently with caution.

Spearman’s Correlations – a)

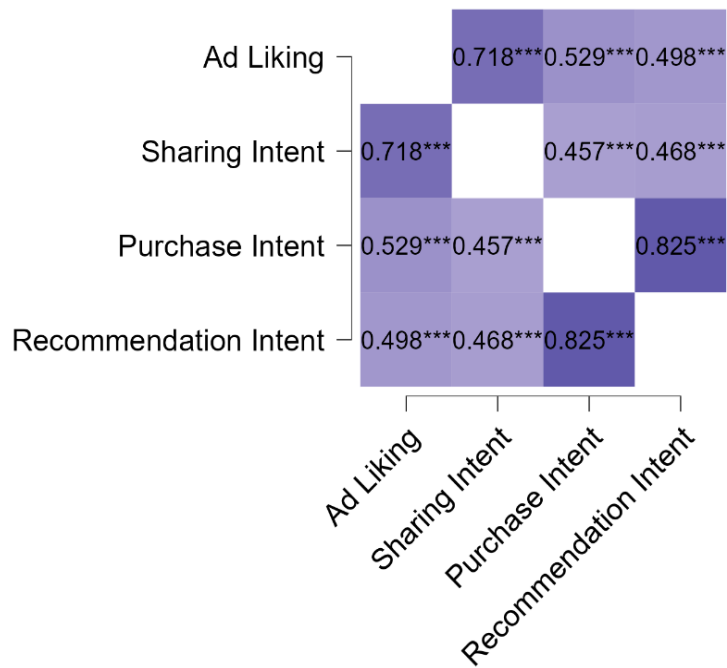
Variable		Mentalizing	Narrative Transportation	Narrative Understanding
Mentalizing	Spearman’s rho			
	p-value			
	Effect size (Fisher’s z)			
	SE effect size			
Narrative Transportation	Spearman’s rho	0.655***		
	p-value	<.001		
	Effect size (Fisher’s z)	0.785		
	SE effect size	0.029		
Narrative Understanding	Spearman’s rho	0.286***	0.283***	
	p-value	<.001	<.001	
	Effect size (Fisher’s z)	0.294	0.290	
	SE effect size	0.028	0.028	
Narrative Presence	Spearman’s rho	0.592***	0.607***	0.224***
	p-value	<.001	<.001	<.001
	Effect size (Fisher’s z)	0.680	0.703	0.228
	SE effect size	0.029	0.029	0.028



Correlation Results (Table) and Heatmap (Figure) between Mentalizing and the Narrative-related measures (Transportation, Understanding, and Presence). * p < .05, ** p < .01, *** p < .001.

Spearman's Correlations – b)

Variable		Ad Liking	Sharing Intent	Purchase Intent
Ad Liking	Spearman's rho			
	p-value			
	Effect size (Fisher's z)			
	SE effect size			
Sharing Intent	Spearman's rho	0.718***		
	p-value	<.001		
	Effect size (Fisher's z)	0.902		
	SE effect size	0.029		
Purchase Intent	Spearman's rho	0.529***	0.457***	
	p-value	<.001	<.001	
	Effect size (Fisher's z)	0.589	0.494	
	SE effect size	0.029	0.028	
Recommen. Intent	Spearman's rho	0.498***	0.608***	0.825***
	p-value	<.001	<.001	<.001
	Effect size (Fisher's z)	0.547	0.507	1.172
	SE effect size	0.028	0.028	0.030



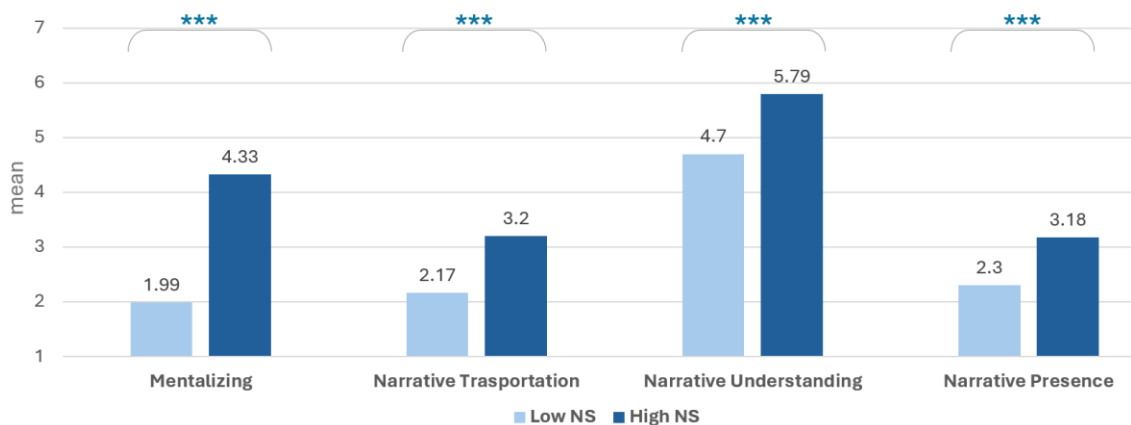
Correlation Results (Table) and Heatmap (Figure) between the ad effectiveness measures (Ad liking, sharing intent, purchase intent, and recommendation intent). * p < .05, ** p < .01, *** p < .001.

Section 14: Descriptive Statistics by NS

Descriptive statistics were calculated by splitting the narrative and outcome variables according to the NS manipulation to observe how the scores varied between H and L conditions. As shown in the results, the manipulation appears to have a significant effect: ads with a high narrative structure yielded higher scores across Mentalizing and all narrative dimensions (Transportation, Understanding and Presence) compared to those with a low narrative structure (table and figure a), as well as Ad Liking and Sharing, Purchase, and Recommendation Intent (table and figure b).

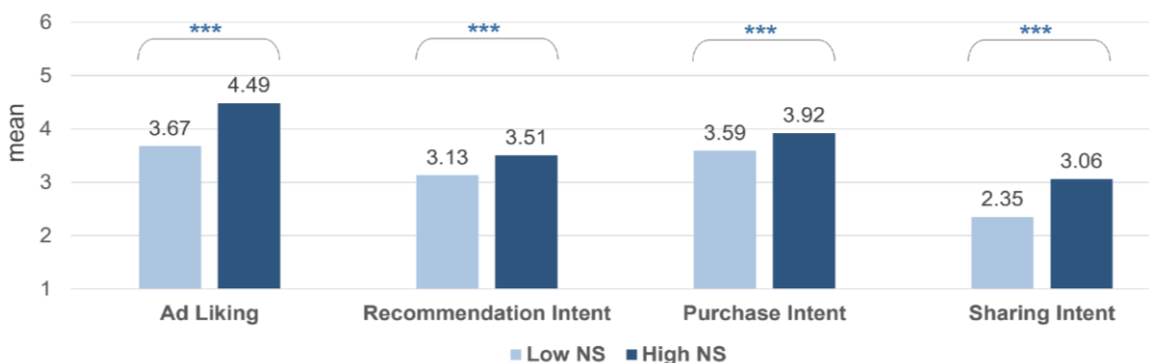
Descriptive statistics – a)

	Mentalizing		Narr. Transportation		Narr. Understanding		Narr. Presence	
	L	H	L	H	L	H	L	H
Valid	675	675	675	675	675	675	675	675
Missing	0	0	0	0	0	0	0	0
Man	1.991	4.329	2.168	3.201	5.695	4.767	2.300	3.183
SD	1.554	1.755	1.134	1.534	1.500	1.149	1.497	1.574
Min	1	1	1	1	1	1	1	1
Max	7	7	7	7	7	7	7	7



Descriptive statistics – b)

	Sharing Intent		Purchase Intent		Recommend Intent		Ad Liking	
	L	H	L	H	L	H	L	H
Valid	675	675	675	675	675	675	675	675
Missing	0	0	0	0	0	0	0	0
Man	2.351	3.064	3.591	3.921	3.132	3.505	3.674	4.486
SD	1.632	1.812	1.883	1.854	1.819	1.793	1.738	1.725
Min	1	1	1	1	1	1	1	1
Max	7	7	7	7	7	7	7	7



Section 15. Multilevel Mediation Model Specification – self report data

The following syntax provides the full specification of the mediation model implemented. The model examines the mediating role of three psychological constructs (FACTOR1, Understanding, and Mentalizing) in the relationship between NS and four outcome variables: Liking, Sharing, Purchase Intention, and Recommendation Intention.

The model was estimated using robust maximum likelihood (MLR) with clustered standard errors at the participant level (SBJ). Parameter labels (e.g., a1, b1, c1) were assigned to facilitate interpretation and indirect effect computation.

```
model <- '  
# Mediation: NS → Mediators  
TranspPres ~ a1*NS  
Understanding ~ a2*NS  
Mentalizing ~ a3*NS  
  
# Mediators → Dependent Variables  
Liking ~ b1*TranspPres + b2*Understanding + b3*Mentalizing + c1*NS  
Sharing ~ b4*TranspPres + b5*Understanding + b6*Mentalizing + c2*NS  
Purchase ~ b7*TranspPres + b8*Understanding + b9*Mentalizing + c3*NS  
Recommendation ~ b10*TranspPres + b11*Understanding + b12*Mentalizing +  
c4*NS  
'  
fit <- sem(model, data = data, cluster = "SBJ", estimator = "MLR")
```

Section 16. Mentalizing Localizer – Frequency-wise LMM Results

This section presents the results of the frequency-wise linear mixed model analyses performed within the Mentalizing localizer, contrasting the four GD stimuli with one another (Table 16A) and the four ToM stimuli with one another (Table 16B).

Table 16A: GD stim comparison

Freq	F Stim	df num Stim	df den Stim	p Bonf Stim	F Chan	df num Chan	df den Chan	p Bonf Chan	F Stim*Chan	df num Stim*Chan	df den Stim*Chan	p Bonf Stim*Chan	N Sbj	N Chan	N obs
1	7.36	3	11196.96	0.01	22.96	63	11196.96	0.00	0.27	189	11196.96	1	44	64	11241
2	38.25	3	11196.96	0.00	16.80	63	11196.96	0.00	0.30	189	11196.96	1	44	64	11241
3	31.41	3	11196.96	0.00	28.03	63	11196.96	0.00	0.24	189	11196.96	1	44	64	11241
4	4.26	3	11196.97	0.63	52.08	63	11196.98	0.00	0.25	189	11196.97	1	44	64	11241
5	3.60	3	11196.98	1.00	59.43	63	11196.99	0.00	0.21	189	11196.98	1	44	64	11241
6	3.41	3	11196.99	1.00	57.09	63	11197.00	0.00	0.24	189	11196.99	1	44	64	11241
7	12.80	3	11197.00	0.00	55.04	63	11197.00	0.00	0.26	189	11197.00	1	44	64	11241
8	28.80	3	11197.00	0.00	41.70	63	11197.00	0.00	0.35	189	11197.00	1	44	64	11241
9	22.67	3	11197.00	0.00	29.84	63	11197.01	0.00	0.30	189	11197.00	1	44	64	11241
10	9.12	3	11197.00	0.00	24.69	63	11197.00	0.00	0.26	189	11197.00	1	44	64	11241
11	10.04	3	11197.00	0.00	27.22	63	11197.00	0.00	0.23	189	11197.00	1	44	64	11241
12	37.89	3	11197.00	0.00	48.83	63	11197.00	0.00	0.32	189	11197.00	1	44	64	11241
13	47.73	3	11197.00	0.00	58.68	63	11197.00	0.00	0.37	189	11197.00	1	44	64	11241
14	37.99	3	11197.00	0.00	64.85	63	11197.00	0.00	0.31	189	11197.00	1	44	64	11241
15	22.93	3	11197.00	0.00	62.04	63	11197.00	0.00	0.21	189	11197.00	1	44	64	11241
16	18.04	3	11197.00	0.00	59.86	63	11197.00	0.00	0.15	189	11197.00	1	44	64	11241
17	17.12	3	11197.00	0.00	53.60	63	11197.00	0.00	0.12	189	11197.00	1	44	64	11241
18	13.67	3	11197.00	0.00	45.46	63	11197.00	0.00	0.15	189	11197.00	1	44	64	11241
19	5.36	3	11197.00	0.13	41.59	63	11197.00	0.00	0.16	189	11197.00	1	44	64	11241
20	3.33	3	11197.00	1.00	37.62	63	11197.00	0.00	0.17	189	11197.00	1	44	64	11241
21	2.36	3	11197.00	1.00	32.93	63	11197.00	0.00	0.21	189	11197.00	1	44	64	11241
22	2.40	3	11197.00	1.00	33.59	63	11197.00	0.00	0.22	189	11197.00	1	44	64	11241
23	2.62	3	11197.00	1.00	34.94	63	11197.01	0.00	0.18	189	11197.00	1	44	64	11241
24	2.93	3	11196.99	1.00	31.74	63	11197.00	0.00	0.21	189	11196.99	1	44	64	11241
25	4.49	3	11197.00	0.45	33.91	63	11197.00	0.00	0.24	189	11197.00	1	44	64	11241
26	2.09	3	11197.00	1.00	33.82	63	11197.01	0.00	0.26	189	11197.00	1	44	64	11241
27	1.95	3	11197.00	1.00	36.80	63	11197.01	0.00	0.26	189	11197.00	1	44	64	11241
28	3.75	3	11197.00	1.00	35.53	63	11197.00	0.00	0.24	189	11197.00	1	44	64	11241
29	5.09	3	11197.00	0.20	35.06	63	11197.00	0.00	0.22	189	11197.00	1	44	64	11241
30	10.71	3	11197.00	0.00	35.98	63	11197.01	0.00	0.22	189	11197.00	1	44	64	11241
31	9.53	3	11197.00	0.00	37.20	63	11197.01	0.00	0.21	189	11197.00	1	44	64	11241
32	10.59	3	11197.00	0.00	37.36	63	11197.01	0.00	0.30	189	11197.00	1	44	64	11241
33	8.54	3	11197.00	0.00	37.41	63	11197.01	0.00	0.27	189	11197.00	1	44	64	11241
34	4.67	3	11197.00	0.35	39.86	63	11197.01	0.00	0.17	189	11197.00	1	44	64	11241
35	5.60	3	11196.99	0.09	41.90	63	11197.01	0.00	0.13	189	11196.99	1	44	64	11241
36	4.47	3	11196.99	0.47	42.98	63	11197.00	0.00	0.17	189	11196.99	1	44	64	11241
37	5.03	3	11196.99	0.21	41.68	63	11197.00	0.00	0.21	189	11196.99	1	44	64	11241
38	3.85	3	11196.98	1.00	42.46	63	11197.00	0.00	0.20	189	11196.98	1	44	64	11241
39	2.37	3	11196.98	1.00	45.07	63	11197.00	0.00	0.18	189	11196.98	1	44	64	11241
40	2.58	3	11196.98	1.00	46.72	63	11197.00	0.00	0.18	189	11196.98	1	44	64	11241
41	2.58	3	11196.98	1.00	46.84	63	11197.00	0.00	0.19	189	11196.98	1	44	64	11241
42	3.14	3	11196.98	1.00	47.43	63	11196.99	0.00	0.20	189	11196.98	1	44	64	11241
43	4.06	3	11196.98	0.83	48.46	63	11196.99	0.00	0.23	189	11196.98	1	44	64	11241
44	4.92	3	11196.98	0.25	48.39	63	11196.99	0.00	0.25	189	11196.98	1	44	64	11241
45	4.50	3	11196.98	0.45	48.19	63	11196.99	0.00	0.19	189	11196.98	1	44	64	11241
46	4.10	3	11196.98	0.79	48.26	63	11196.99	0.00	0.18	189	11196.98	1	44	64	11241
47	5.64	3	11196.98	0.09	47.34	63	11196.99	0.00	0.20	189	11196.98	1	44	64	11241
48	5.08	3	11196.98	0.20	49.09	63	11196.99	0.00	0.19	189	11196.98	1	44	64	11241
49	6.19	3	11196.97	0.04	48.95	63	11196.98	0.00	0.24	189	11196.97	1	44	64	11241
50	6.31	3	11196.94	0.03	35.00	63	11196.95	0.00	0.32	189	11196.94	1	44	64	11241
52	5.39	3	11196.97	0.13	48.38	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
53	3.87	3	11196.97	1.00	48.90	63	11196.99	0.00	0.18	189	11196.97	1	44	64	11241
54	4.83	3	11196.97	0.28	47.92	63	11196.99	0.00	0.23	189	11196.97	1	44	64	11241
55	5.10	3	11196.97	0.19	47.32	63	11196.98	0.00	0.23	189	11196.97	1	44	64	11241
56	4.86	3	11196.97	0.27	48.89	63	11196.99	0.00	0.20	189	11196.97	1	44	64	11241
57	4.00	3	11196.97	0.91	49.87	63	11196.99	0.00	0.18	189	11196.97	1	44	64	11241
58	4.81	3	11196.98	0.29	48.64	63	11196.99	0.00	0.22	189	11196.98	1	44	64	11241

59	5.56	3	11196.98	0.10	47.07	63	11196.99	0.00	0.20	189	11196.98	1	44	64	11241
61	4.10	3	11196.98	0.78	46.23	63	11196.99	0.00	0.21	189	11196.98	1	44	64	11241
62	8.58	3	11196.98	0.00	45.71	63	11196.99	0.00	0.22	189	11196.98	1	44	64	11241
63	6.44	3	11196.97	0.03	48.60	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
64	5.79	3	11196.97	0.07	48.88	63	11196.99	0.00	0.23	189	11196.97	1	44	64	11241
65	9.33	3	11196.97	0.00	47.85	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
66	7.93	3	11196.97	0.00	48.18	63	11196.98	0.00	0.18	189	11196.97	1	44	64	11241
67	6.36	3	11196.97	0.03	48.17	63	11196.98	0.00	0.18	189	11196.97	1	44	64	11241
68	7.28	3	11196.97	0.01	47.94	63	11196.98	0.00	0.18	189	11196.97	1	44	64	11241
69	5.70	3	11196.97	0.08	45.91	63	11196.98	0.00	0.18	189	11196.97	1	44	64	11241
70	5.14	3	11196.97	0.18	46.94	63	11196.98	0.00	0.17	189	11196.97	1	44	64	11241
71	6.33	3	11196.97	0.03	46.49	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
72	5.18	3	11196.97	0.17	44.74	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
73	4.62	3	11196.97	0.38	45.29	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
74	5.13	3	11196.97	0.18	45.82	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
75	7.10	3	11196.97	0.01	45.07	63	11196.98	0.00	0.23	189	11196.97	1	44	64	11241
76	8.62	3	11196.97	0.00	44.88	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
77	8.29	3	11196.97	0.00	44.22	63	11196.98	0.00	0.18	189	11196.97	1	44	64	11241
78	8.86	3	11196.97	0.00	43.11	63	11196.98	0.00	0.17	189	11196.97	1	44	64	11241
79	7.85	3	11196.97	0.00	42.35	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
80	8.40	3	11196.97	0.00	41.48	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
81	9.88	3	11196.97	0.00	41.57	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
82	7.84	3	11196.97	0.00	42.46	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
83	7.17	3	11196.97	0.01	43.08	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
84	9.26	3	11196.97	0.00	41.64	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
85	7.46	3	11196.97	0.01	41.27	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
86	7.19	3	11196.97	0.01	41.94	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
87	7.24	3	11196.97	0.01	40.59	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
88	8.29	3	11196.97	0.00	39.78	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
89	8.49	3	11196.97	0.00	38.89	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
90	8.94	3	11196.97	0.00	39.41	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
91	10.60	3	11196.96	0.00	39.00	63	11196.97	0.00	0.19	189	11196.96	1	44	64	11241
92	8.84	3	11196.97	0.00	38.88	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
93	6.89	3	11196.97	0.02	37.73	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
94	7.78	3	11196.97	0.00	36.65	63	11196.98	0.00	0.18	189	11196.97	1	44	64	11241
96	6.76	3	11196.97	0.02	37.16	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
97	7.38	3	11196.97	0.01	36.73	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
98	8.23	3	11196.97	0.00	37.34	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
99	4.71	3	11196.95	0.33	22.07	63	11196.95	0.00	0.23	189	11196.95	1	44	64	11241
100	3.93	3	11196.91	1.00	6.00	63	11196.92	0.00	0.29	189	11196.91	1	44	64	11241
101	8.67	3	11196.93	0.00	15.82	63	11196.94	0.00	0.26	189	11196.93	1	44	64	11241
102	10.55	3	11196.97	0.00	34.38	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
103	11.09	3	11196.97	0.00	34.65	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
104	10.70	3	11196.97	0.00	33.87	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
105	12.72	3	11196.97	0.00	33.30	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
106	9.58	3	11196.97	0.00	33.05	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
107	8.27	3	11196.97	0.00	32.63	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
108	11.06	3	11196.97	0.00	33.09	63	11196.98	0.00	0.21	189	11196.97	1	44	64	11241
109	9.23	3	11196.97	0.00	33.05	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
110	9.77	3	11196.97	0.00	31.78	63	11196.98	0.00	0.17	189	11196.97	1	44	64	11241
111	8.70	3	11196.97	0.00	31.39	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
112	10.13	3	11196.97	0.00	31.63	63	11196.98	0.00	0.23	189	11196.97	1	44	64	11241
113	11.28	3	11196.97	0.00	31.84	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
114	9.64	3	11196.97	0.00	32.49	63	11196.98	0.00	0.17	189	11196.97	1	44	64	11241
115	9.81	3	11196.96	0.00	31.42	63	11196.97	0.00	0.20	189	11196.96	1	44	64	11241
116	9.99	3	11196.96	0.00	31.28	63	11196.98	0.00	0.21	189	11196.96	1	44	64	11241
117	9.17	3	11196.97	0.00	31.01	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
118	9.60	3	11196.97	0.00	30.34	63	11196.98	0.00	0.19	189	11196.97	1	44	64	11241
119	12.35	3	11196.97	0.00	31.12	63	11196.98	0.00	0.20	189	11196.97	1	44	64	11241
120	10.74	3	11196.97	0.00	30.73	63	11196.98	0.00	0.22	189	11196.97	1	44	64	11241
121	9.98	3	11196.97	0.00	29.02	63	11196.98	0.00	0.23	189	11196.97	1	44	64	11241
122	9.39	3	11196.96	0.00	26.34	63	11196.97	0.00	0.30	189	11196.96	1	44	64	11241
123	9.88	3	11196.94	0.00	18.15	63	11196.96	0.00	0.30	189	11196.94	1	44	64	11241
124	4.42	3	11196.93	0.50	8.81	63	11196.96	0.00	0.28	189	11196.93	1	44	64	11241
125	0.31	3	973.41	1.00	3.14	63	973.41	0.00	0.41	189	973.41	1	44	64	11241

Table 16B: ToM stim comparison

The frequencies on which STIM has an impact amount to 13.6%.

Freq	F Stim	df num Stim	df den Stim	p Bonf Stim	F Chan	df num Chan	df den Chan	p Bonf Chan	F Stim*Chan	df num Stim*Chan	df den Stim*Chan	p Bonf Stim*Chan	N Sbj	N Chan	N Obs
1	5.55	3	11200.97	0.10	19.56	63	11200.98	0.00	0.29	189	11200.97	1	44	64	11245
2	3.10	3	11200.98	1.00	24.72	63	11200.98	0.00	0.24	189	11200.98	1	44	64	11245
3	2.67	3	11200.97	1.00	33.43	63	11200.98	0.00	0.24	189	11200.97	1	44	64	11245
4	8.67	3	11200.98	0.00	41.43	63	11200.98	0.00	0.21	189	11200.98	1	44	64	11245
5	9.02	3	11200.98	0.00	49.52	63	11200.99	0.00	0.20	189	11200.98	1	44	64	11245
6	13.11	3	11200.99	0.00	55.56	63	11201.00	0.00	0.17	189	11200.99	1	44	64	11245
7	15.56	3	11201.00	0.00	56.59	63	11201.00	0.00	0.20	189	11201.00	1	44	64	11245
8	34.61	3	11201.00	0.00	56.18	63	11201.00	0.00	0.29	189	11201.00	1	44	64	11245
9	51.65	3	11201.00	0.00	42.06	63	11201.00	0.00	0.29	189	11201.00	1	44	64	11245
10	28.85	3	11201.00	0.00	26.86	63	11201.00	0.00	0.37	189	11201.00	1	44	64	11245
11	13.51	3	11201.00	0.00	28.81	63	11201.00	0.00	0.42	189	11201.00	1	44	64	11245
12	3.92	3	11201.00	1.00	37.16	63	11201.00	0.00	0.26	189	11201.00	1	44	64	11245
13	6.46	3	11201.00	0.03	43.33	63	11201.00	0.00	0.26	189	11201.00	1	44	64	11245
14	15.07	3	11201.00	0.00	51.54	63	11201.00	0.00	0.27	189	11201.00	1	44	64	11245
15	11.08	3	11201.00	0.00	50.62	63	11201.00	0.00	0.19	189	11201.00	1	44	64	11245
16	8.86	3	11201.00	0.00	47.41	63	11201.00	0.00	0.14	189	11201.00	1	44	64	11245
17	9.20	3	11201.00	0.00	46.00	63	11201.00	0.00	0.11	189	11201.00	1	44	64	11245
18	4.95	3	11201.00	0.24	41.80	63	11201.00	0.00	0.13	189	11201.00	1	44	64	11245
19	6.22	3	11201.00	0.04	38.58	63	11201.00	0.00	0.10	189	11201.00	1	44	64	11245
20	15.35	3	11201.00	0.00	32.72	63	11201.00	0.00	0.10	189	11201.00	1	44	64	11245
21	4.36	3	11201.00	0.55	29.67	63	11201.00	0.00	0.12	189	11201.00	1	44	64	11245
22	2.29	3	11201.00	1.00	32.33	63	11201.00	0.00	0.14	189	11201.00	1	44	64	11245
23	3.21	3	11201.00	1.00	31.40	63	11201.00	0.00	0.13	189	11201.00	1	44	64	11245
24	0.72	3	11201.00	1.00	29.18	63	11201.00	0.00	0.12	189	11201.00	1	44	64	11245
25	0.72	3	11201.00	1.00	32.77	63	11201.00	0.00	0.13	189	11201.00	1	44	64	11245
26	0.81	3	11201.00	1.00	32.61	63	11201.01	0.00	0.09	189	11201.00	1	44	64	11245
27	1.16	3	11201.00	1.00	32.74	63	11201.01	0.00	0.15	189	11201.00	1	44	64	11245
28	1.20	3	11201.00	1.00	32.51	63	11201.01	0.00	0.17	189	11201.00	1	44	64	11245
29	1.34	3	11201.00	1.00	34.30	63	11201.01	0.00	0.17	189	11201.00	1	44	64	11245
30	2.14	3	11201.00	1.00	35.66	63	11201.01	0.00	0.20	189	11201.00	1	44	64	11245
31	1.65	3	11201.00	1.00	36.45	63	11201.01	0.00	0.18	189	11201.00	1	44	64	11245
32	2.30	3	11201.00	1.00	40.27	63	11201.01	0.00	0.17	189	11201.00	1	44	64	11245
33	1.93	3	11200.99	1.00	41.32	63	11201.01	0.00	0.18	189	11200.99	1	44	64	11245
34	1.01	3	11200.99	1.00	43.36	63	11201.01	0.00	0.18	189	11200.99	1	44	64	11245
35	1.12	3	11200.99	1.00	45.04	63	11201.01	0.00	0.19	189	11200.99	1	44	64	11245
36	1.67	3	11200.99	1.00	45.86	63	11201.01	0.00	0.19	189	11200.99	1	44	64	11245
37	1.08	3	11200.98	1.00	48.26	63	11201.00	0.00	0.14	189	11200.98	1	44	64	11245
38	1.30	3	11200.98	1.00	48.38	63	11201.00	0.00	0.14	189	11200.98	1	44	64	11245
39	1.89	3	11200.98	1.00	49.21	63	11201.00	0.00	0.15	189	11200.98	1	44	64	11245
40	1.00	3	11200.98	1.00	50.32	63	11201.00	0.00	0.13	189	11200.98	1	44	64	11245
41	1.17	3	11200.98	1.00	51.89	63	11201.00	0.00	0.16	189	11200.98	1	44	64	11245
42	1.39	3	11200.99	1.00	53.09	63	11201.00	0.00	0.19	189	11200.99	1	44	64	11245
43	1.79	3	11200.98	1.00	53.99	63	11201.00	0.00	0.19	189	11200.98	1	44	64	11245
44	2.87	3	11200.99	1.00	55.23	63	11201.01	0.00	0.19	189	11200.99	1	44	64	11245
45	2.87	3	11200.99	1.00	55.23	63	11201.01	0.00	0.22	189	11200.99	1	44	64	11245
46	2.41	3	11200.99	1.00	54.60	63	11201.01	0.00	0.20	189	11200.99	1	44	64	11245
47	1.96	3	11200.98	1.00	54.93	63	11201.00	0.00	0.20	189	11200.98	1	44	64	11245
48	3.49	3	11200.98	1.00	56.78	63	11201.00	0.00	0.21	189	11200.98	1	44	64	11245
49	1.71	3	11200.97	1.00	55.30	63	11200.99	0.00	0.17	189	11200.97	1	44	64	11245
50	1.39	3	11200.93	1.00	40.45	63	11200.94	0.00	0.17	189	11200.93	1	44	64	11245
51	1.90	3	11200.97	1.00	51.79	63	11200.99	0.00	0.22	189	11200.97	1	44	64	11245
52	2.32	3	11200.98	1.00	53.76	63	11201.00	0.00	0.23	189	11200.98	1	44	64	11245
53	2.10	3	11200.99	1.00	55.24	63	11201.01	0.00	0.23	189	11200.99	1	44	64	11245
54	1.18	3	11200.99	1.00	55.71	63	11201.01	0.00	0.21	189	11200.99	1	44	64	11245
55	0.80	3	11200.98	1.00	53.64	63	11201.00	0.00	0.25	189	11200.98	1	44	64	11245
56	0.75	3	11200.98	1.00	52.62	63	11201.00	0.00	0.25	189	11200.98	1	44	64	11245
57	0.80	3	11200.99	1.00	53.53	63	11201.00	0.00	0.23	189	11200.99	1	44	64	11245
58	0.85	3	11200.99	1.00	53.96	63	11201.00	0.00	0.21	189	11200.99	1	44	64	11245
59	1.50	3	11200.99	1.00	54.99	63	11201.00	0.00	0.23	189	11200.99	1	44	64	11245
60	3.14	3	11200.99	1.00	54.21	63	11201.01	0.00	0.25	189	11200.99	1	44	64	11245
61	2.40	3	11200.99	1.00	54.39	63	11201.01	0.00	0.25	189	11200.99	1	44	64	11245
62	2.33	3	11200.99	1.00	54.15	63	11201.00	0.00	0.29	189	11200.99	1	44	64	11245
63	1.98	3	11200.99	1.00	53.71	63	11201.00	0.00	0.27	189	11200.99	1	44	64	11245

64	3.05	3	11200.99	1.00	55.44	63	11201.00	0.00	0.26	189	11200.99	1	44	64	11245
65	2.83	3	11200.99	1.00	55.16	63	11201.00	0.00	0.27	189	11200.99	1	44	64	11245
66	1.39	3	11200.99	1.00	53.96	63	11201.00	0.00	0.28	189	11200.99	1	44	64	11245
67	1.24	3	11200.99	1.00	54.18	63	11201.00	0.00	0.31	189	11200.99	1	44	64	11245
68	1.61	3	11200.99	1.00	53.41	63	11201.00	0.00	0.32	189	11200.99	1	44	64	11245
69	1.85	3	11200.99	1.00	53.41	63	11201.00	0.00	0.30	189	11200.99	1	44	64	11245
70	2.31	3	11200.99	1.00	51.57	63	11201.00	0.00	0.26	189	11200.99	1	44	64	11245
71	2.51	3	11200.99	1.00	52.09	63	11201.00	0.00	0.30	189	11200.99	1	44	64	11245
72	2.19	3	11200.99	1.00	52.68	63	11201.00	0.00	0.28	189	11200.99	1	44	64	11245
73	2.57	3	11200.99	1.00	52.10	63	11201.00	0.00	0.31	189	11200.99	1	44	64	11245
74	2.21	3	11200.99	1.00	51.46	63	11201.00	0.00	0.31	189	11200.99	1	44	64	11245
75	3.02	3	11200.99	1.00	51.64	63	11201.00	0.00	0.31	189	11200.99	1	44	64	11245
76	3.55	3	11200.99	1.00	50.99	63	11201.00	0.00	0.34	189	11200.99	1	44	64	11245
77	2.34	3	11200.99	1.00	50.31	63	11201.01	0.00	0.30	189	11200.99	1	44	64	11245
78	2.17	3	11200.99	1.00	51.96	63	11201.00	0.00	0.31	189	11200.99	1	44	64	11245
79	3.22	3	11200.99	1.00	51.14	63	11201.00	0.00	0.39	189	11200.99	1	44	64	11245
80	3.70	3	11200.99	1.00	50.07	63	11201.01	0.00	0.38	189	11200.99	1	44	64	11245
81	4.35	3	11200.99	0.56	49.82	63	11201.01	0.00	0.33	189	11200.99	1	44	64	11245
82	2.79	3	11200.99	1.00	49.47	63	11201.00	0.00	0.31	189	11200.99	1	44	64	11245
83	2.26	3	11200.99	1.00	49.16	63	11201.00	0.00	0.34	189	11200.99	1	44	64	11245
84	2.93	3	11200.99	1.00	47.23	63	11201.00	0.00	0.41	189	11200.99	1	44	64	11245
85	3.04	3	11200.99	1.00	46.35	63	11201.01	0.00	0.41	189	11200.99	1	44	64	11245
86	4.44	3	11200.99	0.49	46.92	63	11201.01	0.00	0.40	189	11200.99	1	44	64	11245
87	3.25	3	11200.99	1.00	46.81	63	11201.01	0.00	0.34	189	11200.99	1	44	64	11245
88	2.52	3	11200.99	1.00	46.06	63	11201.01	0.00	0.33	189	11200.99	1	44	64	11245
89	2.56	3	11200.99	1.00	45.92	63	11201.00	0.00	0.32	189	11200.99	1	44	64	11245
90	2.85	3	11200.99	1.00	45.00	63	11201.00	0.00	0.35	189	11200.99	1	44	64	11245
91	3.38	3	11200.99	1.00	45.18	63	11201.00	0.00	0.39	189	11200.99	1	44	64	11245
92	3.37	3	11200.99	1.00	45.48	63	11201.01	0.00	0.35	189	11200.99	1	44	64	11245
93	2.46	3	11200.99	1.00	44.98	63	11201.01	0.00	0.34	189	11200.99	1	44	64	11245
94	2.84	3	11200.99	1.00	43.15	63	11201.01	0.00	0.37	189	11200.99	1	44	64	11245
95	4.67	3	11200.99	0.36	42.43	63	11201.01	0.00	0.40	189	11200.99	1	44	64	11245
96	4.46	3	11200.99	0.48	43.91	63	11201.01	0.00	0.38	189	11200.99	1	44	64	11245
97	3.26	3	11200.99	1.00	43.83	63	11201.01	0.00	0.36	189	11200.99	1	44	64	11245
98	3.73	3	11200.99	1.00	42.50	63	11201.00	0.00	0.39	189	11200.99	1	44	64	11245
99	1.88	3	11200.95	1.00	24.99	63	11200.95	0.00	0.27	189	11200.95	1	44	64	11245
100	0.25	3	11200.93	1.00	7.18	63	11200.94	0.00	0.04	189	11200.93	1	44	64	11245
101	1.21	3	11200.94	1.00	17.84	63	11200.94	0.00	0.18	189	11200.94	1	44	64	11245
102	4.64	3	11200.99	0.37	39.92	63	11201.00	0.00	0.48	189	11200.99	1	44	64	11245
103	2.84	3	11200.99	1.00	38.74	63	11201.00	0.00	0.48	189	11200.99	1	44	64	11245
104	2.69	3	11200.99	1.00	39.63	63	11201.01	0.00	0.42	189	11200.99	1	44	64	11245
105	5.01	3	11200.99	0.22	39.63	63	11201.01	0.00	0.42	189	11200.99	1	44	64	11245
106	4.88	3	11201.00	0.27	40.14	63	11201.01	0.00	0.41	189	11201.00	1	44	64	11245
107	3.76	3	11200.99	1.00	39.63	63	11201.01	0.00	0.41	189	11200.99	1	44	64	11245
108	3.62	3	11200.99	1.00	38.96	63	11201.00	0.00	0.39	189	11200.99	1	44	64	11245
109	2.91	3	11200.99	1.00	37.38	63	11201.00	0.00	0.41	189	11200.99	1	44	64	11245
110	3.29	3	11201.00	1.00	35.91	63	11201.01	0.00	0.43	189	11201.00	1	44	64	11245
111	3.86	3	11201.00	1.00	36.52	63	11201.01	0.00	0.35	189	11201.00	1	44	64	11245
112	4.69	3	11201.00	0.35	36.83	63	11201.01	0.00	0.41	189	11201.00	1	44	64	11245
114	4.58	3	11201.00	0.40	35.34	63	11201.01	0.00	0.45	189	11201.00	1	44	64	11245
115	3.16	3	11200.99	1.00	34.09	63	11201.00	0.00	0.36	189	11200.99	1	44	64	11245
117	5.40	3	11200.99	0.13	34.14	63	11201.00	0.00	0.44	189	11200.99	1	44	64	11245
118	7.25	3	11201.00	0.01	34.57	63	11201.01	0.00	0.48	189	11201.00	1	44	64	11245
119	9.59	3	11201.00	0.00	34.69	63	11201.01	0.00	0.49	189	11201.00	1	44	64	11245
120	4.94	3	11200.99	0.24	35.87	63	11201.00	0.00	0.46	189	11200.99	1	44	64	11245
121	1.93	3	11201.00	1.00	36.03	63	11201.01	0.00	0.39	189	11201.00	1	44	64	11245
122	5.87	3	11200.99	0.07	29.97	63	11201.01	0.00	0.47	189	11200.99	1	44	64	11245
123	3.75	3	11201.00	1.00	19.76	63	11201.01	0.00	0.55	189	11201.00	1	44	64	11245
124	4.59	3	165476.30	0.40	8.19	63	165483.87	0.00	0.47	189	165476.30	1	44	64	11245
125	0.49	3	915.00	1.00	2.62	63	915.00	0.00	0.56	189	915.00	1	44	64	11245

Section 17. Narrative Localizer – Frequency-wise LMM Results

This section presents the results of the frequency-wise linear mixed model analyses performed within the Narrative localizer, contrasting the two Narrative stimuli with one another (Table 17A) and the two Narrative control stimuli with one another (Table 17B).

Table 17A: Narrative stim comparison

Of the two stimuli included in the subset used to evoke Narrative processing (*Narrative EEG localizer*), their difference had a significant effect on the EEG data in only 6.4% of the comparisons performed.

Freq	F Stim	df num Stim	df den Stim	p Bonf Stim	F Chan	df num Chan	df den Chan	p Bonf Chan	F Stim*Chan	df num Stim*Chan	df den Stim*Chan	p Bonf Stim*Chan	N Sbj	N Chan	N Obs
1	12.38	1	5460.97	0.06	0.31	63	5461.08	1	0.31	63	5461.08	1	44	64	5632
2	12.82	1	5461.01	0.04	0.26	63	5461.03	1	0.27	63	5461.03	1	44	64	5632
3	9.87	1	5460.91	0.22	0.19	63	5460.83	1	0.19	63	5460.83	1	44	64	5632
4	1.95	1	5460.92	1.00	0.16	63	5460.84	1	0.16	63	5460.84	1	44	64	5632
5	0.14	1	5461.09	1.00	0.15	63	5461.13	1	0.15	63	5461.13	1	44	64	5632
6	2.74	1	5460.90	1.00	0.17	63	5460.67	1	0.18	63	5460.67	1	44	64	5632
7	10.69	1	5461.02	0.14	0.17	63	5461.16	1	0.18	63	5461.16	1	44	64	5632
8	19.56	1	5460.91	0.00	0.17	63	5461.16	1	0.17	63	5461.16	1	44	64	5632
9	33.51	1	5461.02	0.00	0.22	63	5460.93	1	0.23	63	5460.93	1	44	64	5632
10	47.71	1	5460.93	0.00	0.41	63	5460.86	1	0.42	63	5460.86	1	44	64	5632
11	43.66	1	5460.88	0.00	0.38	63	5460.64	1	0.39	63	5460.64	1	44	64	5632
12	36.86	1	5460.90	0.00	0.32	63	5460.94	1	0.33	63	5460.94	1	44	64	5632
13	25.73	1	5461.03	0.00	0.18	63	5460.85	1	0.19	63	5460.85	1	44	64	5632
14	11.63	1	5461.11	0.08	0.12	63	5461.06	1	0.13	63	5461.06	1	44	64	5632
15	8.91	1	5460.98	0.36	0.14	63	5460.81	1	0.15	63	5460.81	1	44	64	5632
16	10.71	1	5461.06	0.14	0.18	63	5461.21	1	0.19	63	5461.21	1	44	64	5632
17	3.62	1	5461.05	1.00	0.10	63	5460.92	1	0.10	63	5460.92	1	44	64	5632
18	3.00	1	5460.99	1.00	0.08	63	5461.01	1	0.08	63	5461.01	1	44	64	5632
19	1.69	1	5460.86	1.00	0.10	63	5460.82	1	0.10	63	5460.82	1	44	64	5632
20	2.14	1	5461.02	1.00	0.10	63	5460.99	1	0.11	63	5460.99	1	44	64	5632
21	2.97	1	5461.02	1.00	0.16	63	5461.14	1	0.16	63	5461.14	1	44	64	5632
22	8.44	1	5460.94	0.47	0.18	63	5460.82	1	0.18	63	5460.82	1	44	64	5632
23	9.60	1	5461.03	0.25	0.20	63	5460.99	1	0.21	63	5460.99	1	44	64	5632
24	5.38	1	5460.97	1.00	0.19	63	5461.10	1	0.19	63	5461.10	1	44	64	5632
25	0.16	1	5461.00	1.00	0.17	63	5460.70	1	0.17	63	5460.70	1	44	64	5632
26	1.43	1	5460.87	1.00	0.15	63	5460.87	1	0.15	63	5460.87	1	44	64	5632
27	0.19	1	5460.97	1.00	0.14	63	5461.10	1	0.14	63	5461.10	1	44	64	5632
28	0.07	1	5460.97	1.00	0.15	63	5461.18	1	0.15	63	5461.18	1	44	64	5632
29	0.18	1	5461.08	1.00	0.10	63	5460.89	1	0.10	63	5460.89	1	44	64	5632
30	1.37	1	5461.01	1.00	0.10	63	5461.00	1	0.10	63	5461.00	1	44	64	5632
31	0.68	1	5461.02	1.00	0.13	63	5460.94	1	0.13	63	5460.94	1	44	64	5632
32	0.02	1	5460.90	1.00	0.13	63	5460.84	1	0.13	63	5460.84	1	44	64	5632
33	0.11	1	5460.98	1.00	0.12	63	5461.22	1	0.12	63	5461.22	1	44	64	5632
34	0.00	1	5460.97	1.00	0.16	63	5461.12	1	0.16	63	5461.12	1	44	64	5632
35	0.00	1	5461.03	1.00	0.16	63	5460.95	1	0.16	63	5460.95	1	44	64	5632
36	0.04	1	5461.00	1.00	0.14	63	5461.20	1	0.14	63	5461.20	1	44	64	5632
37	0.12	1	5461.02	1.00	0.20	63	5460.98	1	0.20	63	5460.98	1	44	64	5632
38	0.36	1	5460.99	1.00	0.21	63	5461.12	1	0.21	63	5461.12	1	44	64	5632
39	0.57	1	5461.01	1.00	0.20	63	5460.76	1	0.20	63	5460.76	1	44	64	5632
40	0.69	1	5460.93	1.00	0.17	63	5461.00	1	0.17	63	5461.00	1	44	64	5632
41	0.21	1	5461.13	1.00	0.18	63	5461.21	1	0.18	63	5461.21	1	44	64	5632
42	0.14	1	5461.01	1.00	0.20	63	5460.96	1	0.21	63	5460.96	1	44	64	5632
43	0.00	1	5460.99	1.00	0.21	63	5460.97	1	0.21	63	5460.97	1	44	64	5632
44	0.69	1	5460.97	1.00	0.21	63	5461.07	1	0.21	63	5461.07	1	44	64	5632
45	1.02	1	5460.99	1.00	0.24	63	5461.09	1	0.24	63	5461.09	1	44	64	5632
46	1.41	1	5461.08	1.00	0.25	63	5461.01	1	0.25	63	5461.01	1	44	64	5632
47	0.90	1	5461.07	1.00	0.29	63	5460.83	1	0.29	63	5460.83	1	44	64	5632
48	1.24	1	5461.01	1.00	0.28	63	5461.00	1	0.28	63	5461.00	1	44	64	5632
49	3.32	1	5460.90	1.00	0.25	63	5460.78	1	0.25	63	5460.78	1	44	64	5632
50	4.56	1	5460.96	1.00	0.24	63	5461.09	1	0.24	63	5461.09	1	44	64	5632
51	2.11	1	5460.99	1.00	0.22	63	5460.95	1	0.22	63	5460.95	1	44	64	5632
52	1.51	1	5460.98	1.00	0.21	63	5461.05	1	0.21	63	5461.05	1	44	64	5632
53	2.22	1	5461.02	1.00	0.23	63	5460.95	1	0.23	63	5460.95	1	44	64	5632
54	2.60	1	5461.14	1.00	0.26	63	5461.20	1	0.26	63	5461.20	1	44	64	5632
55	4.52	1	5460.97	1.00	0.27	63	5461.16	1	0.26	63	5461.16	1	44	64	5632

56	6.24	1	5460.98	1.00	0.28	63	5460.92	1	0.28	63	5460.92	1	44	64	5632
57	4.37	1	5460.99	1.00	0.25	63	5460.83	1	0.25	63	5460.83	1	44	64	5632
58	3.05	1	5461.08	1.00	0.21	63	5461.02	1	0.21	63	5461.02	1	44	64	5632
59	2.16	1	5460.99	1.00	0.22	63	5461.15	1	0.22	63	5461.15	1	44	64	5632
60	1.64	1	5461.01	1.00	0.23	63	5461.07	1	0.23	63	5461.07	1	44	64	5632
61	2.12	1	5460.99	1.00	0.25	63	5461.10	1	0.25	63	5461.10	1	44	64	5632
62	3.01	1	5461.03	1.00	0.25	63	5461.03	1	0.24	63	5461.03	1	44	64	5632
63	2.54	1	5460.94	1.00	0.23	63	5461.01	1	0.23	63	5461.01	1	44	64	5632
64	2.51	1	5461.04	1.00	0.26	63	5460.88	1	0.26	63	5460.88	1	44	64	5632
65	4.30	1	5461.01	1.00	0.28	63	5461.07	1	0.28	63	5461.07	1	44	64	5632
66	4.50	1	5460.91	1.00	0.24	63	5460.77	1	0.24	63	5460.77	1	44	64	5632
67	3.60	1	5461.16	1.00	0.27	63	5461.25	1	0.27	63	5461.25	1	44	64	5632
68	2.40	1	5460.96	1.00	0.29	63	5461.02	1	0.29	63	5461.02	1	44	64	5632
69	3.17	1	5461.02	1.00	0.25	63	5461.04	1	0.25	63	5461.04	1	44	64	5632
70	3.61	1	5460.95	1.00	0.28	63	5460.78	1	0.28	63	5460.78	1	44	64	5632
71	4.89	1	5461.08	1.00	0.31	63	5460.98	1	0.31	63	5460.98	1	44	64	5632
72	2.27	1	5460.92	1.00	0.26	63	5461.15	1	0.26	63	5461.15	1	44	64	5632
73	1.82	1	5460.92	1.00	0.22	63	5461.02	1	0.22	63	5461.02	1	44	64	5632
74	1.82	1	5461.08	1.00	0.26	63	5461.14	1	0.25	63	5461.14	1	44	64	5632
75	3.73	1	5460.99	1.00	0.29	63	5460.85	1	0.29	63	5460.85	1	44	64	5632
76	4.44	1	5460.97	1.00	0.26	63	5460.86	1	0.26	63	5460.86	1	44	64	5632
77	5.64	1	5460.96	1.00	0.28	63	5460.80	1	0.27	63	5460.80	1	44	64	5632
78	4.92	1	5460.98	1.00	0.26	63	5460.97	1	0.26	63	5460.97	1	44	64	5632
79	4.13	1	5461.02	1.00	0.30	63	5461.28	1	0.30	63	5461.28	1	44	64	5632
80	2.25	1	5460.95	1.00	0.30	63	5461.04	1	0.30	63	5461.04	1	44	64	5632
81	4.85	1	5460.94	1.00	0.30	63	5460.90	1	0.30	63	5460.90	1	44	64	5632
82	8.49	1	5461.01	0.46	0.32	63	5460.93	1	0.32	63	5460.93	1	44	64	5632
83	5.36	1	5460.98	1.00	0.33	63	5460.80	1	0.33	63	5460.80	1	44	64	5632
84	3.99	1	5460.98	1.00	0.33	63	5460.98	1	0.33	63	5460.98	1	44	64	5632
85	3.16	1	5460.98	1.00	0.31	63	5460.95	1	0.30	63	5460.95	1	44	64	5632
86	3.22	1	5461.03	1.00	0.26	63	5461.18	1	0.25	63	5461.18	1	44	64	5632
87	3.53	1	5461.03	1.00	0.26	63	5461.15	1	0.26	63	5461.15	1	44	64	5632
88	4.01	1	5460.97	1.00	0.28	63	5461.04	1	0.28	63	5461.04	1	44	64	5632
89	3.73	1	5460.83	1.00	0.29	63	5460.94	1	0.29	63	5460.94	1	44	64	5632
90	6.04	1	5460.86	1.00	0.29	63	5460.49	1	0.29	63	5460.49	1	44	64	5632
91	3.37	1	5461.00	1.00	0.31	63	5460.87	1	0.31	63	5460.87	1	44	64	5632
92	4.20	1	5460.91	1.00	0.39	63	5460.93	1	0.39	63	5460.93	1	44	64	5632
93	6.92	1	5461.07	1.00	0.38	63	5461.01	1	0.38	63	5461.01	1	44	64	5632
94	4.79	1	5460.90	1.00	0.32	63	5460.89	1	0.32	63	5460.89	1	44	64	5632
95	7.26	1	5460.91	0.90	0.34	63	5460.88	1	0.33	63	5460.88	1	44	64	5632
96	6.30	1	5460.98	1.00	0.38	63	5460.87	1	0.38	63	5460.87	1	44	64	5632
97	5.73	1	5461.03	1.00	0.36	63	5460.94	1	0.36	63	5460.94	1	44	64	5632
98	5.62	1	5460.88	1.00	0.34	63	5460.89	1	0.34	63	5460.89	1	44	64	5632
99	6.96	1	5460.90	1.00	0.34	63	5460.94	1	0.34	63	5460.94	1	44	64	5632
100	4.94	1	5461.05	1.00	0.37	63	5461.03	1	0.37	63	5461.03	1	44	64	5632
101	8.06	1	5461.04	0.58	0.29	63	5460.88	1	0.28	63	5460.88	1	44	64	5632
102	5.82	1	5461.00	1.00	0.37	63	5460.98	1	0.37	63	5460.98	1	44	64	5632
103	9.48	1	5460.96	0.27	0.37	63	5460.91	1	0.37	63	5460.91	1	44	64	5632
104	7.30	1	5461.07	0.89	0.34	63	5460.94	1	0.33	63	5460.94	1	44	64	5632
105	7.55	1	5460.93	0.77	0.33	63	5460.82	1	0.32	63	5460.82	1	44	64	5632
106	7.85	1	5460.91	0.65	0.40	63	5461.01	1	0.39	63	5461.01	1	44	64	5632
107	5.41	1	5461.03	1.00	0.36	63	5461.18	1	0.36	63	5461.18	1	44	64	5632
108	5.58	1	5461.02	1.00	0.36	63	5461.15	1	0.36	63	5461.15	1	44	64	5632
109	7.00	1	5461.00	1.00	0.37	63	5461.06	1	0.37	63	5461.06	1	44	64	5632
110	5.94	1	5460.97	1.00	0.33	63	5460.92	1	0.33	63	5460.92	1	44	64	5632
111	9.25	1	5460.98	0.30	0.32	63	5460.72	1	0.32	63	5460.72	1	44	64	5632
112	11.79	1	5460.96	0.08	0.35	63	5461.05	1	0.35	63	5461.05	1	44	64	5632
113	11.21	1	5461.08	0.10	0.40	63	5461.13	1	0.39	63	5461.13	1	44	64	5632
114	9.21	1	5460.96	0.31	0.37	63	5460.95	1	0.37	63	5460.95	1	44	64	5632
115	5.30	1	5461.07	1.00	0.32	63	5461.19	1	0.32	63	5461.19	1	44	64	5632
116	5.70	1	5461.12	1.00	0.28	63	5460.91	1	0.28	63	5460.91	1	44	64	5632
117	7.92	1	5460.98	0.63	0.33	63	5461.07	1	0.32	63	5461.07	1	44	64	5632
118	5.19	1	5460.97	1.00	0.38	63	5461.01	1	0.37	63	5461.01	1	44	64	5632
119	6.85	1	5461.04	1.00	0.42	63	5461.05	1	0.41	63	5461.05	1	44	64	5632
120	8.11	1	5460.98	0.57	0.47	63	5461.10	1	0.47	63	5461.10	1	44	64	5632
121	7.92	1	5461.06	0.63	0.45	63	5461.06	1	0.45	63	5461.06	1	44	64	5632
122	11.75	1	5461.01	0.08	0.36	63	5461.01	1	0.35	63	5461.01	1	44	64	5632
123	12.91	1	5461.02	0.04	0.37	63	5461.30	1	0.37	63	5461.30	1	44	64	5632
124	10.92	1	182021.08	0.12	0.38	63	182166.62	1	0.38	63	182166.62	1	44	64	5632
125	12.30	1	472.24	0.06	0.39	63	472.24	1	0.39	63	472.24	1	44	64	5632

Table 17B: Narrative Control stim comparison

Of the two stimuli included in the subset used to NOT evoke Narrative processing, they differed so that it could have a significant effect on the recorded EEG frequencies in 55.2% of the comparisons performed.

Freq	F Stim	df num Stim	df den Stim	p Bonf Stim	F Chan	df num Chan	df den Chan	p Bonf Chan	F Stim*Chan	df num Stim*Chan	df den Stim*Chan	p Bonf Stim*Chan	N Sbj	N Chan	N obs
1	1.46	1	5450.95	1.00	8.83	63	5450.95	0.00	0.09	63	5450.95	1	44	64	5622
2	9.14	1	5450.95	0.32	13.24	63	5450.96	0.00	0.10	63	5450.95	1	44	64	5622
3	17.02	1	5450.96	0.00	19.17	63	5450.96	0.00	0.12	63	5450.96	1	44	64	5622
4	11.66	1	5450.97	0.08	24.61	63	5450.97	0.00	0.09	63	5450.97	1	44	64	5622
5	15.85	1	5450.97	0.01	24.08	63	5450.98	0.00	0.16	63	5450.97	1	44	64	5622
6	9.68	1	5450.98	0.24	24.41	63	5450.99	0.00	0.15	63	5450.98	1	44	64	5622
7	7.15	1	5451.00	0.96	28.77	63	5451.00	0.00	0.07	63	5451.00	1	44	64	5622
8	32.40	1	5451.00	0.00	27.51	63	5451.00	0.00	0.10	63	5451.00	1	44	64	5622
9	49.11	1	5451.00	0.00	24.51	63	5451.00	0.00	0.13	63	5451.00	1	44	64	5622
10	18.02	1	5451.00	0.00	22.99	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
11	25.28	1	5451.00	0.00	23.55	63	5451.00	0.00	0.17	63	5451.00	1	44	64	5622
12	30.86	1	5451.00	0.00	31.31	63	5451.00	0.00	0.08	63	5451.00	1	44	64	5622
13	5.07	1	5451.00	1.00	27.62	63	5451.00	0.00	0.04	63	5451.00	1	44	64	5622
14	1.09	1	5451.00	1.00	24.68	63	5451.00	0.00	0.03	63	5451.00	1	44	64	5622
15	1.32	1	5451.00	1.00	26.40	63	5451.00	0.00	0.10	63	5451.00	1	44	64	5622
16	5.16	1	5451.00	1.00	27.97	63	5451.00	0.00	0.18	63	5451.00	1	44	64	5622
17	2.80	1	5451.00	1.00	27.64	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
18	0.84	1	5451.00	1.00	26.66	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
19	0.07	1	5451.00	1.00	24.40	63	5451.00	0.00	0.13	63	5451.00	1	44	64	5622
20	0.00	1	5451.00	1.00	21.24	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
21	0.00	1	5451.00	1.00	19.15	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
22	2.61	1	5451.00	1.00	20.12	63	5451.00	0.00	0.15	63	5451.00	1	44	64	5622
23	2.26	1	5451.00	1.00	18.65	63	5451.00	0.00	0.21	63	5451.00	1	44	64	5622
24	4.74	1	5450.98	1.00	14.66	63	5450.99	0.00	0.20	63	5450.98	1	44	64	5622
25	2.19	1	5451.00	1.00	17.89	63	5451.00	0.00	0.16	63	5451.00	1	44	64	5622
26	0.14	1	5451.00	1.00	19.11	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
27	0.00	1	5451.00	1.00	18.60	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
28	0.23	1	5451.00	1.00	19.15	63	5451.00	0.00	0.17	63	5451.00	1	44	64	5622
29	0.23	1	5450.99	1.00	19.82	63	5451.00	0.00	0.16	63	5450.99	1	44	64	5622
30	1.39	1	5450.99	1.00	20.94	63	5451.00	0.00	0.18	63	5450.99	1	44	64	5622
31	1.73	1	5450.99	1.00	22.03	63	5451.00	0.00	0.17	63	5450.99	1	44	64	5622
32	5.44	1	5450.99	1.00	22.68	63	5451.00	0.00	0.17	63	5450.99	1	44	64	5622
33	4.70	1	5450.99	1.00	23.21	63	5451.00	0.00	0.16	63	5450.99	1	44	64	5622
34	4.75	1	5450.99	1.00	23.62	63	5451.00	0.00	0.16	63	5450.99	1	44	64	5622
35	5.85	1	5450.99	1.00	24.64	63	5450.99	0.00	0.13	63	5450.99	1	44	64	5622
36	4.89	1	5450.98	1.00	25.04	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
37	2.88	1	5450.98	1.00	25.16	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
38	3.54	1	5450.97	1.00	25.86	63	5450.98	0.00	0.14	63	5450.97	1	44	64	5622
39	4.63	1	5450.97	1.00	26.71	63	5450.98	0.00	0.12	63	5450.97	1	44	64	5622
40	4.79	1	5450.97	1.00	26.45	63	5450.98	0.00	0.12	63	5450.97	1	44	64	5622
41	3.89	1	5450.97	1.00	25.86	63	5450.98	0.00	0.15	63	5450.97	1	44	64	5622
42	3.85	1	5450.97	1.00	26.37	63	5450.98	0.00	0.14	63	5450.97	1	44	64	5622
43	4.29	1	5450.97	1.00	26.48	63	5450.98	0.00	0.13	63	5450.97	1	44	64	5622
44	5.42	1	5450.96	1.00	27.61	63	5450.98	0.00	0.14	63	5450.96	1	44	64	5622
45	4.08	1	5450.97	1.00	27.10	63	5450.98	0.00	0.12	63	5450.97	1	44	64	5622
46	6.03	1	5450.97	1.00	27.65	63	5450.98	0.00	0.11	63	5450.97	1	44	64	5622
47	7.66	1	5450.97	0.73	27.74	63	5450.98	0.00	0.14	63	5450.97	1	44	64	5622
48	11.40	1	5450.97	0.09	27.12	63	5450.98	0.00	0.19	63	5450.97	1	44	64	5622
49	8.53	1	5450.94	0.45	24.85	63	5450.95	0.00	0.16	63	5450.94	1	44	64	5622
50	4.61	1	5450.89	1.00	9.36	63	5450.90	0.00	0.09	63	5450.89	1	44	64	5622
51	10.82	1	5450.95	0.13	26.48	63	5450.96	0.00	0.12	63	5450.95	1	44	64	5622
52	11.29	1	5450.98	0.10	26.93	63	5450.99	0.00	0.11	63	5450.98	1	44	64	5622
53	8.23	1	5450.97	0.53	27.80	63	5450.98	0.00	0.12	63	5450.97	1	44	64	5622
54	7.52	1	5450.97	0.78	28.12	63	5450.98	0.00	0.09	63	5450.97	1	44	64	5622
55	10.93	1	5450.97	0.12	28.56	63	5450.98	0.00	0.10	63	5450.97	1	44	64	5622
56	12.80	1	5450.98	0.04	27.98	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
57	12.35	1	5450.98	0.06	27.67	63	5450.99	0.00	0.09	63	5450.98	1	44	64	5622
58	11.63	1	5450.98	0.08	28.33	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
59	15.71	1	5450.98	0.01	28.86	63	5450.99	0.00	0.11	63	5450.98	1	44	64	5622
60	10.28	1	5450.98	0.17	28.35	63	5450.99	0.00	0.11	63	5450.98	1	44	64	5622

61	8.32	1	5450.98	0.50	28.35	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
62	15.69	1	5450.98	0.01	29.06	63	5450.99	0.00	0.13	63	5450.98	1	44	64	5622
63	15.75	1	5450.98	0.01	29.08	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
64	14.41	1	5450.98	0.02	27.96	63	5450.98	0.00	0.08	63	5450.98	1	44	64	5622
65	15.31	1	5450.98	0.01	27.74	63	5450.99	0.00	0.11	63	5450.98	1	44	64	5622
66	20.71	1	5450.98	0.00	27.94	63	5450.99	0.00	0.13	63	5450.98	1	44	64	5622
67	17.70	1	5450.98	0.00	28.05	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
68	17.48	1	5450.98	0.00	27.19	63	5450.99	0.00	0.13	63	5450.98	1	44	64	5622
69	16.23	1	5450.98	0.01	27.52	63	5450.99	0.00	0.10	63	5450.98	1	44	64	5622
70	17.10	1	5450.98	0.00	27.60	63	5450.99	0.00	0.12	63	5450.98	1	44	64	5622
71	17.53	1	5450.98	0.00	26.49	63	5450.99	0.00	0.09	63	5450.98	1	44	64	5622
72	17.24	1	5450.98	0.00	26.12	63	5450.99	0.00	0.11	63	5450.98	1	44	64	5622
73	21.13	1	5450.98	0.00	26.44	63	5450.99	0.00	0.13	63	5450.98	1	44	64	5622
74	22.30	1	5450.99	0.00	26.45	63	5451.00	0.00	0.12	63	5450.99	1	44	64	5622
75	15.98	1	5450.99	0.01	26.78	63	5451.00	0.00	0.10	63	5450.99	1	44	64	5622
76	16.74	1	5450.99	0.01	27.19	63	5451.00	0.00	0.09	63	5450.99	1	44	64	5622
77	17.93	1	5450.99	0.00	26.66	63	5451.00	0.00	0.08	63	5450.99	1	44	64	5622
78	21.49	1	5450.99	0.00	26.64	63	5450.99	0.00	0.10	63	5450.99	1	44	64	5622
79	18.27	1	5450.99	0.00	27.10	63	5451.00	0.00	0.08	63	5450.99	1	44	64	5622
80	21.12	1	5450.99	0.00	26.42	63	5451.00	0.00	0.09	63	5450.99	1	44	64	5622
81	18.31	1	5450.99	0.00	26.10	63	5451.00	0.00	0.10	63	5450.99	1	44	64	5622
82	18.17	1	5450.99	0.00	26.50	63	5451.00	0.00	0.10	63	5450.99	1	44	64	5622
83	18.95	1	5450.99	0.00	26.38	63	5451.00	0.00	0.10	63	5450.99	1	44	64	5622
84	30.28	1	5450.99	0.00	26.35	63	5451.00	0.00	0.11	63	5450.99	1	44	64	5622
85	20.16	1	5450.99	0.00	25.74	63	5451.00	0.00	0.11	63	5450.99	1	44	64	5622
86	17.69	1	5450.99	0.00	25.92	63	5451.00	0.00	0.09	63	5450.99	1	44	64	5622
87	22.90	1	5450.99	0.00	26.14	63	5451.00	0.00	0.11	63	5450.99	1	44	64	5622
88	28.43	1	5450.99	0.00	24.80	63	5451.00	0.00	0.11	63	5450.99	1	44	64	5622
89	33.72	1	5450.99	0.00	24.68	63	5451.00	0.00	0.11	63	5450.99	1	44	64	5622
90	29.87	1	5450.99	0.00	24.97	63	5451.00	0.00	0.12	63	5450.99	1	44	64	5622
91	27.26	1	5450.99	0.00	24.14	63	5451.00	0.00	0.13	63	5450.99	1	44	64	5622
92	27.34	1	5450.99	0.00	23.69	63	5451.00	0.00	0.11	63	5450.99	1	44	64	5622
93	31.58	1	5450.99	0.00	23.89	63	5451.00	0.00	0.09	63	5450.99	1	44	64	5622
94	31.12	1	5450.99	0.00	24.41	63	5451.00	0.00	0.08	63	5450.99	1	44	64	5622
95	31.17	1	5450.99	0.00	24.13	63	5451.00	0.00	0.10	63	5450.99	1	44	64	5622
96	25.22	1	5450.99	0.00	24.43	63	5451.00	0.00	0.12	63	5450.99	1	44	64	5622
97	21.43	1	5450.99	0.00	23.87	63	5451.00	0.00	0.09	63	5450.99	1	44	64	5622
98	24.30	1	5450.99	0.00	23.59	63	5451.00	0.00	0.10	63	5450.99	1	44	64	5622
99	18.87	1	5450.93	0.00	10.86	63	5450.94	0.00	0.09	63	5450.93	1	44	64	5622
100	4.88	1	5450.89	1.00	4.21	63	5450.90	0.00	0.05	63	5450.89	1	44	64	5622
101	25.36	1	5450.95	0.00	16.05	63	5450.96	0.00	0.08	63	5450.95	1	44	64	5622
102	41.75	1	5450.99	0.00	22.79	63	5451.00	0.00	0.13	63	5450.99	1	44	64	5622
103	36.09	1	5451.00	0.00	22.49	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
104	34.81	1	5451.00	0.00	22.58	63	5451.00	0.00	0.11	63	5451.00	1	44	64	5622
105	40.17	1	5451.00	0.00	22.65	63	5451.00	0.00	0.11	63	5451.00	1	44	64	5622
106	45.08	1	5451.00	0.00	20.99	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
107	39.09	1	5451.00	0.00	21.08	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
108	31.71	1	5451.00	0.00	22.31	63	5451.00	0.00	0.13	63	5451.00	1	44	64	5622
109	32.79	1	5450.99	0.00	21.78	63	5451.00	0.00	0.13	63	5450.99	1	44	64	5622
110	36.00	1	5450.99	0.00	21.34	63	5451.00	0.00	0.14	63	5450.99	1	44	64	5622
111	35.87	1	5451.00	0.00	20.81	63	5451.00	0.00	0.09	63	5451.00	1	44	64	5622
112	36.13	1	5451.00	0.00	19.92	63	5451.00	0.00	0.10	63	5451.00	1	44	64	5622
113	38.28	1	5451.00	0.00	20.45	63	5451.00	0.00	0.11	63	5451.00	1	44	64	5622
114	47.08	1	5451.00	0.00	20.91	63	5451.00	0.00	0.15	63	5451.00	1	44	64	5622
115	52.51	1	5451.00	0.00	20.62	63	5451.00	0.00	0.13	63	5451.00	1	44	64	5622
116	41.88	1	5451.00	0.00	21.44	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
117	35.30	1	5451.00	0.00	20.99	63	5451.00	0.00	0.13	63	5451.00	1	44	64	5622
118	34.69	1	5451.00	0.00	20.18	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
119	33.82	1	5451.00	0.00	19.88	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
120	37.65	1	5451.00	0.00	20.01	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
121	40.13	1	5451.00	0.00	19.00	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
122	43.77	1	5451.00	0.00	18.34	63	5451.00	0.00	0.14	63	5451.00	1	44	64	5622
123	47.25	1	5451.00	0.00	19.01	63	5451.00	0.00	0.12	63	5451.00	1	44	64	5622
125	52.63	1	463.22	0.00	19.47	63	463.22	0.00	0.19	63	463.22	1	44	64	5622

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