UNIVERSIDADE CATÓLICA PORTUGUESA

Methodological Innovations in Multidisciplinary Consumer Research towards Sustainable Development: An Applied Psychology Perspective

Thesis submitted to the Portuguese Catholic University for the Doctoral Degree in Applied Psychology: Adaptation and change in contemporary societies

by

Pedro Rodrigues Ribeiro

FACULTY OF EDUCATION AND PSYCHOLOGY

October 2025

UNIVERSIDADE CATÓLICA PORTUGUESA

Methodological Innovations in Multidisciplinary Consumer Research towards Sustainable Development: An Applied Psychology Perspective

Thesis submitted to the Portuguese Catholic University for the Doctoral Degree in Applied Psychology: Adaptation and change in contemporary societies

By Pedro Rodrigues Ribeiro

Supervised by Prof. Patrícia Oliveira-Silva (Universidade Católica Portuguesa);
Prof. Bahar Tunçgenç (Nottingham Trent University);
Prof. Ignacio Cifre Léon (Universitat Ramon Llull).

FACULTY OF EDUCATION AND PSYCHOLOGY

October 2025

I dedicate this work to my grandmother, Florinda Ribeiro, who sadly passed during my time as a PhD candidate. My deepest regret is that she could not have been here to see the end of this journey and the beginning of my life as a researcher. She helped raise me into the man — and the person — I am today, and she remains one of the purest inspirations for the values I hold.

Forever in my heart and mind — from your grandson, who loves you to infinity and back.

List of Abbreviations

A–C

- ACC: *Anterior Cingulate Cortex*
- AIC: *Akaike Information Criterion*
- BCI: *Better Cotton Initiative*
- BF: *Bayes Factor*
- BIC: *Bayesian Information Criterion*
- C2C: *Cradle to Cradle*
- CFA: *Confirmatory Factor Analysis*
- CI: *Credible Interval* / *Confidence Interval*

D–E

- dlPFC: *Dorsolateral Prefrontal Cortex*
- EAI: *Environmental Attitudes Inventory*
- EAI-36: Short 36 item version of the EIA
- EAIs: *Social Environmental Attitudes Inventory*
- EEG: *Electroencephalogram* / *Electroencephalography*
- EFA: *Exploratory Factor Analysis*
- ELPD: *Expected Log Predictive Density*

F–I

- FIR: *Finite Impulse Response*
- fMRI: *Functional Magnetic Resonance Imaging*
- fNIRS: *Functional Near-Infrared Spectroscopy*
- FSC: *Forest Stewardship Council*
- GDP: *Gross Domestic Product*
- GOTS: *Global Organic Textile Standard*
- GRS: *Global Recycled Standard*

- ICA: *Independent Component Analysis*
- IPCC: *Intergovernmental Panel on Climate Change*

K–O

- KMO: *Kaiser-Meyer-Olkin*
- LCA: *Latent Class Analysis*
- LOOC: *Leave One Out Cross-Validation*
- NeuMa: *Neuromarketing*
- OCS: *Organic Content Standard*
- OFC: *Orbitofrontal Cortex*

P–S

- RCS: *Recycled Claim Standard*
- RDS: *Responsible Down Standard*
- ROI: *Region of Interest*
- RWS: *Responsible Wool Standard*
- SABIC: *Sample-size Adjusted Bayesian Information Criterion*
- SD: *Standard Deviation*
- *SDG*s: *Sustainable Development Goals*
- sLORETA: *Standardized Low Resolution Electromagnetic Tomography*
- SnPM: *Statistical Non-Parametric Mapping*
- SPSS: *Statistical Package for Social Sciences*

T–Z

- TPB: *Theory of Planned Behavior*
- UNDESA: *United Nations Department of Economic and Social Affairs*
- VBN: *Value-Belief-Norm*
- vmPFC: *Ventromedial Prefrontal Cortex*

Acknowledgements

There are many people I must thank at this moment, as I reach the end of my PhD journey.

I begin with the two people who brought me into the world—reportedly, as a baby the size of an orange. Since then, they have been the examples I have strived to follow in every aspect of my life.

To my mother, I owe thanks for gifting me the example of compassion and perseverance, for being a consummate professional, and for giving all of herself without ever receiving nearly enough praise or recognition.

To my father, I am grateful for his example of integrity, skepticism, wisdom, and ethics—for being the blueprint of the man I will always aim to be. He taught me to doubt my own misguided certainties, to attempt always to step into the other's shoe, to be respectful, and to be of service to others.

Both have supported me through every chapter of my life, from a contentious boy to a rebellious teenager, to a stressed-out PhD student—through my time abroad, through every dark and bright moment.

To my co-supervisors, Bahar Tunçgenç and Ignacio Cifre-León, I extend my deepest appreciation and respect. I could not have asked for better partners—or better accomplices—in this work. I could not have asked for a better team or for wiser guidance. They have been examples of the kind of researcher I hope to become and have helped illuminate the path to the end of this long, difficult journey. Without them, I would not be the researcher I am today. I extend also a note of thanks to Vivienne Du who stepped in when Bahar gave birth to her child and helped me finish my submission process.

I must thank my external assessor at NTU, Thom Baguley, my discussions with him were truly enlightening and have improved my work at every step. I must also thank him for keeping me grounded in what is possible, aware of what seems too far in my ambition, and checking in on my wellbeing throughout this difficult process.

I must also thank Frederik "Ted" Scharf, both for contributing to my development as a researcher and for always keeping tabs on my progress, showing concern for my wellbeing and reminding me that no matter how much work there is yet to be done, it is important to rest and recover.

Two people I must thank with all my heart are my colleagues at the Human Neurobehavioral Laboratory: Patrícia Batista and Ana Moreno.

Patrícia has been my unofficial fourth supervisor. She has taught me the realities of research, of publication, and of academic life. She has always tempered my expectations and spoken to me candidly and clearly. Our debates have been some of the greatest moments of learning in my life. Her kindness and honesty have been inspirational to me, both personally and professionally.

To Ana Moreno, I owe thanks as one of my dearest friends. She has been the confidant for my frustrations and my moments of pride. She has been the person I turned to in moments of need—a constant throughout this PhD. I am overjoyed to work with her and to share a desk with someone whose journey I take great pride in, just as she has taken pride in mine. I owe her my sanity over these past three years. I could not have dreamt of sharing this journey with someone as kind, compassionate, understanding, wise, brilliant, soulful and human, I remain ever so glad to have had you as my foremost partner, a dream team for all tasks.

I hope to keep working with both for many years to come—until fate pulls us apart, or until we grow sick of one another (a most unlikely scenario). I love them both very deeply—not only as colleagues but as two of the most cherished friends this journey has given me.

I must also thank my friends, Ryan Hill, Frankie Hill, Danielle Reid and Afonso Cosme. They have been a constant reminder of what life has to offer beyond work, offered me advice, moments of enjoyment and fun, hope, but most importantly, friendship. I could not imagine a life lived without them, I could not fathom being the person I am, reaching the heights I have reached early in life, without those who I deem my closest friends, and a big chunk of the family I have chosen.

I must thank CEDH, FEP and Universidade Católica Portuguesa, for taking me in and making me feel at home, for providing what I needed to finish my PhD, for providing me what opportunities there were on offer to make me the professional I am today. I am a better researcher for taking in the culture of quality work, and the undeniably righteous values of these institutions. In thanking these institutions, I must include a small note of thanks to my students, some of which acted as research assistants, but all of which contributed actively to my development as a person and a professional.

Finally, I give my deepest thanks to my main supervisor, Patrícia Oliveira-Silva. Our journey began when I was a lost Master's student in search of a thesis project. She welcomed me into her lab, into a field far removed from the one I came from and introduced me to some of the most incredible people I could ever hope to meet.

To list everything I am thankful to Professor Patrícia for would take up far too much of this thesis. So, let me simply say: thank you, above all, for being my mentor—for giving me the space and the opportunity to grow and develop, every day of the last four years. I am truly lucky to have landed at your door—and luckier still for never having been asked to leave.

All of these people, and many more have contributed to my growth in life and work, and to the ruthless process of my PhD. I extend my sincere thanks to all.

This thesis reflects not only years of scientific work but also a profound personal journey. I began this path as an engineer and gradually found my place within the field of applied psychology. The transition between these worlds, and the curiosity that guided me through it, are further described in **Annex A – Researcher's Memoir: A Journey from Engineering to Applied Psychology**. That annex represents, to me, the human side of this work — a record of the doubts, discoveries, and transformations that shaped the researcher behind the research.

Sumário

Esta tese foi motivada pela urgência da crise climática e pelo reconhecimento da sustentabilidade como um problema multidimensional e com múltiplas partes interessadas, centrado no consumidor. Embora décadas de investigação tenham destacado a interação de várias dimensões que moldam o comportamento do consumidor, as abordagens metodológicas têm frequentemente dependido de autorrelato e abordagens isoladas. Esta tese teve como objetivo principal aplicar o pluralismo metodológico à investigação do comportamento do consumidor em sustentabilidade, através da combinação de instrumentos inovadores, segmentação comportamental e ferramentas neurocientíficas mecanicistas.

O primeiro estudo desenvolveu e aplicou um novo instrumento destinado a medir a perceção das atitudes ambientais do círculo social próximo, modelando esta dimensão em relação às próprias atitudes ambientais num contexto intercultural e numa amostra retirada de Portugal e Espanha. Este estudo concluiu que as atitudes do círculo social e os dados demográficos previam fortemente as atitudes ambientais individuais, destacando o papel da influência proximal. O segundo estudo providenciou avanços na neurociência do consumidor, aplicando a localização espectral da fonte e análises de conectividade funcional aos dados de EEG recolhidos durante um paradigma de compras de supermercado sem restrições. Os resultados revelaram dois mecanismos neurais distintos subjacentes à compra e à rejeição, baseados na avaliação mnemónica e no controlo inibitório, respetivamente, oferecendo uma visão mecanicista sobre a tomada de decisões sustentáveis. O terceiro estudo aplicou a análise de classes latentes às práticas de consumo têxtil, apoiada por uma análise fatorial exploratória para redução da dimensionalidade. Este estudo identificou quatro classes distintas de consumidores e oito dimensões latentes ao longo do ciclo de vida do produto. Os resultados demonstraram a heterogeneidade do consumo sustentável, indo além da segmentação demográfica.

Em conjunto, estes estudos demonstram como o pluralismo metodológico pode ampliar os quadros de normas sociais e identidade, revelar as bases neurais da escolha sustentável e mostrar os perfis heterogéneos dos consumidores, oferecendo implicações práticas para a elaboração de políticas, abordagens educativas e campanhas de marketing social.

Palavras-chave: comportamento do consumidor, consumo sustentável, pluralismo metodológico, influência social, neurociência, análise de classes latentes.

Abstract

This thesis was motivated by the urgency of the climate crisis and the recognition of sustainability as a multidimensional, multi-stakeholder problem centered by the consumer. While decades of research have highlighted the interplay of several dimensions shaping consumer behavior, methodological approaches have often relied on self-report and isolated approaches. This thesis undertook as its primary aim to apply methodological pluralism to consumer research in sustainability, through the combination of novel instruments, behavioral segmentation, and mechanistic neuroscientific tools.

The first study developed and applied a novel instrument meant to measure one's perception of their close social circle's environmental attitudes, modelling this dimension with regards to one's own environmental attitudes in a cross-cultural context and a sample drawn from Portugal and Spain. This study found that social circle attitudes and demographics strongly predicted individual environmental attitudes, highlighting the role of proximal influence. The second study advanced consumer neuroscience by applying spectral source localization and functional connectivity analyses to EEG data collected during an unconstrained grocery shopping paradigm. Results revealed two distinct neural mechanisms underlying purchase and rejection, based upon mnemonic valuation and inhibitory control respectively, offering mechanistic insight into sustainable decision making. The third study applied latent class analysis to textile consumption practices, supported by exploratory factor analysis for dimensionality reduction. This study identified four distinct consumer classes and eight latent dimensions across the product lifecycle. The results showed the heterogeneity of sustainable consumption, moving beyond demographic segmentation.

Together these studies demonstrate how methodological pluralism can extend frameworks of social norms and identity, reveal the neural bases of sustainable choice, and show the heterogenous profiles of consumers, offering practical implications for policy building, educational approaches, and social marketing campaigns.

Keywords: consumer behavior, sustainable consumption, methodological pluralism, social influence, neuroscience, latent class analysis.

Index

Chapter 1: Introduction

1.1. Sustainability and the central role of consumers

The IPCC reports that it is unequivocal how human influence has caused global warming, consequently inducing rapid changes in the atmosphere, the ocean and the land. These changes are unprecedented and at a scale larger than any seen for many centuries or even thousands of years, and have been represented by extreme heatwaves, heavy precipitation and flooding, droughts, tropical cyclones, and more. Continued global warming past the estimated maximum allowance will lead to global monsoon precipitations, further reductions in Arctic Sea ice, snow cover and permafrost, and far more severe wet and dry events. Many of these changes are seen as irreversible (IPCC, 2021). We are in a state of climate emergency (Ripple et al., 2020).

The United Nations have issued Sustainable development as a global priority, defining 17 *SDG*s, to ensure the availability of resources for future generations and to mitigate the global climate crisis (United Nations, 2015; UNDESA, 2024; UNDP, 2023). This concept was originally defined within the Brundtland Report (Brundtland, 1987) as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", in essence, a continuous development of environmental, social and economic realities in the present, without compromising the future (UNDESA, 2024).

The *SDG*s highlight consumption and production as central lever for sustainability (UNDESA, 2015). Overconsumption has been cited as a critical flaw leading to global warming (Joshua, 2017), and when paired to a lack of responsibility at the end of life, due to design flaws or consumer mismanagement, this endangers the circularity of industry (Maitre-Ekern, 2021). Circularity, defined as the closing of the product life-cycle loop, consists of ensuring products at end of life can be recycled and reused for the production of new products, reducing the overreliance on extractive industries and the fast depletion of raw materials (Geisendorf & Pietrulla, 2018; Stanescu, 2021).

Sustainability is not a monolith, it is a multidimensional challenge, with ramifications across three different dimensions: social, environmental and economic, with this three-pillar model widely regarded in academic and policy debates (Purvis et al., 2019). The social dimension relates to equity human rights, community cohesion, quality of life, and intergenerational justice, and can be especially personified by *SDG* 10 on inequality. The environmental dimension concerns the preservation of natural resources, ecosystems, biodiversity, and the stability of climate, and can be especially personified by *SDG* 13 on climate action. The economic dimension stresses long-term viability of markets, efficient use of resources and the insurance that development generates prosperity without creating externalities that undermine the other two dimensions, best personified by *SDG* 8, on decent work and economic growth, and *SDG* 12, on responsible consumption and production (Purvis et al., 2019; United Nations Department of Economic and Social Affairs, 2015).

This multidimensionality brings with it responsibilities for multiple different stakeholders. No problem described so far can be solved by a single entity (Foley et al., 2017). Industry has a role, especially consumer-facing industries, as literature has pointed out that circular transition is motivated by proximity to the consumer (Haddock-Fraser & Tourelle, 2010). The will of the consumer often defines the products in the market, so these companies must pay attention to their satisfaction. Industry, in fact, holds a vital role, being an intrinsic participant in every dimension of sustainability, through its role in building and maintaining communities, extracting and managing resources, holding technological and social responsibilities (Levek et al., 2002; Shrivastava, 1995). Due to its proximity and reliance to consumers, industry must also be actively engaged in their education through social marketing (Fox & Kotler, 1980; Kotler, 1978; Kotler & Anderson, 1987; Kotler & Lee, 2008).

Despite industry's integral involvement, the consumer is central to sustainability, partly for their intrinsic connection to industry (Haddock-Fraser & Tourelle, 2010), but also due to the vast amount of tools at their disposal, like activism ranging from self-education to boycotts and ethical consumption (S. McGregor, 2005; S. L. T. McGregor, 2016). The consumer is, however, a complex piece of the puzzle, as even though they may hold positive intentions towards sustainable behavior, driven by a positive attitude and great efforts in gathering knowledge, this does not always translate into action (Ajzen, 2020; Tomkins et al., 2018). This is due to many different reasons, from actual to perceived barriers. Barriers like price and budget prevent monetary driven action, lack of availability of required tools as well (Fink et al., 2021), but sometimes, a perceived lack of control will also be a barrier to action (Ajzen, 2020; Bosnjak et al., 2020), causing the so-called intention-behavior gap.

The study of consumers, their behavior and decision making, is therefore a paramount issue in modern sustainability research. The study of this topic has the potential to help bridge the intention-behavior gap, to bring consumers closer to industry, to inform social marketing and future policy making. As such this thesis is focused upon the consumer, never disregarding that sustainability is a multi-stakeholder, multi-dimensional role. This thesis therefore positions itself within *SDG* 12, Responsible Consumption and Production, while recognizing the essential interplay with environmental and social dimensions of sustainability. (United Nations Department of Economic and Social Affairs, 2015).

1.2. Understanding Consumer Decision Making

The birth of the consumer began with the death of the *homo economicus*. Consumer research was born from the assertion that humans do not calculate optimally, they are not in possession of all the information, they rely on heuristics, overweight losses, and they are inconsistent. This was the basis for Kahneman and Tversky's (1984) prospect theory. They explored how people make decisions involving risk and came to the conclusion that emotion plays a part in decision making, as the impact of losses can have a much greater emotional impact than the equivalent gain. For Kahneman and Tversky this loss aversion was moderated by the way options are framed, understanding that people prefer certainty of outcome rather than uncertain gain, this makes consumers inconsistent. Thaler (1980) recognized this uncertainty in his Positive Theory of Consumer Choice and introduced a few key ideas.

Thaler modelled consumer decision making after the concept of personal equilibrium, which occurs when a person's expectations align perfectly with the behavior they would choose based on those same expectations. But Thaler also considered other aspects, like the sunk cost, the idea that the more people invest in a decision, the more likely they are to defend it and reinvest, even if it is not the base choice, and also the idea of regret, or what we now call the fear of missing out, meaning people often end up delegating decisions to others. Thaler took the prospect theory and expanded it, turning his ideas into a critique of traditional economic models of the consumer, denying the, at that time, typical models which preferred to assume a perfectly rational, expert-like consumer. This gave way to a wave of theories explaining several different dimensions of consumer choice and behavior.

Thaler, Kahneman and Tversky ended up highlighting the complexity of consumer research. Still today, more than four decades after the death of the *homo economicus* models, there is no one theory that explains all consumer behavior. Instead, different lenses capture different determinants, the emotional like Kahneman and Tversky pointed at, the cognitive like Thaler defined, alongside the social and the contextual. As much as there is no grand theory of the consumer, there is no one field for their study. Psychology, sociology, economics, marketing and neuroscience have all intervened, and created a rich field of ideas, predictive and theoretical models, empirical experimentation, and science.

When faced with the complex field set out by the fathers of consumer research, researchers in the field sought to organize determinants of behavior. This is exactly what Sheth, Newman and Gross (Sheth et al., 1991) tried to do with their theory of consumption values. Here they set out five determinants they dubbed consumption values. The function pertains to the perceived utility of a choice, its practical and utilitarian value. In purchase this value may manifest in attributes such as reliability, durability and price. The social value, linking back to Thaler's regret arises from the value a behavior holds within a social group, and the choices one may make to enhance their own social image. The emotional refers to the ability of a choice to evoke an emotional response, this connects back to Kahneman and Tversky's loss aversion. Sheth and colleagues also had to recognize that, sometimes, people make choices out of curiosity, a category they dubbed the epistemic value, which pertains to the ability of a choice or behavior to satisfy a consumer's curiosity. Finally, conditional value accounts for context-dependent decisions, where choice is contingent on the situation.

Despite neatly categorizing all of these determinants under the umbrella of one single neat theory, Sheth, Newman and Gross could not explain how values become action, for that research had to look for ways to connect values, beliefs and norms. As such, Stern and colleagues (1999) developed the Value-Belief-Norm (VBN) theory. The core principle of VBN is that a consumer's choice for endorsing a cause would come from a chain of psychological processes which link values to beliefs, forming personal norms. This causal model notes that values such as altruism, tradition, openness to change, link with general beliefs regarding the problem, creating an awareness of the potential consequences towards a valued object, like loved ones, this then leads to an acceptance of responsibility, terminating in a felt obligation to act, the personal norm, leading to action. Yet, while VBN accounts for motivation and a sense of responsibility, it does not answer the question of why consumers fail to act even when they value the problem a feel a moral obligation. This gap provides the foundation for Ajzen's (Ajzen, 1991) Theory of Planned Behavior (TPB).

After Stern and colleagues built the bridge between attitudes and perceptions become intentions, Ajzen came to formalize the link between intention and behavior. Ajzen's model posits three main determinants, attitude toward the behavior, a positive or negative evaluation of the action, subjective norms, the perceptions of social expectations and pressures, and the perception of behavioral control, a consumer's perception of their own ability and resources to act. Together, these feed into behavioral intention, the most proximal predictor of actual behavior. This theory became quite popular and well accepted, boasting, in 2024, over fourteen thousand articles and over five hundred thousand citations (Naskar & Lindahl, 2025), with recent studies showing an over 40% variance explained (Maleki et al., 2025). Ajzen's TPB offered a parsimonious yet empirically resilient framework, though its simplicity may partly account for both its popularity and its limitations. This adaptability allowed it to be applied in different fields like sustainability and health (Naskar & Lindahl, 2025), and it also allowed researchers to extract its value while bridging it together with other theories filling more of Sheth's dimensions.

Despite achieving a high level of success, the theory maintains an undeniable criticism, the intention-behavior gap. This is the idea that intention does not always equate to behavior. This may be due to factors like availability or perceived availability (Vermeir & Verbeke, 2008), due to cost and budgetary concerns (Egbue & Long, 2012), a high amount of effort required (Young et al., 2010), or even the actual control over behavior, which in itself is a critique to Ajzen's focus on perceived behavioral control (Carrington et al., 2010). Even pressure from other values may deter behavior, such an example is when social norms exert pressure against the actuation of behavior (Vermeir & Verbeke, 2008).

The social dimension, exposed by Thaler, later Sheth and Stern, was not considered by Ajzen, who viewed consumer decision-making as a more individual process. This dimension's importance is best explained by Tajfel (1978) in his social identity theory. Tajfel's model sits on three core processes, categorization, wherein people categorize themselves and others into groups, for example one may identify themselves as a sustainable clothing consumer and identify others as fast fashion consumers, individuals then identify themselves with a group and adopt its identity, aligning their attitudes and behaviors with in-group norms, they then evaluate their groups by comparing them to other groups, leading to in-group favoritism and out-group derogation. In the context of consumer behavior, this means that consumption has a value beyond functional, it becomes a symbol of identity. What a consumer buys, wears, eats and rejects signals membership, as such behavior reinforces belonging.

This is built upon by Bicchieri (2005) and Cialdini and colleagues (2008). They described the Social Norm's Theory, in which social stimuli guides behavior through two mechanisms, descriptive norms, the perceptions of what most people do in a situation, for example most of my friends and family recycle, so I will too, and injunctive norms, the perceptions of what most people approve of disapprove of, for example, my friends disapprove of me wasting food, so I will more carefully control portions to match what I am able to eat. Cialdini and Bicchieri view these norms as behavioral shortcuts, an answer to Thaler's uncertainty, when unsure of what to do, people will look to what others approve or disapprove of. In the context of sustainability, descriptive norms often drive behavior by making sustainable action appear common, while injunctive norms will activate moral obligations, creating Stern's sense of personal responsibility.

While these social and normative processes shape the context of consumer behavior, they do not fully explain why intentions and norms sometimes fail to translate into action. Insights from neuroscience highlight the role of affective signals, learning systems and executive control in determining when individuals follow through with sustainable choices or fall back on unsustainable defaults.

According to Damásio's (1996) somatic marker hypothesis, decisions are not purely cognitive, they are shaped by affective signals, which themselves are linked to prior outcomes. These markers, supported by the ventromedial prefrontal cortex bias attention and evaluation, preventing the choice for disadvantageous options without explicit calculation. This is supported by the work of Bechara and colleagues (Bechara et al., 1997), who showed that normal participants undergoing a gambling task avoided disadvantageous decks before even being able to articulate why, guided by an anticipatory physiological response, in contrast, those with a damaged ventromedial prefrontal cortex lacked these responses and continued to choose poorly. This shows us that actions like planning for long-term sustainable choices requires explicit control, while unsustainable impulse-based choices typically exploit somatic markers and reward learning.

Schulz's work (Schultz, 1998, 2016) that dopamine neurons signal when an outcome exceeds expectations, but remain unchanged when outcome matches prediction, and suffer a reduction in activity when outcomes fall short of what was expected. This same system guides habit, as experience with the same stimulus allows dopamine responses to shift from the reward to cues predicting reward. This allows for anticipation and preparation of behavior. Once learning stabilizes, these neurons cease responding, which underpins the persistence of habits. Dopamine activity encodes subjective rather than objective value, and diminishes with delay, showing the temporal discounting that explains why immediate reward dominates over long-term sustainable choices.

Self-control is dependent on prefrontal-striatal circuitry that modulates value representations. The ventromedial prefrontal cortex integrates a value signal, while the dorsolateral prefrontal cortex introduces a bias towards long term goals (Hare et al., 2009). A right lateralized network within the frontal cortex, supplementary motor area and subthalamic nucleus operates reactively to cues, or proactively in anticipation of temptation. This system is responsible for proactive control which is particularly relevant to consumer contexts where resisting immediate gain requires preparing to withhold prepotent responses (Aron, 2010). In the context of sustainability, differences may attributed to intertemporal choice circuitry, meaning individuals who often discount future rewards tends to have a weaker engagement of valuation mechanisms within the ventral striatum medial prefrontal cortex and posterior cingulate cortex, leading to frequent impulsive behavior predisposed for short-term gain.

Together these neurocognitive systems help complement the classical theoretical frameworks described. Somatic markers help explain why emotions bias judgment, as stated by Kahneman and Tversky. Dopaminergic prediction errors and habit formation circuitry provide a possible mechanistic explanation for the intention-behavior gap, since repeated cues and learned rewards often override conscious intention. Systems of control and inhibition help explain why sometimes consumers succeed in aligning behavior with norms and values, and other times succumb to impulse. Neuroscience therefore serves to deepen the pluralistic view of consumer behavior, providing grounded mechanistic explanations for cognitive, emotional and social theories.

As such, in consumer research there is no single accepted theory covering all dimensions involved in consumer decision making. As decades of research have shown, a pluralistic view is required to understand consumer phenomena. This plurality is exactly why a plurality of methodologies is required for consumer research, ensuring the ability to fully explore the spectrum of behaviors and influencing factors.

1.3.Gaps in Consumer Research

Despite decades of research in consumer behavior clearly displaying the multidimensional underpinnings of consumer behavior, showing attitudes, values, norms and identity converge to shape action, the methodological toolkit used to study these phenomena has not always kept up in terms of complexity. Many studies remain siloed, relying on single measures, heuristic proxies and abstract constructs, with limited integration of contextual and mechanistic approaches. A significant gap in consumer research lies in how the determinants of behaviour are operationalized, especially with regards to the role of social influence, the segmentation of consumers in their sustainable practices, and the mechanistic bases of decision making. The present thesis aims to address some of these gaps.

As mentioned before, while consumer research has long recognized the role of social identity (Tajfel, 1978) and social norms (Bicchieri, 2005; Goldstein et al., 2008) in the guiding of behavior, even studying this phenomenon directly in the field regarding the effect of the social circle's effect in undertaking sustainable behavior (Allcott, 2011), no instrument has been developed to specifically measure one's perception of the social circle's pro-environmentalism. Most research still treats social influence as a generalized societal pressure or group identity, neglecting the proximal relationships that often have the strongest impact (Zheng et al., 2019). Such an instrument would be beneficial as it would allow for the comparison between personal pro-environmentalism and the pro-environmentalism of the close social circle.

Consumers view sustainability through different lenses, suggesting multiple behavioral profiles might coexist within the population. While several studies model behavior to find how certain determinants affect the adoption of certain choices, few studies have leveraged clustering techniques to find latent segments within the consumer population indicating different patterns of consumption. Often, modelling consumer behavior occurs by testing models like the theory of planned behavior directly on a topic (Paul et al., 2016), or extending these models with additional variables (Chen & Tung, 2014), focusing on developing a model for the sample, but not on exploring how consumer's behavior is segmented within the population, which may yield significant insights and provide new determinants of behavior, as well as provide policy and educational insight.

Beyond segmentation, methodological debates have also centered on how to access unconscious processes. Consumer research, particularly marketing, has long been criticized for its overreliance on self-report measures, which are biased and fail to capture unconscious processes (Plassmann et al., 2015). Neuroscience brought significant insight, as it often leverages multimodal analysis to extract as many relevant metrics as possible. Such an example may be found in Pozharliev and colleague's (2022) study, which took advantage of multiple physiological measurements to detect attention and emotional engagement, showing neurophysiological measurements are capable of outperforming self-report.

Despite the benefits of the use of neuroscience as a method of consumer research, a recent systematic review by Khondakar and colleagues (2024) showed that when EEG is used in neuromarketing, studies are usually limited to asymmetry indices and band-power heuristics, failing to leverage more mechanistic techniques such as source localization, which locates EEG activity through mathematical inference (Jatoi et al., 2016) and functional connectivity, which captures the connectivity between different areas of brain (Allouch et al., 2022). Smidts and colleagues (2014) have shown this gap, and yet we were only able to find four studies leveraging both or either source localization or functional connectivity (Astolfi et al., 2008; De Vico Fallani et al., 2008; Khushaba et al., 2013; Vecchiato et al., 2010).

Taken together, these limitations show a reliance on simple methods to study a problem that is inherently multidimensional. Accordingly this thesis is primarily methodological in aim, it advances the study of sustainable consumer behaviour not by proposing new theories, but by developing novel instruments, applying advanced segmentation approaches, and leveraging mechanistic neuroscientific methods.

1.4.Overview of Studies included in the thesis

This thesis comprises three Studies, each addressing a distinct topic within sustainable consumer behavior while also making a specific methodological contribution.

Study 1 – The Social Circle Effect

Examines how social and demographic predictors shape environmental attitudes within a multinational context, with Portuguese and Spanish samples. A novel instrument was developed to measure perceptions of close social circles' environmental attitudes and leveraging Bayesian modelling techniques. This Study demonstrates that the social circle's attitudes, alongside demographic predictors like gender, education and political orientation, strongly predict one's own environmental attitudes.

Study 2 – How Do You Buy Without Constraints?: Explores the neural mechanisms of real-world purchase decisions in an unconstrained scenario using the NeuMa grocery shopping paradigm. Through the application of fine-grained spectral source localization and functional connectivity, distinct cortical circuits for purchase versus rejection were uncovered, highlighting mnemonic valuation and inhibitory control processes.

Study 3 – Classing Portuguese Textile Consumers: Investigates consumer behavioral profiles in textile sustainability practices across a product's lifecycle. Using latent class analysis of the be@t questionnaire, four distinct consumer profiles were identified, revealing that sustainable consumption is heterogenous and segmented beyond demographics.

Together, these studies contribute to a multilevel understanding of consumer behavior across social, behavioral, and neurocognitive levels, while demonstrating the value of tailored methodological approaches for each context.

1.5.Integrative contribution of the thesis

This thesis advances consumer research by integrating methodological innovation with substantive insights into sustainable behavior. Each of the three studies addresses a specific gap identified earlier, applying appropriate methodological approaches to different topics, while also generating findings that extend existing theories of consumer decision making.

Study 1 develops and applies a novel instrument aimed at capturing the perceptions of the close social circle's environmental attitudes. This responds to the absence of psychometrically sound tools for assessing proximal social influence, allowing direct comparison between personal and perceived social attitudes, The findings show that close social circles are strong predictors of environmental attitudes, alongside demographic variables like gender, education, and political orientation, while failing to find cross-cultural effects. By highlighting the predictive power of intimate contexts, this study refines social norms and identity theories in sustainability research.

Study 2 extends the scope of consumer neuroscience by moving away from the traditional band-power heuristics and asymmetry indices based methods that are traditionally leverages, opting instead for a fine-grained source localization within the Alpha and Beta sub-bands, leveraging different functional connectivity metrics, applied to data collected during an unconstrained naturalistic shopping paradigm. This mechanistic approach allowed us to uncover distinct cortical circuitry activation underlying purchase versus rejection decisions, highlighting the role of mnemonic valuation in purchase and inhibitory control in rejection. The findings advance theoretical models of decision making by demonstrating how inhibitory processes support choice even in unconstrained environments.

Study 3 introduces consumer segmentation into sustainability research by applying latent class analysis in order to cluster consumers along dimensions uncovered using exploratory factor analysis. This work moves beyond segmentation and demographic and theoretical modelling, revealing four distinct consumer classes, differing in their sustainability practices and motivations, alongside eight latent dimensions of textile consumption through different phases of a product's lifecycle. By evidencing this heterogeneity, this study contributes to theories of consumption values and decision making, showing how sustainability is enacted in diverse ways across acquisition, use, maintenance, and disposal of a product.

These three studies demonstrate the power of methodological pluralism to produce convergent and complementary insights into consumer behavior. The thesis thus makes a dual contribution: it expands the methodological toolkit available to consumer researchers while deepening theoretical understanding of how social influence, behavioral diversity, and neural mechanisms to shape decisions.

Beyond the specific contributions of each Study, the Annex B captures the complementary dimensions of this doctoral journey, including teaching, dissemination and service, that shaped the researcher's academic identity and extended the impact of this PhD.

1.6.Summary

This chapter positions sustainability as a multidimensional, multistakeholder challenge, holding the consumer as a central piece sustainable development. It reviewed major theories of consumer behavior across different dimensions, adding a neurocognitive layer to explain why intentions and norms do or do not translate into action. It identifies key gaps in current research, the lack of instruments for proximal social influence, limited research in segmentation of sustainable behavior segmentation, and underuse of mechanistic neuroscientific methods. The thesis responds to these gaps along three studies, developing and applying a social circle attitudes instrument with view of modelling personal environmental attitudes, mapping neural mechanisms of purchase and rejection within an unconstrained naturalistic context, and uncovering latent classes of consumers with regards to patterns in their sustainable behavior. These studies provide an expansion of the methodological toolkit of consumer research, while advancing the theoretical understanding of social, behavioral and neural mechanics shape consumer behavior.

Chapter 2: The Social Circle Effect: How social norms and identity contribute to environmental attitudes (Study 1)

The Social Circle Effect: How social norms and identity contribute to environmental attitudes

Submitted for Publication in Journal of Environmental Psychology; Elsevier

Presently awaiting Editor Approval

Pedro Rodrigues Ribeiro[1,2,3] | prribeiro@ucp.pt | ORCID: 0000-0003-0496-0634
Bahar Tunçgenç[2] | bahar.tuncgenc@ntu.ac.uk | ORCID: 0000-0002-1135-1004
Ignacio Cifre [3] | ignaciocl@blanquerna.url.edu | ORCID: 0000-0003-0644-6022
Patrícia Oliveira-Silva [1] | posilva@ucp.pt | ORCID: 0000-0001-6550-3790

1. Human Neurobehavioral Laboratory, Research Centre for Human Development, Faculty of Education and Psychology, Universidade Católica Portuguesa, Porto, Portugal
2. Department of Psychology, Nottingham Trent University, Nottingham, United Kingdom
3. School of Psychology, Education and Sport Science, Blanquerna Ramon Llull University, Barcelona, Spain

Abstract

Environmental attitudes are recognized as a key factor in the adoption of sustainable consumer behavior. However, their social and cultural determinants-particularly connections with societal norms and social identities are underexplored. This gap limits our understanding of green consumption and represents a missed opportunity in sustainability marketing. Literature shows these attitudes can be predicted by determinants such as one's household, income, age, gender, political orientation and education. Theories on attitude formation and behavioral adoption have shown that these have a social component-individuals tend to develop positive attitudes towards behavior when social norms and their own social circles agree. This study investigated the effect of social and demographic factors on environmental attitudes with data collected from two countries, Portugal and Spain, in different types of shopping locations. The Environmental Attitudes Inventory was used to assess individuals' Environmental Attitudes. This inventory was adapted to also assess participants' perceptions of their close social circle's attitudes. We found that across both countries, the social circle's perceived pro-environmental attitudes and being female positively predicted participants' pro-environmental attitudes. Moreover, left-wing political orientation and higher education predicted increased preservation attitudes. Results can be leveraged for the creation of more impactful social marketing campaigns to promote pro-environmental behavior.

Keywords: Environmental Attitudes; Social Norms; Close Social Circle; Bayesian Statistics; Sustainability; *SD*G 12

Introduction

The United Nations (2024) have identified the change in consumption and mass production patterns as a key sustainable development goal (*SD*G 12 – Responsible consumption and production), reporting that household consumption, including food, housing, mobility, and goods and services account for approximately 60% of global greenhouse gas emissions. According to the World Health Organization (2023) 3.6 billion people live in areas highly susceptible to climate change, with this phenomenon expected to cause 250 thousand deaths every year between 2030 and 2050. Pro-environmental behaviors such as recycling, upcycling and reusing products can help reduce the need for new prime matters, effectively helping to reduce the environmental impact of the consumption economy. All these behaviors require a positive environmental attitude. Despite belonging to individuals, attitudes are largely determined by external social factors, such as social identity and norms dynamics, as well as a range of sociodemographic characteristics (Bicchieri 2005; Krettenauer 2017; Phillips and Englis 2022; Tajfel 1978). To explore these social determinants of people's environmental attitudes, we conducted a cross-national field study in different types of shopping locations in Portugal and Spain.

Attitudes can be defined as evaluations of objects, ideas, or people that may be positive or negative (Olufemi 2012; Yozukmaz & Kiliç 2022). Attitudes compound three main components: cognitive, based around the beliefs or thoughts on the object of assessment; affective, the emotional responses towards the object; and behavioral, the measurable and observable actions towards the object (Perry et al. 2022). Environmental attitudes are, therefore, attitudes towards the natural environment, which may signal favorable or unfavorable evaluations (Milfont and Duckitt 2010). Environmental attitudes are considered to comprise two key dimensions: preservation attitudes, which focus on the protection and conservation of the natural environment, and utilization attitudes, which focus on accentuating the use of natural resources for human or self-benefit (Milfont 2010). Although several demographic factors have been associated with environmental attitudes, other social determinants, such as the influence of one's social circle, have been largely underexplored.

Two well-established psychological frameworks, the Social Identity and Social Norms theories, are informative for understanding the social determinants of consumers' environmental attitudes. Social Identity Theory explains how people categorize themselves as part of a social group through shared beliefs, desire for social mobility, sense of pride, self-esteem and belonging (Nelson 2015; Tajfel 1978). These groups often constitute people in one's close social circle, such as their family and friends, with whom they are strongly bonded (Dunbar 2021). Group identities and social circles shape people's attitudes and preferences, such that people tend to favor their in-groups (i.e., the groups they identify with) over the out-groups (i.e., the groups with different views than the in-group) (Belavadi and Hogg 2021). Depending on the salience of their social identity, people may go so far as to depersonalize out-group members and align their own attitudes and behaviors with those supported by their in-groups' norms (Jans and Fielding 2018).

Similarly, Social Norms Theory (Bicchieri 2005; Legros and Cislaghi 2020) posits that people's behaviors and attitudes are influenced by their perceptions of their group's social norms, which are comprised of two constituents: what people think others are doing (descriptive norms) and what people think others are approving of (injunctive norms). This formulation highlights the importance of our *perceptions* of our group members, rather than what those group members may be doing or approving of, objectively. For instance, research shows that people adjust their attitudes based on perceived group norms to maintain social cohesion (Schultz et al. 2007), dynamically update their own beliefs about norms to adapt to changing contexts (Deutchman 2023), and, over time, internalize these norms, turning them into personal motivations (Legros and Cislaghi 2020). Combining insights from these two theoretical frameworks, it can be said that although social norms influence people's own behaviors and attitudes, not all influences are equal: People tend to be swayed more by their close social circle, with whom they identify and feel a close bond.

Few existing studies have demonstrated the role of people's social circles on their pro-environmental attitudes and behaviors. For example, Huang and colleagues (2024) found that people tend to save more energy if their neighbors do so too. Goldstein & Cialdini (2008) found that using signs that emphasize the shared social identity of hotel customers reinforced their re-use of towels more as compared to signs with informative content or referring to other people's behaviors in general. Descriptive norms have been found to drive pro-environmental behavior, especially when individuals attribute the behaviors of their peers within society to intrinsic motivations, like personal values or genuine concern for the environment (Ejelöv et al. 2022).

In addition to social identity and norm-related factors, a broad range of socio-demographic characteristics may influence people's environmental attitudes. Studies have shown that being a woman or non-binary versus a man (Phillips and Englis 2022), being of older age (Anderson and Krettenauer 2021), having a higher level of education (Liobikienė and Poškus 2019; Rajapaksa, Islam, and Managi 2018) and income (Akram et al. 2023), living in larger households (Huang et al. 2024), and holding more left-wing political opinions (Neumayer 2004) are associated with pro-environmental attitudes and behavior.

Gender is one of the most important sociodemographic factors in this landscape, as gender identity has been shown to play a significant role in predicting pro-environmentalism, with women being more likely to hold positive environmental attitudes, men tending to express less pro-environmental concern, and androgenous people tending to be the most pro-environmental (Phillips and Englis 2022). Women have been shown to more easily embrace pro-environmentalism than men (Idalgo-Crespo et al. 2022), with associations being made with more salient feelings of guilt, moral obligation, and self-identity as reasons (Ivković and Mandić 2024). Societal gender norms have, however, been shown to affect how each gender carries out pro-environmental behavior, as men are more likely to participate in public sphere pro-environmental behaviors, while in societies with weaker traditional gender role beliefs, women are more likely to participate in private-sphere pro-environmental behavior (Xia and Li 2023).

Age has also been found to be a prevalent factor in environmental attitudes. While younger generations tend to display lower emotional connection and affinity to nature, as well as less pro-environmental behaviors than older generations (Collado, Staats, and Sancho 2019; Krettenauer 2017), older generations show a stronger emotional connection to nature (Anderson and Krettenauer 2021), which is overtly reflected in their higher engagement with conservation actions (Yan Wang, Hao, and Liu 2021). Socio-economic status is another factor that studies have examined in relation to environmental attitudes. Education has been shown to positively impact pro-environmental attitudes and behaviors (Liobikienė and Poškus 2019; Rajapaksa et al. 2018), mostly attributed to the critical thinking skills gained at higher levels of education, which allow for a more impactful perception of anthropogenic global warming (Han 2023). Similarly, while several studies have associated higher income with more pro-environmental attitudes, others have shown mixed results and indirect effects, making it hard to derive causality. Income is also an important socio-economic factor in developing pro-environmental attitudes, as it has been found to negatively correlate with pro-environmental behavior, as higher income tends to decrease pro-environmental habits, likely due to the adoption of resource-intensive lifestyles (Akram et al. 2023).

At the intersection of demographics and social influence lies household composition. Household size has been positively correlated with pro-environmental behavior (Huang et al. 2024). In fact, research indicates that social pressure from descriptive norms, for example comparing one's energy consumption to neighbors, has stronger effects on households with initially higher energy usage, leading to greater reductions in energy consumption compared to those initially using less (Allcott 2011). The presence of children and adolescents in a household has been shown to foster sustainable consumption patterns, potentially due to the active influence younger members of the family are capable of exerting, or because the parents may become more environmentally conscious as they regard their children's futures(Collins 2015). As such, familial interactions could represent an important social context directing pro-environmental attitudes. Together, these studies show that multiple demographic factors impact pro-environmental attitudes and behaviors, which should be included in any analysis on the determinants of environmental attitudes.

Another important gap in our knowledge about environmental attitudes is the scarcity of cross-cultural comparisons and studies outside of the USA. Research shows that cultural beliefs and values and national identity significantly influence pro-environmental attitudes (Lou and Li 2022; Nakai 2024). Importantly, the influence of cultural context is moderated by individual-level factors, such as environmental knowledge and attitudes, as well as societal factors, including national identity and cultural values (He and Filimonau 2020; Nakai 2024). These factors can vary across different cultural and national contexts, indicating the complexity and context-dependent nature of pro-environmental decision-making. For instance, in economically more developed and culturally more individualistic countries, citizens' pro-environmental attitudes more frequently develop into actual behavior than in developing and collectivist countries (Morren and Grinstein 2016). Given these societal and cultural differences, it is important to examine environmental attitudes comparatively in different countries.

In this study, we examined the social determinants of environmental attitudes in Portugal and Spain. With a long-lasting shared geographical and historical heritage (Brand 2022), Portugal and Spain are similar in terms of individualism, with both displaying this at high levels (Toubes, del Junco, and Abe 2019). However, some differences between Portugal and Spain may importantly influence their residents' environmental attitudes. For instance, Spain has historically had higher GDP per capita, but also higher unemployment rates (Raimundo and Mestres n.d.; Royo and Manuel 2004). Particularly after the 1970s, the two countries' paths to democracy have diverged, where Portugal had a contentious period of cultural and hierarchical reform, while Spain took a consensus-oriented approach. With this, the two countries' educational models differed significantly, with Portugal emphasizing a non-hierarchical, student-centered education, and providing a higher investment in education, while Spain emphasized adherence to a centrally designed curriculum, maintaining, all the while, a hierarchical and content-centered approach (Fishman and Lizardo 2013). Despite sharing the Iberian Peninsula, Portugal and Spain have had distinct historical and geopolitical trajectories (Ratten 2022), leading to stark differences and unique cultural identities. There are also differences in their in environmental policy, with Portugal having a strong focus on renewable energy (Guerreiro, Jörgens, and Alves 2022), while Spain struggled to integrate its environmental policy and opting instead for a more balanced approach between economic growth and environmental regulation (López-Novo and Morata 2019). Portugal has experienced a growing pro-environmentalist movement despite being socially and economically behind the European average (Queirós 2016), whereas Spain's environmentally friendly attitudes and behaviors have remained below the European average despite its steady economic growth (Sánchez, López-Mosquera, and Lera-López 2016). These differences in culture and environmental policies, especially in recent history, create an interesting case for exploring cross-cultural differences in environmental attitudes in Portugal and Spain.

The widely used experimental and online survey methods in the field of environmental attitudes fail to capture the complexity of real-world consumer behavior, which raises issues with ecological validity and limits the generalizability of the findings to actual consumption environments (East 2016). To counteract this problem, there has been an increase in so-called "store laboratory" research, conducted in lab settings that were designed as shopping locations, which has shown promising results such as the case of Hall and colleagues (2021) who successfully studied the impact of nutrition policies on purchasing behaviors at point-of-sale, indicating the need for more field experiments. To capture the consumers' behaviors in a natural setting, where they already are in a consumption mindset, this study was conducted in the field, focusing on three different types of shopping locations: namely, touristic markets, neighborhood markets, and shopping centers.

This study examined the social determinants of environmental attitudes using an ecological, cross-cultural approach that compared consumers in Portugal to Spain. We hypothesized that (H1) Consumers' perceptions of their close social circles' environmental attitudes will be positively associated with their own environmental attitudes, and (H2) Consumers' environmental attitudes will be different across countries, with residents of Portugal having more pro-environmental attitudes as compared to residents of Spain. In addition, we explored whether the socio-demographic characteristics found to impact people's environmental attitudes in previous research would be significant predictors in our sample as well, and, if so, how those characteristics would interact with the effects examined in H1 and H2; namely, social circle's perceived environmental attitudes and country of residence.

Method

Participants

Following a field work paradigm, participants were recruited by non-probabilistic, convenience sampling, at one of three shopping location types in Portugal (N = 73), in the city of Porto, and Spain (N = 71), in the city of Barcelona, region of Catalonia. Consumers in the three chosen shopping locations were approached to ask if they would like to take part in a research study on environmental attitudes and shopping habits. All participants signed an Informed Consent form before taking part in the study, which was approved by the Ethics and Research Committee of the Faculty of Psychology, Education, and Sports Sciences Blanquerna, Ramon Llull University (approval reference: 2324008D, date: May 1, 2024).Detailed sample characteristics can be found in Table 1, which showed that the Portugal and Spain samples were not significantly different from each other in terms of age, gender, household composition, comfort with income, education level and political orientation (all p's > .05).

Procedure

In this study, participants were asked to fill out an online Qualtrics survey asking them of their and their close social circle's environmental attitudes, and several factors regarding their identity and socioeconomic status. The shopping locations were chosen based on three types which can be found in both Porto and Barcelona. The chosen shopping locations were (i)

Touristic markets: In Barcelona the Boquéria market was chosen, while in Porto the Bolhão market was chosen. Both marketplaces are frequented mostly by tourists and it was expected that at least some of the respondents recruited in these locations were non-natives.

Neighborhood markets: In Barcelona the Sant Gervasi/El Putxet market was chosen, while in Porto the Matosinhos market was chosen. Both markets had a focus on the sale of fresh meat and fish, both held restaurants and cafés. The Matosinhos market did, however, present a slightly different business model, as some of the restaurants present at the location focused on the products sold there, while the Sant Gervasi market did not present such a business model, and focused mostly on selling groceries. Both markets are, however, mostly frequented by locals of the area.

Shopping centers: In Barcelona the shopping center chosen was the Arenas de Barcelona shopping center, while in Porto Norteshopping was chosen. These locations shared similar layouts and similar stores. Both locations had clothing stores, a cinema, a supermarket, and a food court, and both had easy access to public transportation.

To measure the participants' environmental attitudes, we used the short 36-item version of the Environmental Attitudes Inventory, (EAI-36), which was validated for the Portuguese population by Domingues and Gonçalves (2020) applied to the entire sample. This version of the questionnaire was translated into Spanish by IC (see Supplementary Table 3). This scale has two sub-scales, preservation and utilization, with some example items being "I believe that the environment has been severely abused by humans." and "I believe humans were created to evolve to dominate the rest of nature.", respectively. The Preservation subscale had 23 items, whereas the utilization scale had 11 items. Each scale had a possible score between 0 and 7, as the score was given by the mean score of subscale items. Reverse coded items were inverted ($item\ score = 0 - item\ score$).

To measure the participants' perceptions of their close social circle's environmental attitudes, a new adaptation of the EAI was created, which we will call the Social Environmental Attitudes Inventory (EAI_s) here (see Supplementary Table 2). This 12-item version used the highest factor loading item of each of the 12 first order factors from the original EAI (Milfont and Duckitt 2010). The items were shifted into the third plural person (e.g., "(my close friends and family)...think the question of the environment is secondary to economic growth."), and the participants were asked to answer each item based on their perception of their close friends' and family's environmental attitudes.

In addition, the survey asked participants a range of demographics questions, namely their age, gender, household composition, comfort with income, and education level. The answer options for the last 4 demographics questions can be found in Table 1. The political orientation was also measured. To measure the political orientation three questions were posed to participants to ascertain three corresponding dimensions: equality of outcome vs equality of opportunity, government intervention vs individual autonomy, economic redistribution vs free market capitalism. The inclusion of these three dimensions is supported by political science and psychology literature (Elordi 2000; Feldman 1988; Hartwich and Becker 2023). Equality of opportunity refers to ensuring a fair starting point for all members of a society, whereas equality of outcome involves minimizing disparities in results (Elordi 2000). Government interventionism represents support for active state involvement in addressing social issues, while individual autonomy emphasizes personal responsibility while minimizing government involvement (Feldman 1988). Redistribution involves favoring a state-led correction of economic inequality, contrasting with the free-market capitalism approach, which values competitive markets and limited regulation (Hartwich and Becker 2023). The results of each dimension were marked, with a left-wing choice being marked as -1, a centrist choice being marked as 0, and a right-wing choice being marked as 1. The three dimensions were then averaged to gather a composite political orientation score. The Political Orientation instrument is provided in Supplementary Materials.

Table 1

Disambiguation of sample sociodemographic details

Variable	Portugal (n = 71)		Spain (n = 73)		Overall (n = 144)		Significance (α = 95%)
	Mean (*SD*)	Range	Mean (*SD*)	Range	Mean (*SD*)	Range	
Age	41.00 (12.20)	19-77	44.24 (14.92)	20-79	42.60 (14.60)	19-79	W = 2030, p = 0.22
Political Orientation Score	0.05 (0.56)		0.08 (0.53)		0.07 (0.54)		W = 2399, p = 0.72
Gender (%)							
Male / Female / Other	39.44 / 57.75 / 2.82	-	49.32 / 47.95 / 1.37	-	44.44 / 52.78 / 2.08	-	$\chi2(2)$ = 2.78, p=0.43
Missing	0.00	-	1.37	-	0.69	-	
Household composition (%)							
Living with partner and children	19.72	-	24.66	-	22.22	-	$\chi2(4)$ = 4.93, p=0.42
Living with partner and no children	35.21	-	27.40	-	31.25	-	
Living with Parents and/or siblings	21.13	-	15.07	-	18.06	-	

Living with siblings or other relatives	4.23	-	8.22	-	6.25	-	
Living alone	8.45	-	16.44	-	12.50	-	
Missing	11.27	-	8.22	-	9.72	-	
Comfort with Income (%)							
Comfortable	54.93	-	49.32	-	52.08	-	$\chi2(2) = 2.18$, $p=0.54$
Pays expenses	33.80	-	42.47	-	38.19	-	
Hardship	8.45	-	4.11	-	6.25	-	
Missing	2.82	-	4.11	-	3.47	-	
Education level (%)							
Higher Education degree / Up to secondary or vocational education	61.97 / 36.62	-	67.12 / 31.51	-	64.58 / 34.03	-	$\chi2(1) = 2.18$, $p=0.81$
Missing	1.41	-	1.37	-	1.39	-	

Statistical Analysis

Data was analyzed using IBM® Statistical Package for Social Sciences (SPSS, version 29.0.0.0 (241)) (Windows, IBM, Armonk, NY, USA) and R version 4.4.1 (2024-06-14).

Due to the small sample size, it was not possible to proceed with Confirmatory Factor Analysis, therefore, Exploratory Factor Analysis (EFA) was conducted to verify the structure of both the EAI, and the EAIs. Varimax rotation was applied. Both instruments demonstrated suitability for factor analysis, with Bartlett's test indicating that both correlation matrices were significantly different from an identity matrix (p's < 0.001). The EAI demonstrated a Kaiser-Meyer-Olkin (KMO) measure of 0.79 overall, indicating good adequacy. While most items showed a KMO value larger than 0.60, one item showed a KMO value of 0.59, but had good internal consistency, along with the original structure reported on the instrument, so we decided to keep the item. The EAIs showed a KMO measure of middling accuracy, at 0.73.

Although most items displayed individual KMO values larger than 0.60, one showed a value of 0.58. Again, due to the conceptual importance of the item and overall reliability score (preservation = 0.79, utilization = 0.63), we decided to keep this item. It is recommended that future studies replicate this paradigm with a larger sample to conduct either Multi-Group EFA or Confirmatory Factor Analysis, to verify the cross-sample validity of the instrument.

Data was analyzed using Bayesian Mixed Model Regressions. Bayesian models were chosen for their suitability in addressing the constraints of small sample sizes by incorporating prior knowledge, helping to stabilize estimates (Rognli et al. 2023; Smid and Winter 2020). Bayesian models also avoid relying solely on the binary interpretations of frequentist methods, since they provide full posterior distributions of model parameters, and allow for the reporting of credible intervals (*CI*), as well as posterior probabilities (P), which are more intuitive and informative for decision-making. To examine the effect of the social circle's environmental attitudes on the participants' own attitudes (H1), two sets of models were constructed, one with each of EAI's sub-scales –preservation and utilization scores— as the outcome variable. The basic models included age, gender, country, education, comfort with income, household composition and pet ownership as predictor variables. The hypothesis testing models additionally included the social circle's preservation or utilization scores as predictor variables. The basic and hypothesis testing models were compared using the Bayes Factor (BF) along with Leave One Out Cross-Validation (LOOC), based on expected log predictive density (*ELPD*), a measure of how well the model would be expected to predict new, unseen data, by leaving out one observation at a time, fitting the model to the rest of the data, and then calculating how well the model predicts the left-out observation, the logarithm of the predictive density is calculated after doing this for each observation, a higher *ELPD* means a model with less expected error in prediction. In addition, we ran exploratory models with significant variables from the hypothesis testing models to examine if there were any interactions among them. To examine cross-country comparisons (H2) two models were constructed, one with each of EAI's sub-scales –preservation and utilization scores— as the outcome variable. In both models, the binary variable of country (Portugal vs Spain) was included in interaction with the variables found to have a significant effect in the H1 models. For all models, weakly informative priors were added for fixed effects. No random effects were added. The R package BRMS was used to compute Bayesian models, with package Posterior being used to calculate posterior probabilities for each model. The variables included in each model are described in Table 2.

Table 2

Description of Bayesian models

Basic Model	Dependent variable	Independent variables
	Preservation score Utilization score	Age, Gender, Political orientation, Household composition, Education, Comfort with Income and Country
Hypothesis testing models	Dependent variable	Independent variables
	Preservation score	Same as the basic model + Perception of Social Circle's Preservation Score
	Utilization score	Same as the basic model + Perception of Social Circle's Utilization Score
Interaction effects model	Dependent variables	Independent variables
	Preservation score	Significant predictors of one's own preservation score: Social Circle's Perceived Preservation Attitude, political orientation, gender, and education level; and interaction effects between them
	Utilization score	Significant predictors of one's own utilization score: Social Circle's Perceived Utilization Attitude, Gender; and interaction effects between them.
Cross-cultural effects model	Dependent variables	Independent variables
	Preservation score	Significant predictors of one's own preservation score: Social Circle's

		Perceived Preservation Attitude, political orientation, gender, and education level; and country and interaction effects between them
	Utilization score	Significant predictors of one's own utilization score: Social Circle's Perceived Utilization Attitude, Gender; and country and interaction effects between them

Results

Hypothesis 1 Analyses: The effect of the social circle's perceived environmental attitudes on consumers' own environmental attitudes

Preservation models

The basic model for Preservation attitudes revealed a significant negative effect of political orientation (β = -0.27, 95% *CI* [-0.47, -0.07], *P*(<0) = 0.99), indicating that individuals with more right-wing political opinions exhibited lower preservation attitudes. Gender (β = -0.43, 95% *CI* [-0.45, -0.02], *P(*<0) = 0.99) and education level (β = -0.24, 95% *CI* [-0.47, -0.02], *P(*<0) = 0.98) significantly predicted lower preservation attitudes, with people identifying as male and people with a university degree being more likely to exhibit low preservation attitudes. Despite showing a non-significant effect (P < 0.95), consumers in shopping centers had a trend towards more positive preservationist attitudes compared to consumers in the touristic or neighborhood markets. Other predictors, i.e., age, comfort with income, household composition and pet ownership, did not have any significant effects (P<0.95).

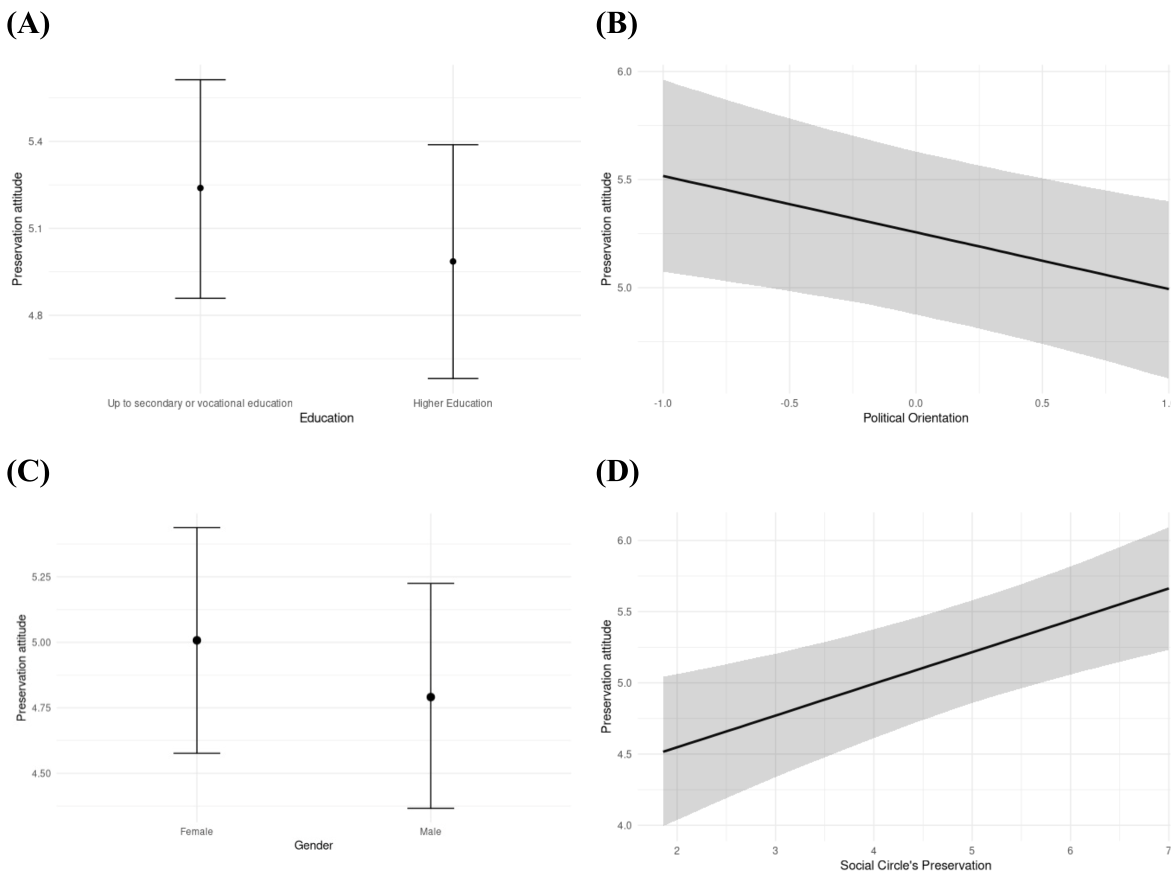
In the hypothesis model, the inclusion of the social circle's preservation attitudes improved model performance (BF = 52.48). The social circle's preservation attitudes were found to be a significant predictor of participants' own preservation attitude (β = 0.21, 95% *CI* [0.09, 0.32], *P(*>0) = 1.00), which confirms our Hypothesis-1 that those with more environmentally conscious social circles tend to have a higher preservation attitude. Political orientation (β = -0.29, 95% *CI* [-0.49, -0.1], *P(*<0) = 0.99), gender (β = -0.22, 95% CI [-0.42,

-0.01], *P(*<0) = 0.98) and education (β = -0.21, 95% *CI* [-0.43, -0.01], *P(*<0) = 0.96) remained significant predictors, while all other predictors remained insignificant (P< 0.95).

Our exploratory model examining the interaction effects between social circle's pro-preservation attitudes and political orientation, gender, and education did not reveal any significant effects (P< 0.95).

Figure 1

Significant effects in preservation models



Note. **(A)** Effect of education on preservation attitude, showing those with a higher education degree have a higher preservation score. **(B)** Effect of political orientation on preservation attitude, showing those with a more right leaning (higher) political score tend to have lower preservation attitudes. **(C)** Effect of gender on preservation attitude, showing that females tend to be more preservationist than males. **(D)** Effect of the social circle's perceived preservation attitude on one's own preservation attitude, showing that people with a social circle perceives as more preservationist tend to be more preservationist themselves.

Utilization models

The basic model for utilization attitudes the effect of one's age was insignificant by a slight margin, (β = 0.005, 95% *CI* [-0.003, 0.01], *P(*>0) = 0.93), with older people displaying more pro-utilization attitudes. No other variables were found to be significant (P<0.95).

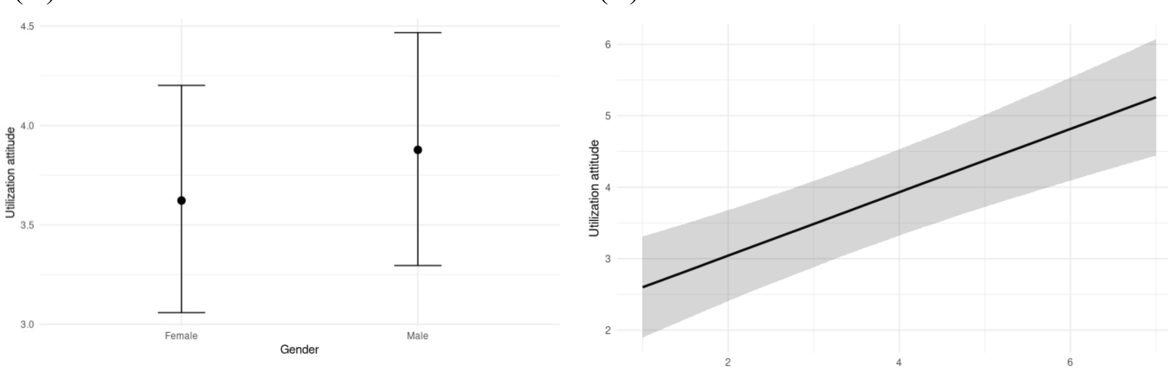
The hypothesis testing model significantly outperformed the basic model (Bayes factor = 52.48). The social circle's utilization was found to be a strong positive predictor of the participants' own utilization attitudes (β = 0.42, 95% *CI* [0.27, 0.57], *P(*>0) = 1.00), which confirms our Hypothesis 1 that individuals who have a social circle with high utilization attitudes are more likely to adopt similar attitudes. Gender was a significant predictor (β = 0.28, 95% *CI* [-0.06, 0.62], *P(*>0) = 0.95), with males being more pro-utilization. No other predictors were significant (P<0.95).

Our exploratory model examining the interaction effects between social circle's pro-utilization attitudes and gender did not reveal any significant effects (*P*< 0.95).

Figure 2

Significant effects in utilization models

(A) (B)



Note. **(A)** Effect of gender on utilization attitude, showing that males tend to have higher utilization attitude scores. **(B)** Effect of the social circle's perceived utilization attitude on one's own utilization attitude, showing that people with a social circle perceived as more utilizationist tend to have higher utilization attitude scores.

Model comparisons

The hypothesis testing models were superior to the basic models, as indicated by their higher BFs and LOOC-Validation scores (*ELPD*) favoring the Hypothesis models (preservation model *BF* = 52.48, *ELPD* = -5.9 (*SE*= 5.0); utilization model *BF* = 52.48, *ELPD* = -13.2 (*SE* = 7.0)).

Hypothesis 2 Analyses: The moderation effect of country on the social determinants of consumers' own environmental attitudes

Preservation

A cross-cultural model for preservation attitudes showed no cross-cultural effects (β = 0.01, 95% *CI* [-0.80, 0.87], *P(*<0) = 0.51). However, the social circle's preservation attitudes showed consistent effect across both countries (β = 0.27, 95% *CI* [-0.05, 0.59], *P(*>0) = 0.95). Interaction effects between the country and political orientation, gender, and education were also included in this model but did not reveal any significant effects (P< 0.95).

Utilization

For the utilization attitudes, the social circle's utilization attitudes showed stable effects across countries (β = 0.41, 95% *CI* [0.024, 0.84], *P(*>0) = 0.96). Again, the country of residence showed no effects (β = 0.21, 95% *CI* [-0.65, 1.06], *P(*<0) = 0.69). Interaction effects between the country and gender were also included in this model but did not reveal any significant effects (P< 0.95).

Discussion

The present study revealed insights into the social determinants of environmental attitudes. Our first hypothesis—that one's close social circle influences individual environmental attitudes—was supported, with perceived social circle attitudes emerging as a strong predictor of consumers' own environmental attitudes in both Portugal and Spain.

Political orientation, gender, and education were also found to be significant predictors: right-leaning individuals, those with higher education degrees, and men had lower preservation scores than their left-leaning, less formally educated, and female counterparts. Additionally, men were found to have higher utilization scores than women. This paper introduces, as well, a novel adaptation of the EAI, the EAIs, an instrument meant to measure perception of individuals regarding their social circle's environmental attitudes. This is an important innovation as people's perceptions of their close social circle guide are at the inception of their conception of social norms (Bicchieri 2005).

As discussed previously, social groupings can often define the behavior of their constituents, as can be understood by frameworks like the Social Identity Theory (Nelson 2015; Tajfel 1978) and Social Norms theory (Dunbar 2021). Both the dynamics of our own social in-group, which many times constitute those within our own close social circle, and the intergroup dynamics with our identified out-groups create stimuli for our decision making and our adoption of new attitudes and behaviors (Belavadi and Hogg 2021; Dunbar 2021; Jans and Fielding 2018; Tajfel 1978). As such our results fall quite in line with what was previously established in literature by, now, demonstrating that the social circle influences our environmental attitudes. We add to the few studies that have demonstrated the effect of the social circle in the adoption of pro-environmentalism, such as those conducted by Huang and colleagues (2024) and Goldstein and colleagues (2008). Our findings also help to show that this effect might not be country dependent, which could be widely applicable in international social marketing initiatives for sustainable consumption.

Similarly, our results fall in line with established literature when it comes to the effect of gender, as shown by Phillips and Englis (2022) and Idalgo-Crespo and colleagues (2022), as our results demonstrate that women tend to have higher preservation attitudes and lower utilization attitudes than men. Our results go along with established literature in demonstrating that people holding more left-leaning ideas hold more preservationist attitudes than those holding right-wing views, as was previously shown by Neumayer (2004).

Despite our results agreeing in large part with established literature, there were also divergences, as previous studies had shown a higher education degree to be a predictor of pro-environmental behavior, as shown by Liobikienė and Poškus (2019) and Rajapaksa and colleagues (2018), with this effect being largely attributed to the critical thinking skills gained during this education period. Our results conflict with those previously presented, showing that people with a higher education degree are less preservationist. It is difficult to speculate as to the reasons for this effect. A cross-cultural study focused on investigating this phenomenon would be necessary to provide any definitive answers. But it could be that parasitic variables like the comparatively lower income of Portuguese and Spanish populations within Europe, or the structure and frequency of engagement with sustainability-related topics could be responsible for this effect.

Our results also contradict established literature which showed the positive effect of effect of different household compositions and sizes on pro-environmentalism, like that of (Collins 2015) showing that the presence of children or adolescents in the household could exert pressure towards the adoption of pro-environmental behavior. In fact, in our sample, household composition showed no effects on either preservation or utilization attitudes. More studies are required to confirm our findings, given our relatively well balanced and transcultural sample. Our results also contradict established literature regarding the effect of age on preservation and utilization attitudes, as shown by several studies in the past decade (Anderson and Krettenauer 2021; Duron-Ramos et al. 2020; Krettenauer 2017; Yan Wang et al. 2021). This can't be said to be an event hailing from a cultural effect, as Wang and colleagues' (Y Wang, Hao, and Liu 2021) study demonstrated this effect across several different cultures throughout different countries. It is possible that our lack of effect could be due to an urban sampling bias, or possibly due to the convergence of cohorts across age groups with shared exposure to factors like environmental crises. Our results add to a disparate literature with regards to income, as authors like Akram and colleagues (2023) and Ferreira and Santana (2021) conflict when discussing how income impacts environmental attitudes, while some point to a negative correlation between income and pro-environmentalism, others point to the near-unsurmountable barriers faced by lower-income individuals in the adoption of sustainable behavioral patterns. Our lack of significant effects from income largely reflect this disparate pattern in literature.

These results seem to indicate the importance of the social circle in the formation of pro-environmental attitudes. This importance could be leveraged for impactful interventions, aimed at maximizing its effect. We suggest that future interventions regarding sustainability and sustainable development could function in a bring-your-friends-and-family style. The effect of social pressure has already been shown by studies such as Huang and colleagues' (2024) with people adopting behaviors due to the pressure of their social circle or social in-group, such as a neighborhood adopting them first. This is amply explained by Bicchieri's (2005) social norms theory, which details how others' behavior in society guides our own choices. In fact, these interventions have already been applied before, for example by Severijns and colleagues (2024) who compared individual vs social participation in a 30-day sustainable diet challenge. The results of Severijns' study demonstrated that while both groups enjoyed a reduction in animal product intake over the course of the program, a 3 month follow-up showed while the group which was encouraged to involve their friends and family had maintained their habits and were eating significantly less meat, the group which ran the challenge individually had largely regressed. Involvement of the social circle in sustainability education initiatives, therefore, promotes long-lasting habits, and, as our results show, the adoption of pro-environmental attitudes by someone within the social circle promotes this adoption throughout the group.

Similarly, impactful campaigns may encourage highly pro-environmental individuals to speak up within their social groups and demonstrate pro-environmental behavior in an active way. Research has shown that encouraging individuals to visibly model green behaviors and speak up within their social group have proven successful in influencing both descriptive and injunctive norms. Examples of this include Burn's (1991) study which engaged neighbor to neighbor outreach, or even Bollinger and Gillingham's (2020) use of local ambassadors to promote solar adoption, which led to measurable improvements.

Gender was found to be a significant predictor of both preservation and utilization attitudes. This means that gender significantly impacts both the perception and engagement with the natural environment and trend towards the use of the resources it provides. Men tend to be less prone to the protection of the environment and tend to more often use natural resources without concern for impact in terms of sustainability. This is largely consistent with literature, where studies such as Idalgo-Crespo and colleagues' (2022) and Ivković and Mandić's (2024) had already shown and analyzed women's tendency towards sustainability. Xia and Li (2023) have hypothesized that this may be function of societal norms and gender roles, however, showing that each gender engages with pro-environmentalism in a different way, with men being more overt and engaging with it in public spaces, while women engage within a more private sphere. It must, however, be stated that our sample, especially for Portugal, had less men than women, which could have impacted the results.

While null cross-cultural effects were found, this does not mean that cultural and national effects do not influence environmental attitudes. In fact, wider studies focusing on larger regions could show that cross-national effects do exist, this has been the example of Guerreiro and colleagues (2022) and López-Novo and Morata (2019) who have shown these differences at European level. The lack of cross-cultural effects could be explained by both cultures showing a high level of individualism when compared to the rest of Europe as shown by (Toubes et al. 2019). The shared culture between the two Iberian nations may also overshadow the differences between the two countries. Studies could be drawn up focusing on Western nations, the Global North, and it could even be useful to compare between the Global North and the Global South. Additional considerations for future research are to recruit beyond urban samples to improve diversity and ability to detect subtle effects.

Some limitations can be pointed out in this study. The political orientation instrument, while based on literature, needs to be validated. It could be useful as well to understand the relationship between environmental attitudes and the dimensions of political orientation which are not represented in this study, like the authoritarian and libertarian dimensions represented within the political compass model of political orientation (Lester 1994). The way in which the household composition was collected does not directly account for household size; future studies may account for household size and age, as these were pointed at in literature as being predictors of pro-environmental behaviors (Huang et al. 2024).

This research has yielded positive results which could be translated into further research in the marketing, psychology, and political science arenas. Some of the knowledge gained could be directly applied in new social marketing campaigns, with high potential to yield positive results in the sustainable development field.

Conclusion

Using a field-based approach across shopping locations in Portugal and Spain, this study explored the social predictors of environmental attitudes. We found individuals who perceive their close social circle as pro-environmental tend to adopt stronger preservationist attitudes themselves. Gender, political orientation, and education also showed to shape environmental views, with women and left-leaning individuals reporting more pro-environmental attitudes, while men, right-wing leaning individuals, and those with higher education degrees tending to be less preservationist. These findings highlight social influence as a powerful engine in shaping environmental attitudes and by extension pro-environmental behaviors, independently from national context. We propose leveraging this effect in social marketing by encouraging visible, vocal pro-environmental behavior withing peer-groups to shift social norms and promote lasting sustainable habits.

References

Akram, Farheen, Abid Rashid Gill, Muhammad Abrar ul Haq, Afrasiyab Arshad, and Hafiz Abid Mahmood Malik (2023), "Barriers to Enduring Pro-Environmental Habits among Urban Residents," *Applied Sciences*, 13(4), 2497.

Allcott, Hunt (2011), "Social Norms and Energy Conservation," *Journal of Public Economics*, 95(9–10), 1082–95.

Anderson, D J and T Krettenauer (2021), "Connectedness to Nature and Pro-Environmental Behaviour from Early Adolescence to Adulthood: A Comparison of Urban and Rural Canada," *Sustainability (Switzerland)*, 13(7), https://www.scopus.com/inward/record.uri?eid=2-s2.0-85103838677&doi=10.3390%2fsu13073655&partnerID=40&md5=146fcc505f9ddd0fcec57b33e9fe7330.

Belavadi, S and M A Hogg (2021), "Social Identity and Intergroup Competition," in *The Oxford Handbook of the Psychology of Competition*, Oxford University Press, 476–95, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85194993750&partnerID=40&md5=78587b125c49d36accc2e56dc401e084.

Bicchieri, Cristina (2005), *The Grammar of Society*, Cambridge University Press.

Brand, J P (2022), "The Beginnings of Psychological Assessment in Spain and Portugal," in *International Histories of Psychological Assessment*, Cambridge University Press, 134–50, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85193346240&doi=10.1017%2f9781108755078.009&partnerID=40&md5=dd6afecefcd85dd8943fc2645c24f902.

Burn, Shawn M. (1991), "Social Psychology and the Stimulation of Recycling Behaviors: The Block Leader Approach," *Journal of Applied Social Psychology*, 21(8), 611–29.

Collado, S, H Staats, and P Sancho (2019), "Normative Influences on Adolescents' Self-Reported Pro-Environmental Behaviors: The Role of Parents and Friends," *Environment and Behavior*, 51(3), 288–314, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85041303921&doi=10.1177%2f0013916517744591&partnerID=40&md5=d0c1047f2dbf8d1b94656f8ecf6ac761.

Collins, R (2015), "Keeping It in the Family? Re-Focusing Household Sustainability," *Geoforum*, 60, 22–32, https://www.scopus.com/inward/record.uri?eid=2-s2.0-84928583857&doi=10.1016%2fj.geoforum.2015.01.006&partnerID=40&md5=96e41423cedae6467c868ddbb3110bce.

Deutchman, Paul (2023), "People Update Their Injunctive Norm Beliefs and Moral Judgements after Receiving Descriptive Norm Information."

Domingues, Rita B. and Gabriela Gonçalves (2020), "Assessing Environmental Attitudes in Portugal Using a New Short Version of the Environmental Attitudes Inventory," *Current Psychology*, 39(2), 629–39.

Dunbar, Robin (2021), *Friends : Understanding the Power of Our Most Important Relationships*, London: Little Brown.

Duron-Ramos, M F, S Collado, F I García-Vázquez, and M Bello-Echeverria (2020), "The Role of Urban/Rural Environments on Mexican Children's Connection to Nature and Pro-Environmental Behavior," *Frontiers in Psychology*, 11, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85083065010&doi=10.3389%2ffpsyg.2020.00514&partnerID=40&md5=9076a0bb767d58102e70f74374b44cc5.

East, R (2016), "Bias in the Evaluation of Research Methods," *Marketing Theory*, 16(2), 219–31, https://www.scopus.com/inward/record.uri?eid=2-s2.0-84968571759&doi=10.1177%2f1470593115609797&partnerID=40&md5=95505c115fdd54d45305109cb0e2fcc2.

Ejelöv, Emma, Magnus Bergquist, André Hansla, and Andreas Nilsson (2022), "Why Are They Eco-Friendly? Attributing Eco-Friendly Descriptive Norms to Intrinsic Motivation Increases pro-Environmental Purchase Intention," *PLOS ONE*, 17(10), e0265839.

Elordi, Carlos (2000), "Ideology, Assessing Its Impact and Political Choices," *Public Perspective*, 34–36, https://ropercenter.cornell.edu/sites/default/files/2018-07/112034.pdf.

Feldman, Stanley (1988), “Structure and Consistency in Public Opinion: The Role of Core Beliefs and Values,” *American Journal of Political Science*, 32(2), 416.

Ferreira, Maria Augusta and Suely Santana (2021), “LOW-INCOME PEOPLE AND PRO-ENVIRONMENTAL BEHAVIOR: BEYOND MONEY ISSUES, A LITERATURE REVIEW,” *Millenium: Journal of Education, Technologies, and Health*, 2021(14), 71–78.

Fishman, Robert M. and Omar Lizardo (2013), “How Macro-Historical Change Shapes Cultural Taste,” *American Sociological Review*, 78(2), 213–39.

Gillingham, Kenneth and Bryan Bollinger (2020), “Social Learning and Solar Photovoltaic Adoption,” *SSRN Electronic Journal*, https://papers.ssrn.com/abstract=3500930.

Goldstein, Noah J., Robert B. Cialdini, and Vladas Griskevicius (2008), “A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels,” *Journal of Consumer Research*, 35(3), 472–82.

Guerreiro, Luís, Helge Jörgens, and Vicente Alves (2022), “Energy Governance in Portugal,” in *Handbook of Energy Governance in Europe*, Cham: Springer International Publishing, 959–91.

Hall, M G, I C A Higgins, A H Grummon, A J Lazard, C E Prestemon, J Mendel Sheldon, and L S Taillie (2021), “Using a Naturalistic Store Laboratory for Clinical Trials of Point-of-Sale Nutrition Policies and Interventions: A Feasibility and Validation Study,” *International Journal of Environmental Research and Public Health*, 18(16), https://www.scopus.com/inward/record.uri?eid=2-s2.0-85113178250&doi=10.3390%2fijerph18168764&partnerID=40&md5=7d1944a11a0c4749a629464d459e9f01.

Han, Gun-Soo (2023), “Relationships between Outdoor Recreation-Associated Flow, Pro-Environmental Attitude, and Pro-Environmental Behavioral Intention,” *Sustainability*, 15(13), 10581.

Hartwich, Lea and Julia C. Becker (2023), “The Role of Ideological and Intergroup Mechanisms in Predicting Opposition to Redistribution and Discrimination Against the Lower Social Class,” *Journal of Social and Political Psychology*, 11(1), 167–81.

He, L and V Filimonau (2020), “The Effect of National Culture on Pro-Environmental Behavioural Intentions of Tourists in the UK and China,” *Tourism Management Perspectives*, 35, https://www.scopus.com/inward/record.uri?eid=2-s2.0-

85087111797&doi=10.1016%2fj.tmp.2020.100716&partnerID=40&md5=10f74d0feb37cb48b72cf15de7a95370.

Huang, J, W Li, X Cheng, and K Cui (2024), "What's the Difference between Factors Influencing Household Waste Management and Energy-Saving Behavior? A Meta-Analysis," *Management of Environmental Quality*, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85199149497&doi=10.1108%2fMEQ-03-2024-0103&partnerID=40&md5=2a910aafeb70304d51602c0b3806edcd.

Idalgo-Crespo, J, F Benítez-Troya, J L Amaya-Rivas, M Soto, A F Terán-Alvarado, and A Hidalgo-Crespo (2022), "Does Gender Influence a Person's Environmental Concern and pro-Environmental Behaviours?," in *Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology*, ed. Larrondo Petrie M M, J Texier, A Pena, and J A S Viloria, Latin American and Caribbean Consortium of Engineering Institutions, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85140011558&doi=10.18687%2fLACCEI2022.1.1.673&partnerID=40&md5=5d1f6f36f012a50580ddeecbbd43cd48.

Ivković, D and A Mandić (2024), "Psychological and Socio-Demographic Drivers of pro-Environmental Behaviour in Generation Z," in *Tourism in a VUCA World: Managing the Future of Tourism*, Emerald Publishing, 119–41, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85200113289&doi=10.1108%2f978-1-83753-674-020241009&partnerID=40&md5=55384fd0715ca5ced3a893de0ef7ce85.

Jans, L and K Fielding (2018), "The Role of Group Processes in Environmental Issues, Attitudes, and Behaviours," in *Environmental Psychology: An Introduction*, wiley, 228–37, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85084755072&doi=10.1002%2f9781119241072.ch23&partnerID=40&md5=45a222c42449b929f6ad6bf9da6d1cc5.

Krettenauer, T (2017), "Pro-Environmental Behavior and Adolescent Moral Development," *Journal of Research on Adolescence*, 27(3), 581–93, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85008512144&doi=10.1111%2fjora.12300&partnerID=40&md5=cca3cbc8e8cfccf91c58713205b986ae.

Legros, Sophie and Beniamino Cislaghi (2020), “Mapping the Social-Norms Literature: An Overview of Reviews,” *Perspectives on Psychological Science*, 15(1), 62–80.

Lester, J. C. (1994), “The Evolution of the Political Compass (and Why Libertarianism Is Not Right-Wing),” *Journal of Social and Evolutionary Systems*, 17(3), 231–41.

Liobikienė, Genovaitė and Mykolas Simas Poškus (2019), “The Importance of Environmental Knowledge for Private and Public Sphere Pro-Environmental Behavior: Modifying the Value-Belief-Norm Theory,” *Sustainability*, 11(12), 3324.

López-Novo, Joaquín and Francesc Morata (2019), “The Implementation of IEAs in Spain: From National Energy Considerations to EU Environmental Constraints.,” in *International Environmental Agreements and Domestic Politics*, Routledge, 313–40.

Lou, X and L M W Li (2022), “The Mediating Role of Self-Enhancement Value on the Relationship of Power Distance and Individualism with Pro-Environmental Attitudes: Evidence from Multilevel Mediation Analysis with 52 Societies,” *Cross-Cultural Research*, 56(5), 445–66, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85130569299&doi=10.1177%2f10693971221093122&partnerID=40&md5=5267ceae057fe7e4aa15317088efac9d.

Milfont, Taciano L. (2010), “The Psychological Meaning of Preservation and Utilization Attitudes: A Study Using the Natural Semantic Network Technique,” *Psyecology*, 1(1), 123–36.

Milfont, Taciano L. and John Duckitt (2010), “The Environmental Attitudes Inventory: A Valid and Reliable Measure to Assess the Structure of Environmental Attitudes,” *Journal of Environmental Psychology*, 30(1), 80–94.

Morren, Meike and Amir Grinstein (2016), “Explaining Environmental Behavior across Borders: A Meta-Analysis,” *Journal of Environmental Psychology*, 47, 91–106.

Nakai, Ryo (2024), “Nationalism and Environmentalism from the Global Perspective: A Comparative Survey Analysis of Eco-nationalism,” *Nations and Nationalism*.

Nelson, B R (2015), *New Developments in Social Identity Research*, New Developments in Social Identity Research, Nova Science Publishers, Inc., https://www.scopus.com/inward/record.uri?eid=2-s2.0-84956501859&partnerID=40&md5=faaa0a2307f418a1db342ccfa23934a3.

Neumayer, Eric (2004), “The Environment, Left-Wing Political Orientation and Ecological Economics,” *Ecological Economics*, 51(3–4), 167–75.

Olufemi, T D (2012), “Theories of Attitudes,” in *Psychology of Attitudes*, Nova Science Publishers, Inc., 61–78, https://www.scopus.com/inward/record.uri?eid=2-s2.0-84892069474&partnerID=40&md5=07934921c943b60255bea0826836eb05.

Perry, L R, T P Moorhouse, K Jacobsen, A J Loveridge, and D W Macdonald (2022), “More than a Feeling: Cognitive Beliefs and Positive—but Not Negative—Affect Predict Overall Attitudes toward Predators,” *Conservation Science and Practice*, 4(2), https://www.scopus.com/inward/record.uri?eid=2-s2.0-85122327404&doi=10.1111%2fcsp2.584&partnerID=40&md5=f3014689a7b4533df8d779f157aacb7a.

Phillips, D M and B G Englis (2022), “Green Consumption Is Both Feminine and Masculine—Just Ask the Androgynous Consumer,” *Journal of Consumer Behaviour*, 21(5), 1028–39, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85127674955&doi=10.1002%2fcb.2052&partnerID=40&md5=4ebedc1d9fed10ad574cab60c06fe2a5.

Raimundo, António and Laia Mestres “Iberia: Spain and Portugal,” in *Europe’s Brexit*, Agenda Publishing, 173–92.

Rajapaksa, Darshana, Moinul Islam, and Shunsuke Managi (2018), “Pro-Environmental Behavior: The Role of Public Perception in Infrastructure and the Social Factors for Sustainable Development,” *Sustainability*, 10(4), 937.

Ratten, V (2022), “World Heritage Sites in Portugal and Spain,” in *Contributions to Management Science*, Springer Science and Business Media Deutschland GmbH, 115–21, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85130972312&doi=10.1007%2f978-3-030-97699-6_7&partnerID=40&md5=89725a09d788a7644509695a6fe1f9d8.

Rognli, Erling W., Rune Zahl-Olsen, Sondre Sverd Rekdal, Asle Hoffart, and Thomas Bjerregaard Bertelsen (2023), “Editorial Perspective: Bayesian Statistical Methods Are Useful for Researchers in Child and Adolescent Mental Health,” *Journal of Child Psychology and Psychiatry*, 64(2), 339–42.

Royo, Sebastián and Paul Christopher Manuel (2004), *Spain and Portugal in the European Union : The First Fifteen Years Introduction: Some Lessons from the Fifteenth Anniversary of the Accession of Portugal and Spain to the European Union*, 1, 1st ed., Routledge.

Schultz, P. Wesley, Jessica M. Nolan, Robert B. Cialdini, Noah J. Goldstein, and Vladas Griskevicius (2007), "The Constructive, Destructive, and Reconstructive Power of Social Norms," *Psychological Science*, 18(5), 429–34.

Severijns, Rosaly, Igor Asanov, Sandra Streukens, Stephan B. Bruns, Pablo Moleman, Jasperina Brouwer, Joey van Griethuijsen, and Sebastien Lizin (2024), "Involving Family and Friends Helps Sustainable Diets Last Longer," *npj Climate Action 2024 3:1*, 3(1), 1–9, https://www.nature.com/articles/s44168-024-00192-4.

Smid, Sanne C. and Sonja D. Winter (2020), "Dangers of the Defaults: A Tutorial on the Impact of Default Priors When Using Bayesian SEM With Small Samples," *Frontiers in Psychology*, 11, 611963, https://osf.io/m6byv.

Tajfel, H. (1978), "Social Categorization, Social Identity and Social Comparison," in *Differentiation between Social Groups: Studies in the Social Psychology of Intergroup Relations*, 61–76.

Toubes, Diego R., Julio García del Junco, and Masataka Abe (2019), "Cross-Cultural Analysis of Japanese and Mediterranean Entrepreneurs During the Global Economic Crisis," *Journal of International and Global Studies*, 10(2).

United Nations Department of Economic and Social Affairs (UNDESA)) (2024), *The Sustainable Development Goals Report 2024*, https://unstats.un.org/*SD*gs/report/2024/.

Wang, Y, F Hao, and Y Liu (2021), "Pro-Environmental Behavior in an Aging World: Evidence from 31 Countries," *International Journal of Environmental Research and Public Health*, 18(4), 1–13, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85100655782&doi=10.3390%2fijerph18041748&partnerID=40&md5=50817990239a61c785bac7c1b86481c4.

Wang, Yan, Feng Hao, and Yunxia Liu (2021), "Pro-Environmental Behavior in an Aging World: Evidence from 31 Countries," *International Journal of Environmental Research and Public Health*, 18(4), 1748.

World Health Organization (2023), "Climate Change and Health," *https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health*.

Xia, W and L M W Li (2023), "Societal Gender Role Beliefs Moderate the Pattern of Gender Differences in Public- and Private-Sphere pro-Environmental Behaviors," *Journal of Environmental Psychology*, 92, https://www.scopus.com/inward/record.uri?eid=2-s2.0-

85175572001&doi=10.1016%2fj.jenvp.2023.102158&partnerID=40&md5=b65d7baa71ff43e4e9ccea05ad7f3338.

Yozukmaz, N and B Kiliç (2022), "ATTITUDES IN TOURISM AND TRAVELING AS A TOOL/INSTRUMENT FOR ATTITUDE CHANGE," in *Routledge Handbook of Social Psychology of Tourism*, Taylor and Francis, 111–20, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85143469589&doi=10.4324%2f9781003161868-11&partnerID=40&md5=aac98436e9ee8f7de750ec466edf6a56.

Supplementary Material 1

Exploratory Factor Analysis

Environmental Attitudes Inventory

When running EFA for the Environmental Attitudes Inventory, it was found that most items matched the second-order structure reported by Domingues and Gonçalves (2020), with the exception of items 28 and 29, which loaded onto the Preservation factor, rather than the Utilization factor, both reverse-coded items, and item 14 which did not load into either factor. Cronbach's alpha was calculated for the structure originally proposed, along with the structure uncovered through EFA, noting that the adding the items to 'correct factor' resulted in a loss of internal consistency (Preservation: 0.88 < 0.91; Utilization: 0.79 < 0.73), leading to the decision to keep the factor structure obtained for our sample. Due to item 14's poor fit with either factor, along with its redundancy, and the fact it reduced reliability, it was decided the item would be excluded from the final factor structure. The resulting factor structure can be viewed in Table 1:

Table 1

Final Factor Structure for the Environmental Attitudes Inventory

	Preservation	Utilization
Items included	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 16, 17, 18, 22, 23, 24, 28, 29, 31, 32, 33, 34, 35, 36	10, 11, 13, 15, 19, 20, 21, 25, 26, 27, 30
Cronbach's Alpha	0.91	0.79
Factor loadings	-0.03 < X < 0. 85 ($\bar{x} = 0.56, SD = 0.21$)	0.24 < X < 0.85 ($\bar{x} = 0.54$, SD = 0.20)

Social Environmental Attitudes Inventory

Similarly to the Environmental Attitudes Inventory, the EAIs showed an emerging two factor structure, while two items loaded onto the wrong factor, according to the original structure of the Environmental Attitudes Inventory, and item 14 loaded into neither factor. It was decided that both items loaded into the wrong factor would be placed in their original factor, with item 7 (item 19 of the Environmental Attitudes Inventory) showing a factor loading of 0.87 on the Preservation factor and item 12 (item 35 of the Environmental Attitudes Inventory) showing a factor loading of 0.110 on the Utilization factor. The final factor structure is displayed in Table 2:

Table 2

Final Factor Structure for the Social Environmental Attitudes Inventory

	Preservation	Utilization
Items included	1, 2, 3, 6, 7, 8, 11	4, 5, 9, 10, 12
Chronbach's Alpha	0.79	0.63
Factor loadings	-0.42 < X < 0. 80 ($\bar{x} = 0.67, SD = 0.14$)	0.52 < X < 0.72 ($\bar{x} = 0.62$, SD = 0.09)

Supplementary Table 1

Below, the political orientation instrument described in the main paper is presented:

Table 1

Political Orientation measurement instrument structure

Dimension	Question	Options	Marking
Equality of outcome vs. equality of opportunity	Which statement aligns more with your views on social equality?	Society should focus on ensuring equal outcomes for everyone.	-1
		Equal opportunities are more important than equal outcomes.	1
		Unsure/Other	0
Government intervention vs individual autonomy	What is your opinion on the role of government in individuals' lives?	Government should play an active role in addressing social issues.	-1
		Government intervention should be minimized to protect individual freedoms.	1
		Balanced approach.	0
Economic redistribution vs free market capitalism	How do you think the government should be running the economy?	Intervening to ensure equitable distribution of wealth.	-1
		Favoring free-market principles that privilege economic-growth.	1
		A mix of both approaches.	0

Supplementary Table 2

Table 2

Translation for the trilingual 36 item Environmental Attitudes Inventory (EAI-36)

Item #	English (Milfont and Duckitt 2010)	Portuguese (Domingues and Gonçalves 2020)	Spanish (by Ignacio Cifre, Pedro Rodrigues Ribeiro)
1	I really like going on trips into the countryside, for example to forests or fields.	Eu gosto mesmo de passear pelo campo, por exemplo em florestas ou zonas rurais.	Me gusta mucho hacer excursiones al campo, por ejemplo a bosques o campos.
2	Being out in nature is a great stress reducer for me.	Estar perto da natureza reduz-me o stresse.	Estar en la naturaleza es un gran reductor del estrés para mí.
3	I enjoy spending time in natural settings just for the sake of being out in nature.	Gosto de passar tempo em espaços naturais, simplesmente porque gosto de estar no meio da natureza.	Disfruto pasar tiempo en entornos naturales por el simple hecho de estar en la naturaleza.
4	Industry should be required to use recycled materials even when this costs more than making the same products from new raw materials.	A indústria devia ser obrigada a usar materiais reciclados, mesmo quando a produção sai mais cara.	Se debería exigir a la industria que utilice materiales reciclados incluso cuando esto cueste más que fabricar los mismos productos a partir de nuevas materias primas.

5	People in developed societies are going to have to adopt a more conserving life-style in the future.	No futuro, as pessoas nas sociedades desenvolvidas vão ter de adotar um estilo de vida mais adequado à conservação da natureza.	Las personas de las sociedades desarrolladas tendrán que adoptar en el futuro un estilo de vida más conservador.
6	I think people in developed societies are going to have to adopt a more conserving life-style in the future.	Eu acho que as pessoas nas sociedades desenvolvidas vão ter de adotar um estilo de vida mais adequado à conservação da natureza no futuro.	Creo que la gente de las sociedades desarrolladas tendrá que adoptar en el futuro un estilo de vida más conservador.
7	I would get involved in an environmentalist organization.	Eu seria capaz de me envolver numa organização ambientalista.	Me involucraría en una organización ecologista.
8	Environmental protection costs a lot of money. I am prepared to help out in a fund-raising effort.	A proteção do ambiente custa muito dinheiro. Estou disposto(a) a ajudar em capanhas de recolha de fundos.	La protección del medio ambiente cuesta mucho dinero. Estoy dispuesto a ayudar en un esfuerzo de recaudación de fondos.
9	I would like to support an environmental organization.	Eu gostaria de apoiar uma organização ambientalista.	Me gustaría apoyar una organización medioambiental.
10	The worst thing about the loss of the rain forest is that it will restrict the development of new medicines.	A pior coisa da perda da floresta tropical é que vai limitar o desenvolvimento de novos medicamentos.	Lo peor de la pérdida de la selva tropical es que restringirá el desarrollo de nuevos medicamentos.
11	One of the most important reasons to keep lakes and rivers clean is so that	Uma das razões mais importantes para manter os rios e lagos limpos é para que as pessoas possam praticar desportos aquáticos.	Una de las razones más importantes para mantener limpios los lagos y los ríos es

	people have a place to enjoy water sports.		que la gente tenga un lugar para disfrutar de los deportes acuáticos.
12	We need to keep rivers and lakes clean in order to protect the environment, and not as places for people to enjoy water sports.	Precisamos de manter os rios e lagos limpos para proteger o ambiente, e não para termos lugares para as pessoas praticarem desportos aquáticos.	Necesitamos mantener limpios los ríos y lagos para proteger el medio ambiente y no como lugares para que la gente disfrute de deportes acuáticos.
13	Science and technology will eventually solve our problems with pollution, overpopulation, and diminishing resources.	A ciência e a tecnologia irão eventualmente resolver os nossos problemas de poluição, excesso de população e escassez de recursos naturais.	La ciencia y la tecnología eventualmente resolverán nuestros problemas de contaminación, superpoblación y disminución de recursos.
14	Modern science will not be able to solve our environmental problems.	A ciência moderna não será capaz de resolver os nossos problemas ambientais.	La ciencia moderna no podrá resolver nuestros problemas ambientales.
15	Modern science will solve our environmental problems.	A ciência moderna irá resolver os nossos problemas ambientais.	La ciencia moderna resolverá nuestros problemas ambientales.
16	If things continue on their present course, we will soon experience a major ecological catastrophe.	Se as coisas continuarem neste rumo, em breve estaremos perante uma grande catástrofe ecológica.	Si las cosas continúan como están, pronto viviremos una gran catástrofe ecológica.
17	Humans are severely abusing the environment.	Os seres humanos estão a abusar gravemente do ambiente.	Los seres humanos están abusando gravemente del medio ambiente.
18	I believe that the environment has been severely abused by humans.	Acredito que os seres humanos abusaram severamente do ambiente.	Creo que los seres humanos han abusado gravemente del medio ambiente.

19	I'd prefer a garden that is wild and natural to a well-groomed and ordered one.	Eu prefiro um jardim pouco cuidado e natural a um bem tratado e organizado.	Prefiero un jardín salvaje y natural a uno bien cuidado y ordenado.
20	I'd much prefer a garden that is well groomed and ordered to a wild and natural one.	Eu prefiro um jardim bem tratado e organizado a um não tratado e natural.	Prefiero un jardín bien cuidado y ordenado a uno salvaje y natural.
21	Grass and weeds growing between pavement stones really look untidy.	A relva e as ervas daninhas a crescer entre as pedras do pavimento dão realmente um ar descuidado.	La hierba y la maleza que crecen entre las aceras parecen realmente desordenadas.
22	I am concerned about saving water or other natural resources.	Preocupo-me com a poupança de água e de outros recursos naturais.	Me preocupa ahorrar agua u otros recursos naturales.
23	In my daily life I try to find ways to conserve water or power.	No meu dia-a-dia, tento encontrar formas de poupar água ou energia.	En mi vida diaria trato de encontrar formas de conservar agua o energía.
24	Whenever possible, I try to save natural resources.	Sempre que possível, tento poupar recursos naturais.	Siempre que puedo, trato de salvar los recursos naturales.
25	Humans were meant to rule over the rest of nature.	Os seres humanos estão destinads a dominar a natureza.	Los humanos estaban destinados a gobernar el resto de la naturaleza.
26	Humans beings created or evolved to dominate the rest of nature.	Os seres humanos foram criados ou evoluíram para dominar a natureza.	Los seres humanos fueron creados o evolucionados para dominar el resto de la naturaleza.

27	I believe humans were created to evolve to dominate the rest of nature.	Eu acredito que os seres humanos tenham sido criados ou evoluído para dominar a natureza.	Creo que los humanos fueron creados para evolucionar y dominar el resto de la naturaleza.
28	Humans do NOT have the right to damage the environment just to get greater economic growth.	Os seres humanos não têm o direito de danificar o ambiente apenas para alcançar um maior crescimento económico.	Los seres humanos NO tienen derecho a dañar el medio ambiente sólo para obtener un mayor crecimiento económico.
29	We should no longer use nature as a resource for economic purposes.	Nós não devíamos continuar a usar a natureza como um recurso para fins económicos.	Ya no deberíamos utilizar la naturaleza como recurso con fines económicos.
30	The question of the environment is secondary to economic growth.	A questão do ambiente é secundária face ao crescimento económico.	La cuestión del medio ambiente es secundaria al crecimiento económico.
31	I believe protecting the environment is an important issue.	Acredito que a proteção do ambiente é um assunto importante.	Creo que la protección del medio ambiente es una cuestión importante.
32	I believe nature is valuable for its own sake.	Acredito que a natureza é um bem valioso por si só.	Creo que la naturaleza es valiosa por sí misma.
33	I get upset at the idea of forests being cleared for agriculture.	Chateia-me que as florestas estejam a ser devastadas para a agricultura.	Me molesta la idea de que se talen bosques para la agricultura.
34	Families should be encouraged to limit themselves to two children or less.	As famílias deviam ser encorajadas a limitar o número de filhos a dois ou menos.	Se debe alentar a las familias a limitarse a dos hijos o menos.

35	A married couple should have as many children as they wish, as long as they can adequately provide for them.	Um casal deve ter tantos filhos quantos quiser, de*SD*e que possa cuidar adequadamente deles.	Una pareja casada debe tener tantos hijos como desee, siempre que pueda mantenerlos adecuadamente.
36	Our government should educate people concerning the importance of having two children or less.	O nosso Governo devia educar as pessoas sobre a importância de ter dois filhos ou menos.	Nuestro gobierno debería educar a la gente sobre la importancia de tener dos hijos o menos.

Chapter 3: How do you buy without constraints? A source localized, fine-grained functional connectivity look into the NeuMa dataset (Study 2)

How do you buy without constraints? A source localized, fine-grained functional connectivity look into the NeuMa dataset

Submitted for Publication in Cognitive Neurodynamics; Springer Nature

Presently awaiting Editor Approval

Pedro Rodrigues Ribeiro[1,2,3] | prribeiro@ucp.pt | ORCID: 0000-0003-0496-0634

Ignacio Cifre [2] | ignaciocl@blanquerna.url.edu | ORCID: 0000-0003-0644-6022

Bahar Tunçgenç[3] | bahar.tuncgenc@ntu.ac.uk | ORCID: 0000-0002-1135-1004

Patrícia Oliveira-Silva [1] | posilva@ucp.pt | ORCID: 0000-0001-6550-3790

1. Human Neurobehavioral Laboratory, Research Centre for Human Development, Faculty of Education and Psychology, Universidade Católica Portuguesa, Porto, Portugal
2. School of Psychology, Education and Sport Science, Blanquerna Ramon Llull University, Barcelona, Spain
3. Department of Psychology, Nottingham Trent University, Nottingham, United Kingdom

Abstract

Understanding how the brain supports everyday purchasing decisions is key to understanding consumer behavior. However, the field has relied heavily on self-report metrics and stringently controlled laboratory tasks, offering limited naturalism and mechanistic insight. In this study, we explored the neural architecture of everyday purchasing decisions under naturalistic, unconstrained conditions. We merged a naturalistic shopping paradigm with source-localized, fine-grained, spectral connectivity to identify cortical networks governing real purchase decisions. Twenty-one adults freely browsed a real supermarket flyer while their eye movements and brain activity (EEG) were recorded, deciding, without time or budgetary constraints, which products to buy and not to buy. We analyzed Alpha and Beta sub-band activity across 12 Brodmann-based regions of interest using source-localized EEG and functional connectivity metrics. Bayesian logistic regression identified predictors of Buy and No Buy decisions. Buy decisions engaged memory-based valuation and action preparation networks, marked by parahippocampal Alpha and medial frontal Beta activity. No-Buy decisions activated attentional reorientation and inhibitory control circuits, characterized by anterior cingulate and dorsolateral prefrontal Alpha-Beta patterns. Across all bands, connectivity peaked in the Beta 1 range, with the dlPFC acting as a central hub, suggesting that even unconstrained buying requires executive regulation. We propose a model in which Buy is defined by an identification of a familiar product, the evaluation of its subjective value and a motor control pathway indicating the purchase action while No Buy is defined by attention reorientation away from an unfamiliar product and inhibition of the Buy action. These findings bridge everyday consumer choice with cognitive neuroscience, showing that self-control is not a response to external limits, it is embedded in the very act of deciding.

Keywords: Neuromarketing; Source Localization; Functional Connectivity;

Introduction

Most consumer research relies on constrained and highly artificial tasks, typically imposing uniform limits on budget and time. Researchers like Bettman (1998) have highlighted the need for more ecologically valid consumer paradigms that approximate real shopping experience. Similarly, Chandon (2009) emphasized that consumer behavior is inherently heterogeneous and cannot fully be captured under artificial experimental constraints. Georgiadis and colleagues (2023) operationalized these ideas in the development of the NeuMa database, which employed a naturalistic shopping paradigm, based on a real supermarket flyer presented in an unconstrained setting, where the only boundaries were those defined by the participants themselves. Constrained and unconstrained decision making exert distinct cognitive demands (Boyacı et al., 2024), with constrained decision making, like budgetary restrictions (Engelmann & Tamir, 2009), being the most studied (Yu et al., 2023). Nevertheless, such a paradigm might simplify the model for consumer decision making, allowing for a holistic view of how consumers make purchasing decisions.

Beyond developing ecologically valid paradigms for consumer research, a central debate concerns neuroscience's potential contribution to models of consumer decision making. Economists like Gul and Pesendorfer (2008) have argued that most of the current decision-making models are largely silent regarding the underlying biological mechanisms, concluding that neuroscience would not be a valuable addition to the field of consumer research. Despite this, researchers like Yoon and colleagues (2012) have categorically disagreed, emphasizing that a major gap lies in understanding how goods are internally represented and valued by consumers, with neuroscience providing necessary inputs. Illustrative examples include Plassman and colleagues (2010) who demonstrated that orbitofrontal regions are linked to appetitive and aversive valuation of items, and Kable and Glimcher (2010) who showed that immediate and delayed rewards are encoded differently within the brain's valuation network. The benefits of integrating neuroscience methods into marketing research are further exemplified by Pozharliev and colleagues (2022), who employed multimodal physiological measures to detect attention and emotional engagement. Their findings revealed that these neurophysiological indices outperformed self-reports, showing that the level of attention a consumer allocates to advertising moderates the impact of ad quality on behavior activation. Such effects were made observable through physiological metrics, such as eye-tracking fixations which have historically been used in cognitive neuroscience.

Adding to this debate comes the critique that traditional approaches to marketing research have long been criticized for their reliance on self-reports, which are prone to social desirability bias and fail to capture unconscious processes (Plassmann et al., 2015). Neuroscience offers a valuable corrective by elucidating the neural mechanisms underlying consumer choice, revealing the influence of emotion and implicit bias, and challenging the assumptions of fully rational consumers (Plassmann et al., 2015; Smidts et al., 2014).

To understand how neuroscience can advance consumer research beyond self-reports, it is essential to consider the neural systems that underpin decision making, where affective signals, learning mechanisms and executive control jointly shape consumer choices. Damásio's (1996) Somatic Marker Hypothesis showed us that the ventromedial prefrontal cortex (vmPFC) integrates affective signals. This biases attention to stimuli and the evaluation of contexts, helping to avoid disadvantageous options. Bechara and colleagues (1997) later provided empirical support for this hypothesis, showing that individuals with vmPFC fail to avoid disadvantageous decisions. This work highlights the intrinsic interplay between memory and emotion, stationed within the limbic system (Gupta et al., 2011), and the prefrontal cortex in decision making.

Extending beyond affective processing, Schultz's research (1998, 2016) made us aware that beyond the affective system, the brain's reward centers hold vital importance in decision making. He demonstrated that dopaminergic neurons increase their firing rate when outcomes exceed expectations and pause when outcomes fall short. Later on, it was shown that, with repetition, dopamine activity shift from being used primarily to signal reward and starts providing predictive cues, meaning dopamine guides habit. This mechanism also explains temporal discounting, as this system prefers immediate rewards, valuing them more strongly than delayed ones.

While dopaminergic systems shape how rewards anticipation and the limbic system anchors decision making in past experience, the prefrontal cortex provides the executive control necessary to regulate these signals, and to balance immediate impulses against long-term goals. This role of cognitive inhibition is the primarily mediated by the dorsolateral pre-frontal cortex (dlPFC), which supports executive control, self-regulation and the suppression of impulsive behavior (Kohno et al., 2017). Activity in this region has been associated with reduced impulsivity and stronger preference for delayed rewards (Cho et al., 2012). The dlPFC operates in concert with the vmPFC

(Hare et al., 2009), which integrates value-related and memory-related information to maximize subjective gains (Gluth et al., 2015; Venkatraman et al., 2009). Whereas the vmPFC encodes value, the dlPFC biases this value signal toward long-term goals. Complementing these two regions, the orbitofrontal cortex (OFC) completes the circuit by handling affective components, especially within risky conditions (Krain et al., 2006), contributing to evaluating reward and affective value (Engelmann & Tamir, 2009). Yet, impulse control alone does not fully account for consumer decision making. Much of its complexity arises from the integrated functioning of the prefrontal cortex.

These affective, learning, and executive control systems form the neural architecture that manages consumer choice. Yet, in practice, especially in the use of Electroencephalography, consumer neuroscience has often relied on indirect measures to capture their activity (Khondakar et al., 2024). For instance, typically band-power metrics and asymmetry indices have been used as heuristic markers of attention, memory load and motivational tendencies, offering temporal precision without much spatial insight into the underlying brain networks at play.

Nevertheless, additional spectral heuristics can deepen our understanding of consumer behavior. Traditional EEG neuromarketing studies tend to examine broad frequency bands, such as Delta, Theta, Alpha, Beta and Gamma. For cognitive research, Alpha and Beta hold special relevance, as they are consistently linked with attention, memory, and task performance (Babu Henry Samuel et al., 2018; Gould et al., 2011). Yet, these bands are themselves heterogeneous, meaning different subranges within Alpha or Beta support distinct cognitive processes. Subdividing them enables a finer-grained analysis and reveals more specific associations with memory load, attention and performance efficiency. Each sub-band plays a characteristic role. Alpha 1 (8.5-10 Hz) is modulated by memory load and linked to attentional control (Babu Henry Samuel et al., 2018; Gould et al., 2011). Alpha 2 (10.5-12 Hz) is modulated by task-specific stimuli (Babu Henry Samuel et al., 2018). Beta 1 (12.5-18 Hz) is strongly involved in attention (Gould et al., 2011). Beta 2 (18.5-21 Hz) relates to task performance and novelty detection (Dzhebrailova & Korobeĭnikova, 2013; Walsh et al., 2025). Beta 3 (21.5-30 Hz) shows increased engagement during attentionally demanding tasks (Walsh et al., 2025). Together, these sub-bands illustrate the nuanced contributions of Alpha and Beta oscillations to cognition, ranging from memory load and task modulation to performance to novelty detection and sustained attention.

These band-power heuristics generally dominate the field of neuromarketing. Most studies focus on band-power, asymmetry indices, especially frontal Alpha, band rations, and Event-Related Potentials or ERPs (Khondakar et al., 2024; Khurana et al., 2021). Although these indices serve as useful proxies for cognitive processes such as attention, memory, and motivational states, they do not provide informational about the specific neural sources underlying these functions. This limitation arises from the high temporal resolution but low spatial resolution of EEG, in contrast to imaging modalities such as functional magnetic resonance imaging (fMRI) (Schrooten et al., 2019). In the absence of the ability to collect multimodal data with fMRI, it is possible to extend EEG beyond heuristic through Source Localization. While less spatially precise than fMRI, source location enables the mapping of frequency-domain EEG activity to specific cortical regions (Jatoi et al., 2016). When combined with functional connectivity analyses, these methods allow researchers to capture large-scale network dynamics (Allouch et al., 2022).

Only a handful of studies have employed source localization to neuromarketing or consumer research. To our knowledge, merely four studies have undertaken this approach (Astolfi et al., 2008; De Vico Fallani et al., 2008; Khushaba et al., 2013; Vecchiato et al., 2010). This gap responds directly to Smidts and colleagues' (2014) call for more mechanistic consumer neuroscience. Integrating band-power metrics with source localization and functional connectivity provides a more comprehensive perspective on consumer decision making, revealing whch oscillatory patterns emerge, where they originate, and how distributed brain networks interact to shape choice behavior.

This study, therefore, seeks to reintroduce the techniques of source localization and fine-grained frequency sub-band analysis and functional connectivity, ubiquitously found in broader EEG and neuroscience literature, into the consumer neuroscience and neuromarketing field. This technique provides a response to calls for a more mechanistic approach to consumer decision-making research. Allied to these techniques is the exploration of the novel NeuMa dataset (Georgiadis et al., 2023). This dataset presents a naturalistic approach to unconstrained consumer decision making in a grocery shopping scenario. As such this study aims to present a comparison of brain areas and networks activated within this paradigm to understand the brain areas and networks activated during naturalistic consumer decision-making scenarios.

Methods

Sample

This study used publicly available, anonymized data from the NeuMa dataset (Georgiadis et al., 2023). The original NeuMa dataset included 42 participants; 21 were excluded in this study due to EEG signal quality issues that prevented reliable use for our connectivity analyses, leaving 21 participants constituting the sample for this study (see *Data Analysis* and *Supplementary Material*). The sample used for this study had an average age of 29.81(SD = 6.57), with 13 subjects identifying as male and 8 identifying as female. While most participants identified as right-handed, one participant identified as ambidextrous. Of the 21 participants, 19 have at least a college degree, with 8 of these having graduated from a Master's program, and 2 having a basic education. In terms of marital status, 15 participants were single at the time of data collection, with one being divorced and 5 being married. Only four of the 21 participants reported having children. Most participants reported visiting the supermarket one to two times per week, with only five reporting a minimum number of supermarket visits of two and a maximum of three. Two participants reported a typical supermarket visit taking under 15 minutes, one reported taking longer than 60 minutes, 13 reported their supermarket visits lasting between 15 and 30 minutes, and five reported these moments lasting between 30 and 60 minutes. Four participants reported using a shopping list during supermarket visits, while 17 reported not using a shopping list. A more detailed view of sociodemographic and psychometric data characterizing the sample is displayed in Table 1.

Table 1

Sample characterization

Variable	Mean (*SD*)	Range
Aspects affecting consumption		
Perception of price impact	7.34 (2.13)	1-10
Perception of brand impact	7.00 (1.26)	5-9
Perception of discount impact	7.48 (1.72)	4-10
Perception of advertisement impact	4.00 (2.30)	1-8

Perception of suggestion impact [1]	5.67 (1.93)	1-9
Big five personality traits		
Openness to experience	3.71 (0.64)	2.0-4.5
Conscientiousness	3.55 (0.72)	2.5-5.0
Extraversion	3.45 (0.77)	2-4.5
Agreeableness	3.43 (0.79)	1.0-5.0
Neuroticism	2.88 (0.98)	1.5-4.5
Other personality traits		
Verbal/Visual information processing	3.24 (0.17)	2.9-3.5
Utilitarian shopping motivation	3.68 (0.63)	2.3-4.9
Hedonic shopping motivation	2.77 (0.65)	0.7-4.1
Spontaneity	2.42 (0.73)	1.6-4.0
Variety seeking	3.07 (0.61)	1.8-4.0
Bargain hunting	3.08 (0.49)	2.3-4.3

Note. For the purposes of this paper suggestion is interpreted as peer-to-peer recommendation based on Nguyen and Nguyen (2024), as the original paper is not explicit in this regard. For more information on the scales and instruments used, please see (Georgiadis et al., 2023).

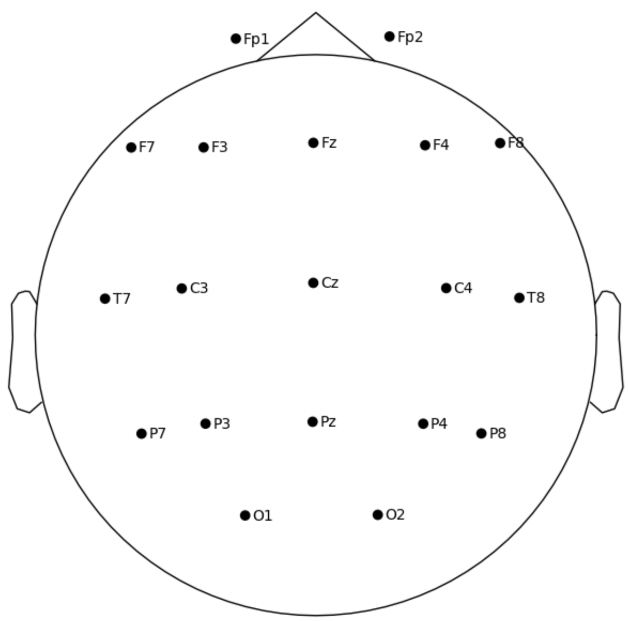
Experimental Paradigm

Participants engaged in a naturalistic shopping simulation designed to closely replicate real-world purchasing behavior. The task design was set to closely mimic real-world scenarios. Participants were shown a computerized six-page grocery store flyer. Each page contained 24 products of different grocery categories (e.g., apples of different types). Unlike constrained laboratory settings, the participants were freely able to look through the flyer, moving forwards and backwards without time constraints and were free to Buy as many products as they wanted to, without budgetary constraints or quantity limitations. On average, participants spent 42.26 ± 26.34 seconds per page (range: 8.21-145.75 seconds). Participants spent on average 1.76 ± 1.82 seconds per product (range: 0-17.37 seconds). Participants were able to select products for Buy by clicking the products on the flyer, at which point they were presented with a form requesting them to present their level of familiarity with the product, and how often they normally Buy this product in real life.

Throughout the task, EEG and eye tracking data were simultaneously recorded. For eye-tracking, participants were placed at a 50 cm distance of a 28 inch LCD screen. A two-minute resting baseline was collected prior to the task beginning. EEG was collected with a 21-electrode montage following the 10-20 system. By database suggestion, 2 channels were not considered due to poor signal quality, with a 19 channels montage having been considered in the end. Figure 1 displays the montage used.

Figure 1

Montage used in data collection



Note. Topographic map of electrode placements in the montage used for data collection. The montage contained 19 electrodes placed according to the international 10-20 system.

Data preprocessing

Due to concerns of data distortion, the raw version of the NeuMa dataset was chosen. EEG data was preprocessed using *MATLAB*® (version R2024b, update 4) (The MathWorks Inc., 2024) and

EEGLAB (version 2025.0.0) (Delorme et al., 2025). Some participants were excluded due to persistent artifacts and phase distortion, due to this fact a more complete analysis report is presented in supplementary materials. After extensive evaluation of filter performance, we applied a zero-phase FIR filter with a Blackman-Harris window of order 500 and a bandpass of 0.8 to 45 Hz, in order to avoid edge effects within the necessary passband. The selected FIR (Blackman-Harris, order 500) filter achieved < 0.5 radian phase lag in a majority of subjects and over 40 dB stop-band attenuation.

Artifact correction was performed via independent component analysis using EEGLAB's *runica* function. Components were classified and removed only if they were clearly identified as artifacts by both manual inspection and the *ICLabel* plugin (Pion-Tonachini et al., 2019). Residual outliers exceeding three standard deviations from the signal mean were excluded from analysis. The final dataset included 21 participants. Signals were then mean-centered and root mean square normalized to allow valid comparisons across subjects and conditions.

Data was epoched through code provided by the publishers of the dataset based upon the mouse clicks and the gaze of subjects, related to pre-processed eye-tracking data. EEG epochs reflect moments where subjects were looking at specific products. Epochs were divided by bought and not bought products and placed in tab separated text files for easy importing into the LORETA (version 20240713) (Pascual-Marqui et al., 1994) software which was used for the subsequent analysis.

Data Analysis

Once epoched the EEG data was imported into LORETA. Within LORETA, the first step was to convert electrode labels into spatial coordinates and registered in a *.sxyz* file. This was subsequently used to compute the transformation matrix. Epochs corresponding to bought and not bought product viewings were averaged during conversion to cross-spectral matrices per frequency band. The bands analyzed are presented in Table 2. Delta and Theta wave analysis was excluded as many product viewing segments are under 1 second and are, therefore, unsuitable for the analysis of these bands.

Table 2

Frequency bands and their cognitive associations

Band	Range (Hz)	Associations	Citations
Alpha 1	8.5-10	Modulated by memory load; enhances attentional filtering	(Babu Henry Samuel et al., 2018; Gould et al., 2011)
Alpha 2	10.5-12	Modulated by stimulus features; supports task adaptation	(Babu Henry Samuel et al., 2018)
Beta 1	12.5-18	Facilitates selective attention and visual scanning	(Gould et al., 2011)
Beta 2	18.5-21	Responds to novelty and performance monitoring	(Dzhebrailova & Korobeĭnikova, 2013; Walsh et al., 2025)
Beta 3	21.5-30	Associated with sustained attention and behavioral inhibition	(Walsh et al., 2025)

Note. Alpha and Beta sub-bands were subdivided to enable fine-grained mapping of attention and memory processes.

Cross-spectral matrices were then converted to frequency-domain sLORETA images. Regions of interest (ROIs) were defined using ROI Maker, referencing Brodmann areas aligned with cognitive and affective processing. sLORETA images were then extracted into ROI-specific activity profiles. For clarity, defined Brodmann areas and the cognitive-affective regions referenced in this manuscript are provided in Table 3.

Table 3

ROI definition and justification

ROI	Broadmann Area	Side	Corresponding Area	Area association
1	32	-	Dorsal ACC	Calculating effort-reward tradeoffs; Monitors conflict and exerts cognitive effort (Hogan et al., 2018).
2	25	R	Subgenual Cingulate Cortex	Key limbic lobe node for emotional valuation; Heavily linked with mood and affective appraisal (Scharnowski et al., 2020).
3	24	-	Ventral ACC	Recruited when actions involve competing rewards and risks or require monitoring errors (Marsh et al., 2007).
4	9	R	dlPFC	Central to executive control and working memory; Associated with cognitive control and self-regulation in decision tasks; Involved in reward processing and feedback (Silva et al., 2018).
5	9	L		
6	28	-	Entorhinal Cortex	Major memory hub which interfaces between neocortex and the hippocampus (H. Schultz et al., 2015).
7	19	-	Visual Association Cortex	Involved in complex visual processing (Zilles, 2004).
8	25	L	-	-
9	40	R	Inferior Parietal Lobe/ Supramarginal Gyrus	Supports multimodal integration, attention, working memory, and numerical cognition (Olson & Berryhill, 2008).
10	40	L		

11	31	R	Posterior Cingulate Cortex	Part of the DMN; supports autobiographical memory, self-referential thought and valuation (Uddin et al., 2008).
12	31	L	Posterior Cingulate Cortex	

Note. Side is represented by R – Right, and L – Left, or – for non-lateralized ROIs.

Using LORETA's *Connectivity 1* utility three connectivity measures were computed per frequency band between all ROIs. These were: (i) total coherence, referring to the degree coherence, a spectral measure of the time-invariant relationship between signals in different brain areas (Sun et al., 2004), (ii) lagged linear connectivity, focusing on the time-delayed interactions between brain areas, helping to distinguish between genuine and spurious couplings (La Foresta et al., 2019), and (iii) lagged phase synchronization, referring to the time-delayed alignment of the phases of oscillatory signals from different brain areas, indicating their peaks and troughs co-occur at a constant time delay (Vysata et al., 2014).

Extracted source activity per frequency sub-band was modelled as a function of the buy/no buy binary through Bayesian logistic regression. Due to substantial multicollinearity, it was not feasible to replicate the analysis for functional connectivity nodes, nor was it feasible to include all significant ROIs simultaneously across frequency bands within a single model. High pairwise correlation among predictors could harm posterior covariance, misleading inclusion Bayes Factors. R (version 4.4.2) (R Core Team, 2021) and package brms (version 2.22.0) (Bürkner, 2017) were used for Bayesian modelling of the data. All models used default non-informative Gaussian priors, and effects were considered statistically significant when the 95% credible interval excluded zero. Evidence for predictor inclusion was evaluated using Bayes Factors (Savage-Dickey method), interpreted according to Jeffreys' scale. Bayes Factors close to 1 were taken as anecdotal evidence, and effects were therefore interpreted as trends rather than robust findings.

A paired-sample *t*-test on log-transformed data was computed to compare the *bought* and *not-bought* conditions within subjects. Statistical significance was assessed using non-parametric randomization (SnPM) with 5000 permutations, providing corrected thresholds and p-values. For both source-localized power and functional connectivity matrices, tests were performed across all frequency bands and all ROI pairs. Matrices were thresholded at $p < .05$ (corrected) and effect sizes (Cohen's *d*), values were corrected for multiple comparisons using LORETA's default correction method.

Results

Source Localization

Log-transformed t-statistic tests didn't indicate significant differences for any voxels in any of the analyzed sub-bands, $t(0.05) = 3.596$. However, several non-significant small effects were found ($t > 0.872$, Cohen's $d = 0.2$), indicating trends towards larger activity in some structures in each band (see Supplementary material 1 shows for the voxels surpassing the threshold with small non-significant effects per sub-band, and Supplementary material 2 for maps displaying small effects trends).

Functional Connectivity

Lagged Linear Connectivity

A paired-samples t-test within subjects comparing node connectivity within bands revealed a total of 202 significant connections differing between the Buy and Not Buy conditions across all bands ($p < .05$), corresponding to 56 unique node pairs, which indicates consistent patterns of altered connectivity across frequency bands rather than diffuse or isolated effects.

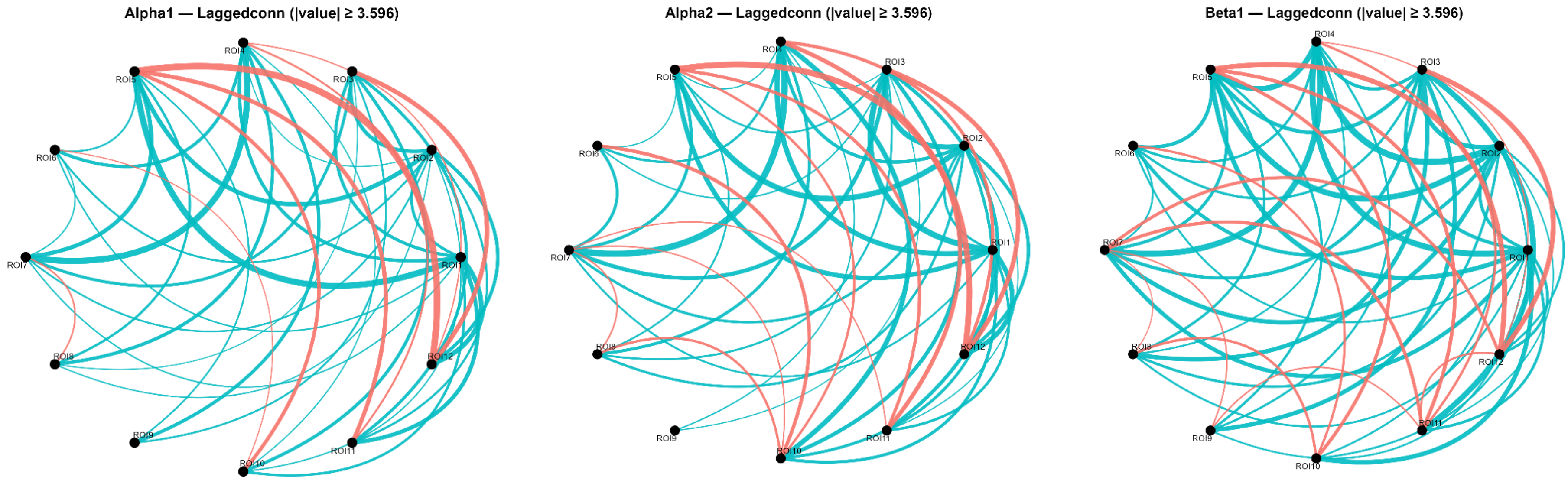
All twelve ROIs served as nodes in at least one significant edge in at least one sub-band, indicating a distributed pattern of connectivity differences. ROI 3 (Brodmann area 24, cingulate gyrus) exhibited the largest number of connections across all bands, with a peak of 11 connections in Beta 1. In contrast, ROI 9 (Brodmann area 40, inferior parietal lobule) exhibited the fewest significant connections, while ROIs 6 and 10 also showed comparatively low connectivity, indicating limited engagement in the observed contrasts.

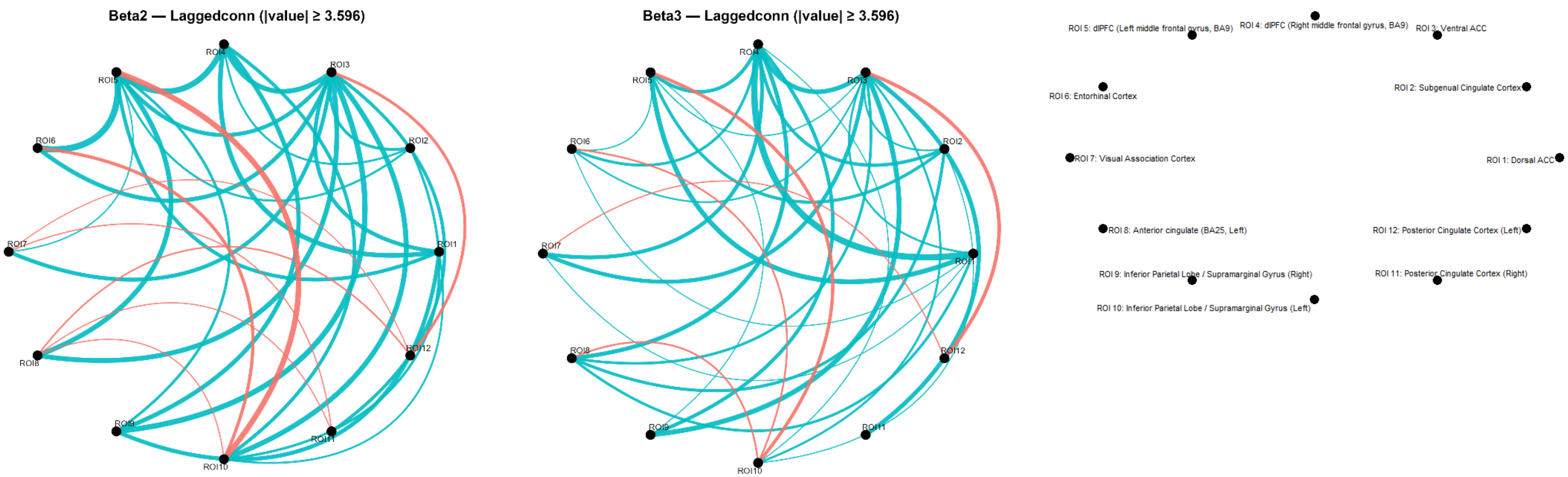
The Beta 1 band yielded the greatest number of significant node pairs ($n = 52$), followed by Alpha 2 ($n = 45$), Alpha 1 ($n = 41$), and Beta 2 and Beta 3 ($n = 32$ each). The strongest observed contrast occurred between ROI 2 and ROI 4, with a peak t-value of 6.56 ($p < .01$).

Significant nodes may be viewed in Figure 2, while a detailed specification of significant node pairs presented in Supplementary material 3.

Figure 2

Lagged Connectivity Maps per Band





Note. Blue represents significant connections for the No Buy condition, while Red represents significant connections for the Buy condition.

Lagged Phase Synchronization

A paired-samples t-test comparing phase-synchronization connectivity within bands revealed a total of 159 statistically significant connections across all bands ($p < .05$), corresponding to 49 unique node pairs. This again points to patterned, cross-band alterations rather than diffuse or isolated effects.

All twelve ROIs took part in at least one significant connection in at least one band, indicating a distributed pattern of connectivity differences. ROI 4—the middle frontal gyrus (Brodmann area 9, part of the dlPFC)—showed the greatest overall involvement, contributing to 42 significant edges across the five sub-bands and peaking at 11 connections in Beta 1. In contrast, ROI 11—the precuneus (Brodmann area 31)—was the least engaged node, serving as a node in only 12 significant contrasts, when comparing between the Buy and Not Buy conditions.

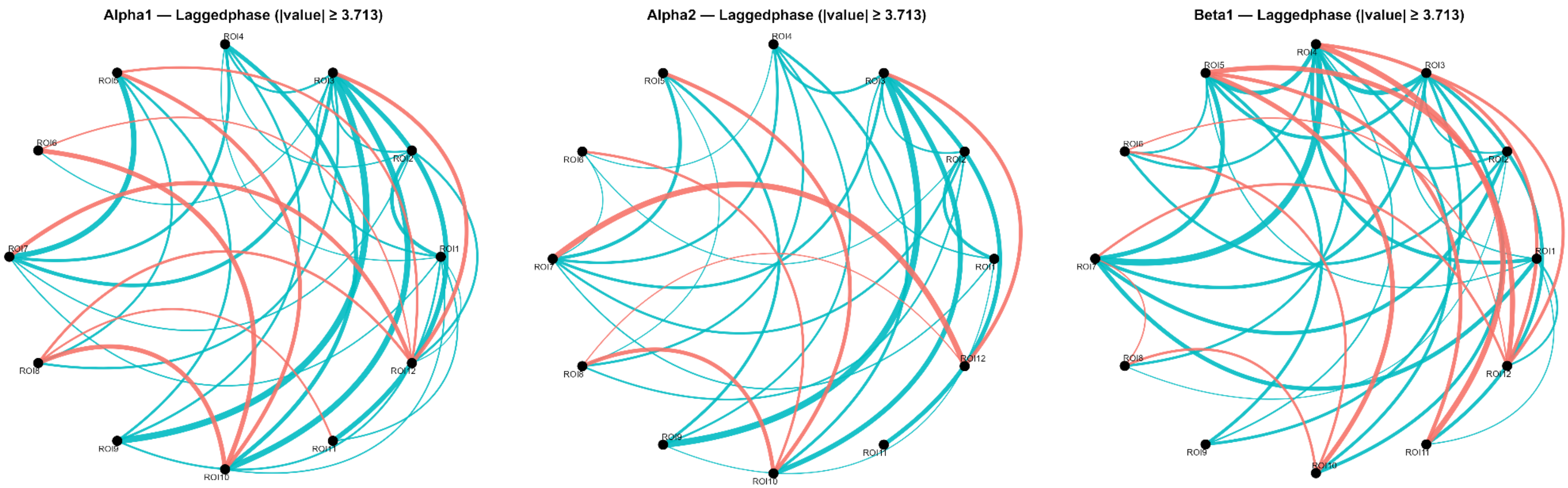
The band-by-band breakdown sees Beta 1 with the highest number of significant node pairs, 37, followed by Alpha 1, 34, Beta 2, 34, Alpha 2, 28, and Beta 3, 26.

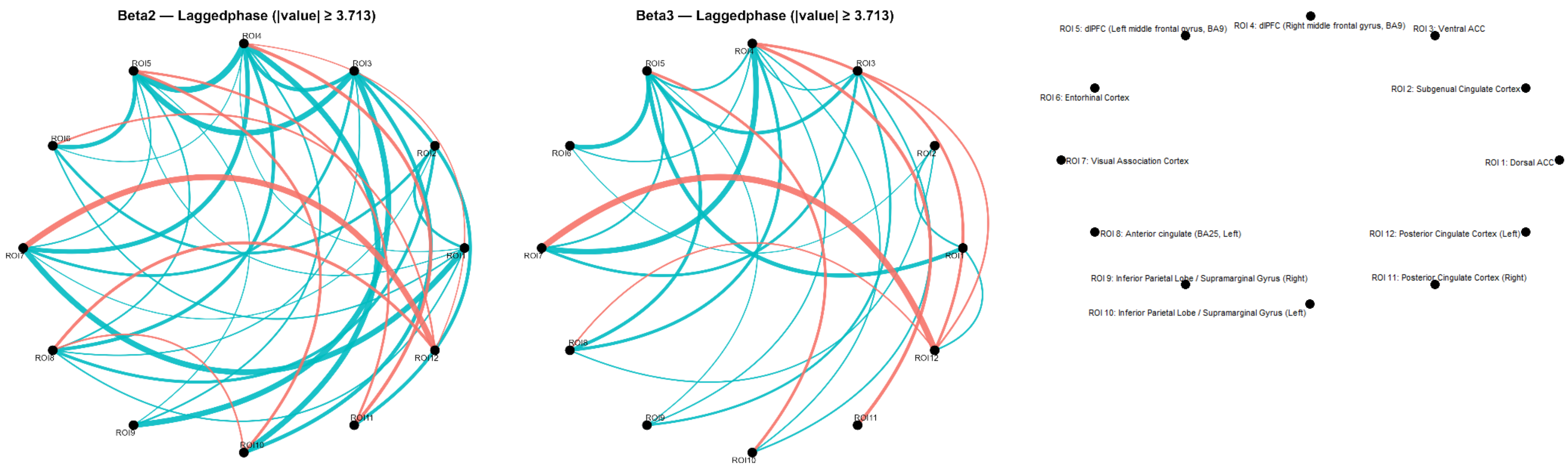
The strongest effect was observed between ROI 4 (middle frontal gyrus, Brodmann area 9) and ROI 7 (lingual gyrus, Brodmann area 19) in Beta 1, with a peak t-value of 6.31 ($p < .01$).

Significant phase-synchronization nodes are illustrated in Figure 3, and the full list of significant node pairs is provided in Supplementary material 3.

Figure 3

Lagged Phase Synchronization Maps per Band





Note. Blue represents significant connections for the No Buy condition, while Red represents significant connections for the Buy condition.

Total Coherence

A paired-samples t-test comparing total coherence connectivity within bands revealed a total of 12 statistically significant connections across all bands ($p < .05$), corresponding to 12 unique node pairs.

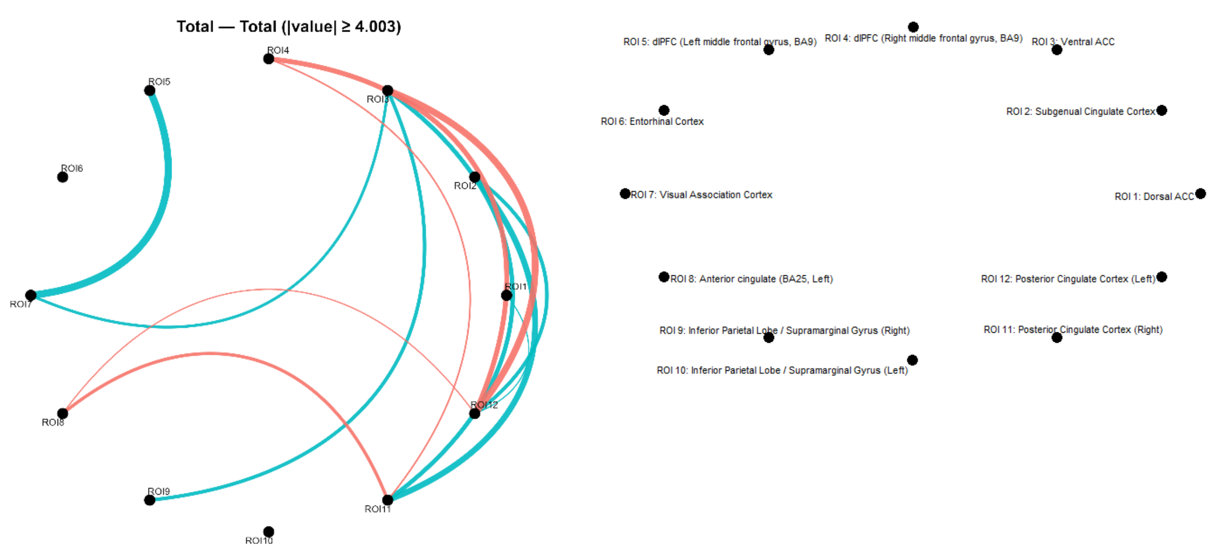
All ROIs, with the exception of 6 and 10, had at least one significant connection, indicating a distributed but sparse pattern of coherence differences. ROI 3—the anterior cingulate gyrus (Brodmann area 24)—and ROI 12—the parahippocampal/posterior cingulate complex (Brodmann areas 28–31)—showed the greatest overall involvement, contributing to four and five significant edges. In contrast, ROIs 4 and 5 (both within the dorsolateral prefrontal cortex) and ROIs 8 and 9 exhibited the fewest connections, each participating in only one or two significant contrasts.

The strongest effect was observed between ROI 5 (middle frontal gyrus, Brodmann area 9) and ROI 7 (inferior parietal lobule, Brodmann area 40), with a peak t-value of 5.26 ($p < .01$).

Significant total coherence nodes are illustrated in Figure 4, and the full list of significant node pairs is provided in Supplementary material 3.

Figure 4

Total Coherence Map



Note. Blue represents significant connections for the No Buy condition, while Red represents significant connections for the Buy condition.

Modelling

Bayesian logistic modelling within each frequency band identified 24 statistically reliable ROI predictors, distributed across all five bands. Beta 2 yielded the most significant predictors, with six, followed by Beta 1 and 3 with five each, and Alpha 1 and 2 with four predictors each. However, Bayes Factors for all significant predictors were close to 1, indicating only anecdotal evidence for their inclusion. These effects should, therefore, be interpreted as trends, rather than a robust finding.

Notably, ROI 12, corresponding to Brodmann area 31, the cingulate gyrus, demonstrated consistent positive associations in three higher frequency bands, Alpha 2, Beta 1 and Beta 2, while ROI 8, the anterior cingulate, Brodmann area 25, displayed negative associations in Alpha 1, Alpha 2 and Beta 1.

Maps displaying the estimates of significant ROIs in each frequency band can be viewed in Figure 5.

Table 4

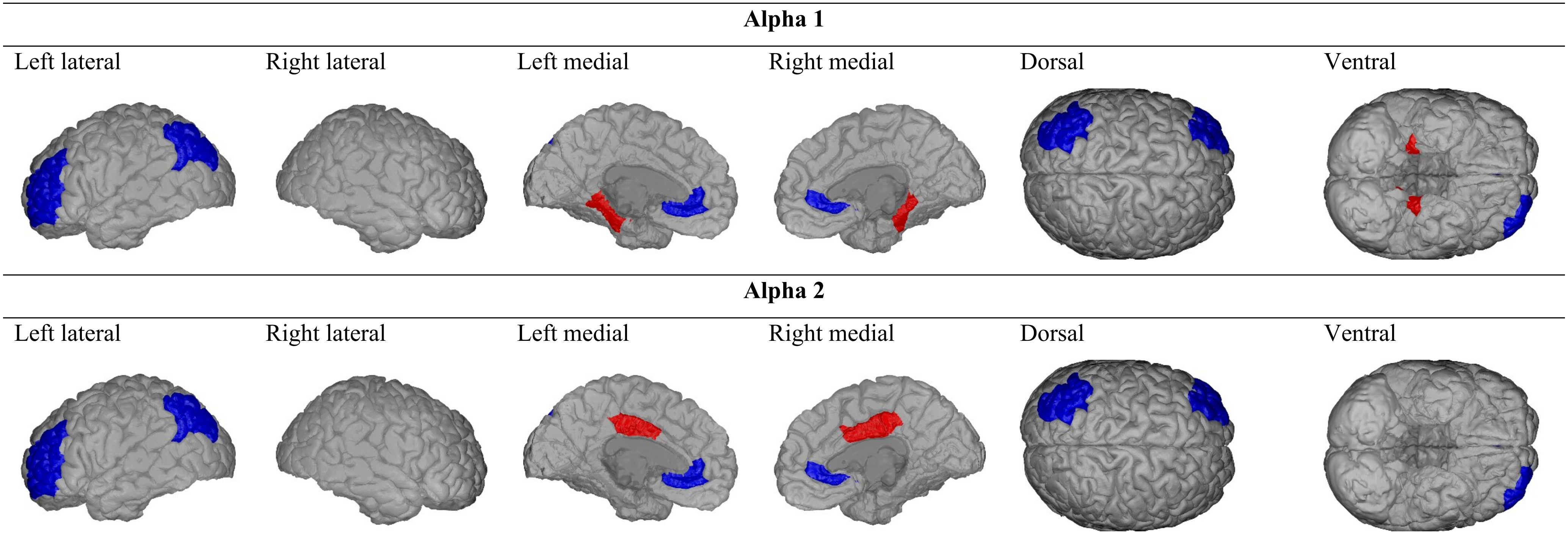
Summary of Bayesian logistic modelling outcomes per frequency sub-band

Sub-band	Significant ROIs	Estimate (β, credible interval)	Bayes Factor	Effect directionality
Alpha 1 (R^2 = 0.392)	5 (Left middle frontal gyrus, BA 9)	-68.07 [−149.95, −1.15]	0.99	Towards No Buy
	6 (Parahippocampal gyrus, BA 28)	+121.49 [9.32, 258.05]	1.00	Towards Buy
	8 (Anterior cingulate; BA 25)	−144.28 [−305.66, −8.57]	0.98	Towards No Buy
	10 (Left inferior parietal lobe; BA 40)	−103.60 [−191.36, −32.42]	0.99	Towards No Buy
Alpha 2 (R^2 = 0.516)	5 (Left middle frontal gyrus; BA 9)	−78.89 [−183.75, −6.44]	0.98	Towards No Buy
	8 (Anterior cingulate; BA 25)	−175.68 [−356.20, −44.36]	0.99	Towards No Buy
	10 (Left inferior parietal lobe; BA 40)	−111.63 [−231.55, −14.40]	0.98	Towards No Buy
	12 (Cingulate gyrus, BA 31)	+224.46 [12.42, 501.40]	0.95	Towards Buy
Beta 1 (R^2 = 0.389)	2 (Medial Frontal Gyrus, BA 25)	+242.00 [6.67, 528.39]	0.99	Towards Buy
	8 (Anterior cingulate; BA 25)	−167.09 [−335.00, −22.74]	1.00	Towards No Buy
	9 (Right inferior parietal lobe; BA 40)	+106.72 [44.15, 182.31]	0.98	Towards Buy
	11 (Precuneus; BA 31)	−365.65 [−624.57, −161.61]	1.00	Towards No Buy
	12 (Cingulate gyrus, BA 31)	+363.31 [153.50, 628.86]	0.98	Towards Buy
Beta 2 (R^2 = 0.459)	2 (Medial Frontal Gyrus, BA 25)	+341.23 [96.07, 652.95]	0.99	Towards Buy
	4 (Right middle frontal gyrus; BA 9)	−110.87 [−198.20, −38.83]	0.98	Towards No Buy
	6 (Parahippocampal gyrus, BA 28)	−271.53 [−507.38, −81.89]	0.99	Towards No Buy
	9 (Right inferior parietal lobe; BA 40)	+83.84 [12.32, 171.52]	0.97	Towards Buy

	11 (Precuneus; BA 31)	−291.14 [−563.28, −84.11]	0.99	Towards No Buy
	12 (Cingulate gyrus, BA 31)	+295.70 [81.82, 581.81]	0.99	Towards Buy
Beta 3 (R^2 = 0.489)	3 (Cingulate gyrus; BA 24)	+149.00 [14.28, 314.60]	1.01	Towards Buy
	4 (Right middle frontal gyrus; BA 9)	−188.21 [−337.65, −72.33]	0.99	Towards No Buy
	5 (Left middle frontal gyrus; BA 9)	−90.86 [−197.29, −4.80]	0.99	Towards No Buy
	6 (Parahippocampal gyrus, BA 28)	−321.40 [−601.95, −111.61]	0.99	Towards No Buy
	10 (Left inferior parietal lobe; BA 40)	+144.13 [26.74, 288.43]	1.00	Towards Buy

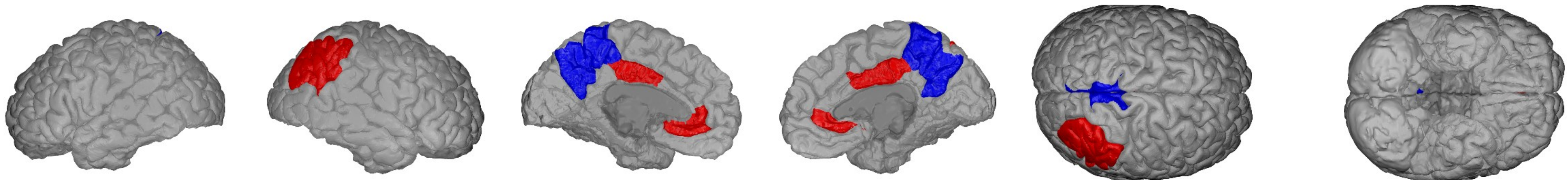
Figure 5

Significant ROI predictors of the participants' Buy vs No-Buy decisions based on logistic Bayesian modelling



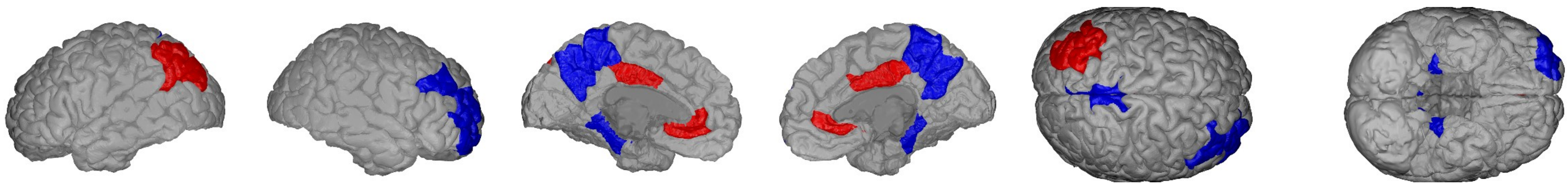
Beta 1

Left lateral | Right lateral | Left medial | Right medial | Dorsal | Ventral



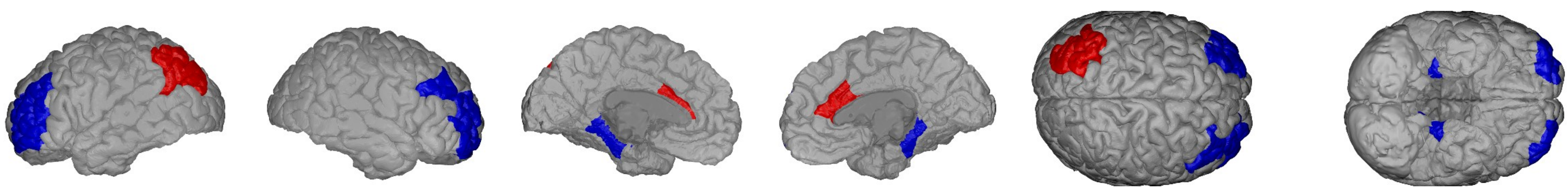
Beta 2

Left lateral | Right lateral | Left medial | Right medial | Dorsal | Ventral



Beta 3

Left lateral | Right lateral | Left medial | Right medial | Dorsal | Ventral



Note. Images created through the MIT BrainPainter utility, using the Desikan-Kiliani atlas (Marinescu et al., 2019).

Discussion

The paradigm presented within the NeuMa dataset (Georgiadis et al., 2023) responds to call from literature by introducing a naturalistic experiment on unconstrained consumer Buy. This study has contributed to recent calls for a more mechanistic understanding of consumer decision-making by integrating a naturalistic paradigm with source-localized EEG connectivity. While the NeuMa flyer task increases ecological realism relative to scripted laboratory paradigms, it still presents a controlled simulation and cannot replicate the full sensory context of real-world purchasing. We mapped Alpha and Beta sub-bands to 12 Brodmann-based ROIs. The innovation presented in this paper positions this work to bridge the gap between laboratory EEG findings and the complex dynamics that govern consumer decision-making.

The analyses incurred revealed trends for spectral segmentation of decision architecture (Table 5). Across five Alpha and Beta sub-bands we identified 24 ROI predictors with regression signs clearly separating Buy and No Buy. Participants' Buy decisions were reflected in Alpha activity in parahippocampal areas, and Alpha and Beta sub-band activity in the posterior cingulate areas. In contrast, No buy decisions were associated with low Alpha activity in the anterior cingulate, and Beta activity in the left middle frontal power. Connectivity patterns ended up echoing this split. The dlPFC showed up as a central hub, contributing to the most edges in phase synchrony. These patterns indicate that the polarity of decisions was driven by frequency-specific exchanges between memory-based valuation hubs and inhibitory control nodes.

Table 5

Significant ROI × band effects on Buy (β > 0) and No-Buy (β < 0) outcomes with linked cognitive functions

Cognitive function	**Predictors of Buy** *(ROI + Band)*	**Predictors of non-Buy** *(ROI + Band)*	**Key references**
Mnemonic valuation and episodic recall	Parahippocampal gyrus – low Alpha (Alpha 1)	-	(Babu Henry Samuel et al., 2018; Kopelman et al., 2007)

Episodic control and default mode stabilization	Posterior cingulate cortex – high Alpha and low Beta (Alpha 2 and Beta 1)	-	(Aponik-Gremillion et al., 2022; Bonnefond & Jensen, 2013)
Action planning and sequencing	Medial frontal gyrus – low Beta (Beta 1 and Beta 2)	-	(Basha et al., 2023)
Attention to salient external stimuli	Right inferior parietal lobe – low Beta (Beta 1)	-	(Singh-Curry & Husain, 2009)
Top-down inhibition of irrelevant information	-	Anterior cingulate cortex – low Alpha (Alpha 1)	(Adams et al., 2017; Liu et al., 2016)
Alpha-gain control	-	Left middle frontal gyrus – low Alpha (Alpha 1)	(Liu et al., 2016)
Visuospatial re-orienting	-	Left inferior parietal lobe – low Alpha (Alpha 1)	(Corbetta et al., 2008)
Memory and arousal reallocation	-	Precuneus – low Beta (Beta 1)	(Malekmohammadi et al., 2023; Neuner et al., 2014)
Working memory maintenance and timing	-	Parahyppocampal gyrus – low Beta (Beta 1)	(Costers et al., 2020; Proshina et al., 2024)
Sustained attention and behavioral inhibition	-	Right middle frontal gyrus – high Beta (Beta 3)	(Demeter et al., 2011; Sundby et al., 2021)

As depicted in Table 5, Buy decisions were characterized by the recruitment of the Parahippocampal gyrus within the low Alpha band, consistent with episodic recall (Babu Henry Samuel et al., 2018; Kopelman et al., 2007). High Alpha and low Beta power within the posterior cingulate region, seeming to indicate default-mode valuation and internal scene construction (Aponik-Gremillion et al., 2022; Bonnefond & Jensen, 2013). Beta 1 and 2 power in the medial frontal gyrus showed the most positive coefficients, suggesting the preparation of the motor schema for product Buy (Basha et al., 2023). Right inferior parietal lobe low Beta activity likely held the role of attention maintenance on the salient product, as indicated by reports of this area's contributions to goal-directed orientation (Singh-Curry & Husain, 2009).

Results indicate that No Buy decisions seemed to recruit a filter and reorient attention culminating in dlPFC inhibition. Here we saw the recruitment of the anterior cingulate cortex and left middle frontal gyrus, areas which are consistent with suppression of task-irrelevant information and anticipatory top-down control (Adams et al., 2017; Liu et al., 2016). The recruitment of the left inferior parietal lobe within low Alpha and the precuneus within low-Beta follows, areas associated with the re-allocation of visuo-spatial attention and the adjustment of arousal away from undervalued stimuli (Corbetta et al., 2008; Malekmohammadi et al., 2023; Neuner et al., 2014). The recruitment of the parahippocampus within low Beta seems to indicate the management of working memory and subjective time estimation during long periods of deliberation (Costers et al., 2020; Proshina et al., 2024). High Beta oscilations within the right middle frontal gyrus, where the dlPFC is located, seem to indicate sustained attention and behavioral inhibition through action stopping (Demeter et al., 2011; Sundby et al., 2021).

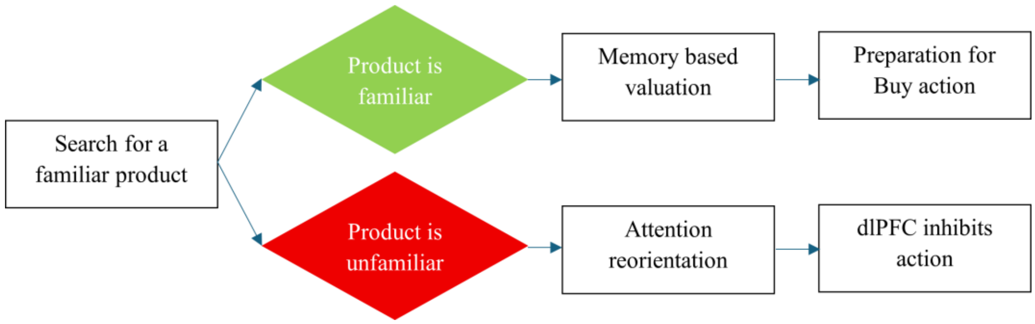
Despite the distributed pattern of connectivity on display, which makes results inconclusive, it is possible to expose some significant edges in the functional connectivity networks. The connection between the anterior cingulate cortex and the dlPFC in No Buy in both Phase Synchrony and Lagged connectivity would seem to support our hypothesis that inhibition was an important process in product rejection. Similarly, the connection between the dlPFC and the Inferior Parietal Lobe during no Buy could indicate that product rejection triggered an attentional shift. At the same time the connection between the Entorhinal Cortex and the Inferior Parietal Lobe in Buy would seem to support our hypothesis that participants were searching for familiar products in the flyer and focusing on these. The subsequent connection between the Entorhinal and the Posterior cingulate could mean that a positive evaluation of the product against a memory template could trigger a go command for the Buy action. These connections seem to support the proposed model.

The relative prominence of the Beta 1 and Alpha 1 bands aligns well with our hypothesis, reflecting the Alpha 1 band's involvement in memory processes (Babu Henry Samuel et al., 2018; Gould et al., 2011) and the Beta 1 band's role in attentional control (Gould et al., 2011). Given that the task required continuous shifts of attentional focus to evaluate multiple products, it is expected that Beta 1 would consistently show the strongest connectivity. Interestingly, Beta 2 activity was less pronounced than anticipated, despite its established association with novelty detection and performance monitoring (Dzhebrailova & Korobeĭnikova, 2013; Walsh et al., 2025). This attenuation may reflect participants' preference for familiar items and reduced engagement with novel products or simply the high familiarity induced by the use of a real supermarket flyer, where most products were already well known to them.

The two networks described above are schematized within Figure 6, which postulates a hypothesis for cognitive progression within the two conditions of Buy and No Buy. On the Buy arm, the sensory input is matched with a positive template from previous buying experiences, with the system then recruiting a memory-based valuation network which helps to decide the subjective value of the product, flowing forward to central pre-frontal go command that assembles the motor schema. On the No Buy arm, a product is deemed irrelevant, likely because it is unfamiliar, then triggering attentional reorientation, culminating in dlPFC led inhibition of the Buy action. Overall, this framework suggests that the decision process begins with the detection of product familiarity, if a product is unfamiliar, the Buy action is inhibited, if it is familiar, its subjective value is evaluated against memory templates and a motor control schema is initiated.

Figure 6

Network schematic summarizing the hypothesized cognitive progression during Buy and No-Buy decisions based on source-localized Alpha/Beta activity and connectivity patterns



While the NeuMa flyer task markedly improves upon tightly scripted lab paradigms in terms of naturalism, several factors temper generalization. First source localized EEG cannot resolve sub-cortical drivers, such as the ventral striatum or the amygdala, which are key portions of the neural decision-making apparatus (Dixon & Dweck, 2021; Feng et al., 2024), and as such our mechanistic inferences are limited to cortical circuitry. An extension of this study's multimodality to include fMRI or fNIRS would overcome the spatial ceiling (Hocke et al., 2015). Participants still sat aware of time and EEG-cap discomfort, factors which may bias them towards rapid No Buy. A point-of-purchase replication might serve as a test of the paradigm's robustness in fully natural retail contexts. The small sample size reduced over concerns of EEG phase shifting restrict population-wide inference and might inflate graph metric variance. Therefore, while the current results delineate cortical correlates of buying and inhibition, the lack of subcortical resolution prevents direct inference on dopaminergic reward valuation or limbic–prefrontal feedback loops that likely mediate these cortical signatures.

These concerns motivate us to suggest a future extension of NeuMa. Our proposal is for a two-arm paradigm, where one cohort would repeat the unconstrained Buy protocol without any changes, while another would undergo the same experiment with an explicit budget cap and time limit, creating a constrained versus unconstrained decision-making dataset. Simultaneously, EEG, eye-tracking and fMRI recordings, or mobile high density fNIRS for in-store deployment, would validate sLORETA sources, capture sub-cortical valuation nodes and reveal whether the dlPFC remains a central node, or even is amplified or reduced in its involvement when external constraints increase inhibitory demand. Comparing connectivity across both cohorts would test our hypothesis that inhibition drives the Buy/No Buy binary.

As summarized in Figure 6, we introduce a provisional model whereby Buy decisions are guided by a “retrieve, value, act” process, and No-buy decisions are guided by a “filter, re-orient, inhibit” process. The prefrontal cortex, namely the dlPFC, the posterior cingulate region and the medial frontal gyrus, anchors the fork, releasing motor plans once mnemonic valuation dominates, or vetoing the Buy arc when inhibitory signals prevail. Our results bridge consumer choice theory and neuro-mechanistic models by indicating that even in the absence of external constraints consumers invoke inhibition systems. Testing the model alongside constrained purchasing scenarios may clarify whether this inhibitory architecture is a universal construct or flexibly up regulated by external pressure, an insight with far-reaching implications across consumer theory.

Conclusion

This study answers long standing calls in consumer neuroscience and neuromarketing literature by pairing a naturalistic unconstrained task with source-level fine-grained functional connectivity. By doing so, it bridges the ecological validity gap that has long separated consumer research from mechanistic neuroscience. Our results allowed us to hypothesize a mechanistic inferential model proposal, two complementary cortical pathways that shape everyday purchase decisions, wherein Alpha-band mnemonic circuitry and Beta-band executive function loops formed two mirroring pathways in decision making. One pathway retrieves positive product memories and executes Buy, another filters irrelevant items, re-orients attention and inhibits action. Across metrics the dorsolateral prefrontal cortex displayed network centrality within the buy/no buy binary. Our findings suggest that everyday consumer activity regularly involves self-control mechanisms, challenging the concept that inhibition surfaces under specific constraints. Future studies might expand on this paradigm to match unconstrained and constrained purchasing to test how strongly prefrontal control scales with external pressures, and how subcortical nodes affect the network. Also, comparing constrained and unconstrained purchasing contexts will be key to determining whether prefrontal control acts as a constant cognitive scaffold or scales dynamically with situational demands. Ultimately, our findings suggest that the act of buying is not merely a behavioral outcome, it is a neural dialogue between memory, value, and control that defines the very essence of human decision making.

References

Adams, N. E., Sherfey, J. S., Kopell, N. J., Whittington, M. A., & LeBeau, F. E. N. (2017). Hetereogeneity in neuronal intrinsic properties: A possible mechanism for hub-like properties of the rat anterior cingulate cortex during network activity. *ENeuro*, *4*(1). https://doi.org/10.1523/ENEURO.0313-16.2017

Allouch, S., Yochum, M., Kabbara, A., Duprez, J., Khalil, M., Wendling, F., Hassan, M., & Modolo, J. (2022). Mean-Field Modeling of Brain-Scale Dynamics for the Evaluation of EEG Source-Space Networks. *Brain Topography*, *35*(1), 54–65. https://doi.org/10.1007/S10548-021-00859-9

Aponik-Gremillion, L., Chen, Y. Y., Bartoli, E., Koslov, S. R., Rey, H. G., Weiner, K. S., Yoshor, D., Hayden, B. Y., Sheth, S. A., & Foster, B. L. (2022). Distinct population and singleneuron selectivity for executive and episodic processing in human dorsal posterior cingulate. *ELife*, *11*. https://doi.org/10.7554/ELIFE.80722

Astolfi, L., De Vico Fallani, F., Cincotti, F., Mattia, D., Bianchi, L., Marciani, M. G., Salinari, S., Colosimo, A., Tocci, A., Soranzo, R., & Babiloni, F. (2008). Neural basis for brain responses to TV commercials: A high-resolution EEG study. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *16*(6), 522–531. https://doi.org/10.1109/TNSRE.2008.2009784

Babu Henry Samuel, I., Wang, C., Hu, Z., & Ding, M. (2018). The frequency of alpha oscillations: Task-dependent modulation and its functional significance. *NeuroImage*, *183*, 897–906. https://doi.org/10.1016/J.NEUROIMAGE.2018.08.063

Basha, D., Kalia, S. K., Hodaie, M., Lopez Rios, A. L., Lozano, A. M., & Hutchison, W. D. (2023). Beta band oscillations in the motor thalamus are modulated by visuomotor coordination in essential tremor patients. *Frontiers in Human Neuroscience*, *17*. https://doi.org/10.3389/FNHUM.2023.1082196

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science (New York, N.Y.)*, *275*(5304), 1293–1295. https://doi.org/10.1126/SCIENCE.275.5304.1293

Bettman, J. R., Luce, M. F., & Payne, J. W. (1998). Constructive Consumer Choice Processes. *Journal of Consumer Research*, *25*(3), 187–217. https://doi.org/10.1086/209535

Bonnefond, M., & Jensen, O. (2013). The role of gamma and alpha oscillations for blocking out distraction. *Communicative and Integrative Biology*, *6*(1). https://doi.org/10.4161/CIB.22702

Boyacı, T., Canyakmaz, C., & de Véricourt, F. (2024). Human and Machine: The Impact of Machine Input on Decision Making Under Cognitive Limitations. *Management Science*, *70*(2), 1258–1275. https://doi.org/10.1287/MNSC.2023.4744

Bürkner, P. C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. *Journal of Statistical Software*, *80*, 1–28. https://doi.org/10.18637/JSS.V080.I01

Chandon, P., Hutchinson, J. W., Bradlow, E. T., & Young, S. H. (2009). Does in-store marketing work? effects of the number and position of shelf facings on brand attention and evaluation at the point of purchase. *Journal of Marketing*, *73*(6), 1–17. https://doi.org/10.1509/JMKG.73.6.1

Cho, S. S., Pellecchia, G., Ko, J. H., Ray, N., Obeso, I., Houle, S., & Strafella, A. P. (2012). Effect of continuous theta burst stimulation of the right dorsolateral prefrontal cortex on cerebral blood flow changes during decision making. *Brain Stimulation*, *5*(2), 116. https://doi.org/10.1016/J.BRS.2012.03.007

Corbetta, M., Patel, G., & Shulman, G. L. (2008). The Reorienting System of the Human Brain: From Environment to Theory of Mind. *Neuron*, *58*(3), 306. https://doi.org/10.1016/J.NEURON.2008.04.017

Costers, L., Van Schependom, J., Laton, J., Baijot, J., Sjøgård, M., Wens, V., De Tiège, X., Goldman, S., D'Haeseleer, M., D'hooghe, M. B., Woolrich, M., & Nagels, G. (2020). Spatiotemporal and spectral dynamics of multi-item working memory as revealed by the n-back task using MEG. *Human Brain Mapping*, *41*(9), 2431–2446. https://doi.org/10.1002/HBM.24955

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *351*(1346), 1413–1420. https://doi.org/10.1098/RSTB.1996.0125

De Vico Fallani, F., Astolfi, L., Cincotti, F., Mattia, D., Marciani, M. G., Gao, S., Salinari, S., Soranzo, R., Colosimo, A., & Babiloni, F. (2008). Structure of the cortical networks during successful memory encoding in TV commercials. *Clinical Neurophysiology*, *119*(10), 2231–2237. https://doi.org/10.1016/J.CLINPH.2008.06.018

Delorme, A., Makeig, S., Humphries, C., Enghoff, S., Jung, T.-P., Bell, T., Lee, T.-W., & Finelli, L. (2025). *EEGLab version 2025.0.0*. Swartz Center % for Computational Neuroscience, Institute for Neural Computation, % University of California.

Demeter, E., Hernandez-Garcia, L., Sarter, M., & Lustig, C. (2011). Challenges to attention: A continuous arterial spin labeling (ASL) study of the effects of distraction on sustained attention. *NeuroImage*, *54*(2), 1518–1529. https://doi.org/10.1016/J.NEUROIMAGE.2010.09.026

Dixon, M. L., & Dweck, C. S. (2021). The Amygdala and the Prefrontal Cortex: The Co-construction of Intelligent Decision-Making. *Psychological Review*, *129*(6), 1414–1441. https://doi.org/10.1037/REV0000339

Dzhebrailova, T. D., & Korobeĭnikova, I. I. (2013). Spatial organization of the beta2 EEG frequency band and effectiveness of the intellectual activity in humans. *Zhurnal Vyssheĭ Nervnoĭ Deiatelnosti Imeni I P Pavlova*, *63*(6), 667–676. https://doi.org/10.7868/S004446771306004X

Engelmann, J. B., & Tamir, D. (2009). Individual differences in risk preference predict neural responses during financial decision-making. *Brain Research*, *1290*, 28–51. https://doi.org/10.1016/j.brainres.2009.06.078

Feng, C., Liu, Q., Huang, C., Li, T., Wang, L., Liu, F., Eickhoff, S. B., & Qu, C. (2024). Common neural dysfunction of economic decision-making across psychiatric conditions. *NeuroImage*, *294*. https://doi.org/10.1016/J.NEUROIMAGE.2024.120641

Georgiadis, K., Kalaganis, F. P., Riskos, K., Matta, E., Oikonomou, V. P., Yfantidou, I., Chantziaras, D., Pantouvakis, K., Nikolopoulos, S., Laskaris, N. A., & Kompatsiaris, I. (2023). NeuMa - the absolute Neuromarketing dataset en route to an holistic understanding of consumer behaviour. *Scientific Data*, *10*(1). https://doi.org/10.1038/s41597-023-02392-9

Gluth, S., Sommer, T., Rieskamp, J., & Büchel, C. (2015). Effective Connectivity between Hippocampus and Ventromedial Prefrontal Cortex Controls Preferential Choices from Memory. *Neuron*, *86*(4), 1078–1090. https://doi.org/10.1016/j.neuron.2015.04.023

Gould, I. C., Rushworth, M. F., & Nobre, A. C. (2011). Indexing the graded allocation of visuospatial attention using anticipatory alpha oscillations. *Journal of Neurophysiology*, *105*(3), 1318–1326. https://doi.org/10.1152/JN.00653.2010

Gul, F., & Pesendorfer, W. (2008). The Case for Mindless Economics. In *The Foundations of Positive and Normative Economics* (pp. 2–40). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195328318.003.0001

Gupta, R., Koscik, T. R., Bechara, A., & Tranel, D. (2011). The amygdala and decision-making. *Neuropsychologia*, *49*(4), 760–766. https://doi.org/10.1016/j.neuropsychologia.2010.09.029

Hare, T. A., Camerer, C. F., & Rangel, A. (2009). Self-control in decision-making involves modulation of the vmPFC valuation system. *Science (New York, N.Y.)*, *324*(5927), 646–648. https://doi.org/10.1126/SCIENCE.1168450

Hocke, L. M., Cayetano, K., Tong, Y., & Frederick, B. (2015). Optimized multimodal functional magnetic resonance imaging/near-infrared spectroscopy probe for ultrahigh-resolution mapping. *Neurophotonics*, *2*(4), 045004. https://doi.org/10.1117/1.NPH.2.4.045004

Hogan, P. S., Galaro, J. K., & Chib, V. S. (2018). Roles of Ventromedial Prefrontal Cortex and Anterior Cingulate in Subjective Valuation of Prospective Effort. *Cerebral Cortex (New York, NY)*, *29*(10), 4277. https://doi.org/10.1093/CERCOR/BHY310

Jatoi, M. A., Kamel, N., Malik, A. S., Faye, I., Bornot, J. M., & Begum, T. (2016). EEG-based brain source localization using visual stimuli. *International Journal of Imaging Systems and Technology*, *26*(1), 55–64. https://doi.org/10.1002/IMA.22157

Kable, J. W., & Glimcher, P. W. (2010). An "As Soon As Possible" Effect in Human Intertemporal Decision Making: Behavioral Evidence and Neural Mechanisms. *Journal of Neurophysiology*, *103*(5), 2513–2531. https://doi.org/10.1152/jn.00177.2009

Khondakar, M. F. K., Sarowar, M. H., Chowdhury, M. H., Majumder, S., Hossain, M. A., Dewan, M. A. A., & Hossain, Q. D. (2024). A systematic review on EEG-based neuromarketing: recent trends and analyzing techniques. *Brain Informatics 2024 11:1*, *11*(1), 1–25. https://doi.org/10.1186/S40708-024-00229-8

Khurana, V., Gahalawat, M., Kumar, P., Roy, P. P., Dogra, D. P., Scheme, E., & Soleymani, M. (2021). A Survey on Neuromarketing Using EEG Signals. *IEEE Transactions on*

Cognitive and Developmental Systems, *13*(4), 732–749. https://doi.org/10.1109/TCDS.2021.3065200

Khushaba, R. N., Wise, C., Kodagoda, S., Louviere, J., Kahn, B. E., & Townsend, C. (2013). Consumer neuroscience: Assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking. *Expert Systems with Applications*, *40*(9), 3803–3812. https://doi.org/10.1016/j.eswa.2012.12.095

Kohno, M., Morales, A. M., Guttman, Z., & London, E. D. (2017). A neural network that links brain function, white-matter structure and risky behavior. *NeuroImage*, *149*, 15–22. https://doi.org/10.1016/j.neuroimage.2017.01.058

Kopelman, M. D., Bright, P., Buckman, J., Fradera, A., Yoshimasu, H., Jacobson, C., & Colchester, A. C. F. (2007). Recall and recognition memory in amnesia: Patients with hippocampal, medial temporal, temporal lobe or frontal pathology. *Neuropsychologia*, *45*(6), 1232–1246. https://doi.org/10.1016/j.neuropsychologia.2006.10.005

Krain, A. L., Wilson, A. M., Arbuckle, R., Castellanos, F. X., & Milhama, M. P. (2006). Distinct neural mechanisms of risk and ambiguity: A meta-analysis of decision-making. *NeuroImage*, *32*(1), 477–484. https://doi.org/10.1016/j.neuroimage.2006.02.047

La Foresta, F., Morabito, F. C., Marino, S., & Dattola, S. (2019). High-Density EEG Signal Processing Based on Active-Source Reconstruction for Brain Network Analysis in Alzheimer's Disease. *Electronics 2019, Vol. 8, Page 1031*, *8*(9), 1031. https://doi.org/10.3390/ELECTRONICS8091031

Liu, Y., Bengson, J., Huang, H., Mangun, G. R., & Ding, M. (2016). Top-down Modulation of Neural Activity in Anticipatory Visual Attention: Control Mechanisms Revealed by Simultaneous EEG-fMRI. *Cerebral Cortex*, *26*(2), 517–529. https://doi.org/10.1093/CERCOR/BHU204

Malekmohammadi, A., Ehrlich, S. K., Rauschecker, J. P., & Cheng, G. (2023). Listening to familiar music induces continuous inhibition of alpha and low-beta power. *Journal of Neurophysiology*, *129*(6), 1344–1358. https://doi.org/10.1152/JN.00269.2022

Marinescu, R. V., Eshaghi, A., Alexander, D. C., & Golland, P. (2019). BrainPainter: A software for the visualisation of brain structures, biomarkers and associated pathological processes. *Multimodal Brain Image Analysis and Mathematical Foundations of Computational Anatomy : 4th International Workshop, MBIA 2019, and 7th International Workshop, MFCA 2019, Held in Conjunction with MICCAI 2019,* *Shenzhen, China, October 17, 11846*, 112. https://doi.org/10.1007/978-3-030-33226-6_13

Marsh, A. A., Blair, K. S., Vythilingam, M., Busis, S., & Blair, R. J. R. (2007). Response options and expectations of reward in decision-making: The differential roles of dorsal and rostral anterior cingulate cortex. *NeuroImage*, *35*(2), 979. https://doi.org/10.1016/J.NEUROIMAGE.2006.11.044

Neuner, I., Arrubla, J., Werner, C. J., Hitz, K., Boers, F., Kawohl, W., & Shah, N. J. (2014). The default mode network and EEG regional spectral power: A simultaneous fMRI-EEG study. *PLoS ONE*, *9*(2). https://doi.org/10.1371/JOURNAL.PONE.0088214

Nguyen, C., & Nguyen, N. (2024). Assessing the impacts of peer-to-peer recommender system on online shopping: PLS-SEM approach. *Innovative Marketing*, *20*(4), 1–12. https://doi.org/10.21511/im.20(4).2024.01

Olson, I. R., & Berryhill, M. (2008). Some Surprising Findings on the Involvement of the Parietal Lobe in Human Memory. *Neurobiology of Learning and Memory*, *91*(2), 155. https://doi.org/10.1016/J.NLM.2008.09.006

Pascual-Marqui, R. D., Michel, C. M., & Lehmann, D. (1994). Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. *International Journal of Psychophysiology*, *18*(1), 49–65. https://doi.org/10.1016/0167-8760(84)90014-X

Pion-Tonachini, L., Kreutz-Delgado, K., & Makeig, S. (2019). ICLabel: An automated electroencephalographic independent component classifier, dataset, and website. *NeuroImage*, *198*, 181. https://doi.org/10.1016/J.NEUROIMAGE.2019.05.026

Plassmann, H., O'Doherty, J. P., & Rangel, A. (2010). Appetitive and Aversive Goal Values Are Encoded in the Medial Orbitofrontal Cortex at the Time of Decision Making. *The Journal of Neuroscience*, *30*(32), 10799–10808. https://doi.org/10.1523/JNEUROSCI.0788-10.2010

Plassmann, H., Venkatraman, V., Huettel, S., & Yoon, C. (2015). Consumer neuroscience: Applications, challenges, and possible solutions. *Journal of Marketing Research*, *52*(4), 427–435. https://doi.org/10.1509/JMR.14.0048;PAGEGROUP:STRING:PUBLICATION

Pozharliev, R., Rossi, D., & De Angelis, M. (2022). *A picture says more than a thousand words: Using consumer neuroscience to study instagram users' responses to influencer advertising*. https://doi.org/10.1002/mar.21659

Proshina, E., Mitiureva, D., & Sysoeva, O. (2024). Distinct brain systems are involved in subjective minute estimation with eyes open or closed: EEG source analysis study. *Frontiers in Neuroscience*, *18*. https://doi.org/10.3389/FNINS.2024.1506987

R Core Team. (2021). R: A language and environment for statistical computing. In *R Foundation for Statistical Computing*.

Scharnowski, F., Nicholson, A. A., Pichon, S., Rosa, M. J., Rey, G., Eickhoff, S. B., Van De Ville, D., Vuilleumier, P., & Koush, Y. (2020). The role of the subgenual anterior cingulate cortex in dorsomedial prefrontal–amygdala neural circuitry during positive-social emotion regulation. *Human Brain Mapping*, *41*(11), 3100. https://doi.org/10.1002/HBM.25001

Schrooten, M., Vandenberghe, R., Peeters, R., & Dupont, P. (2019). Quantitative analyses help in choosing between simultaneous vs. Separate EEG and FMRI. *Frontiers in Neuroscience*, *13*(JAN), 426525. https://doi.org/10.3389/FNINS.2018.01009/BIBTEX

Schultz, H., Sommer, T., & Peters, J. (2015). The Role of the Human Entorhinal Cortex in a Representational Account of Memory. *Frontiers in Human Neuroscience*, *9*(NOVEMBER), 628. https://doi.org/10.3389/FNHUM.2015.00628

Schultz, W. (1998). Predictive reward signal of dopamine neurons. *Journal of Neurophysiology*, *80*(1), 1–27. https://doi.org/10.1152/JN.1998.80.1.1

Schultz, W. (2016). Dopamine reward prediction error coding. *Dialogues in Clinical Neuroscience*, *18*(1), 23. https://doi.org/10.31887/DCNS.2016.18.1/WSCHULTZ

Silva, P. H. R., Spedo, C. T., Barreira, A. A., & Leoni, R. F. (2018). Symbol Digit Modalities Test adaptation for Magnetic Resonance Imaging environment: A systematic review and meta-analysis. *Multiple Sclerosis and Related Disorders*, *20*, 136–143. https://doi.org/10.1016/J.MSARD.2018.01.014

Singh-Curry, V., & Husain, M. (2009). The functional role of the inferior parietal lobe in the dorsal and ventral stream dichotomy. *Neuropsychologia*, *47*(6), 1434–1448. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2008.11.033

Smidts, A., Hsu, M., Sanfey, A. G., Boksem, M. A. S., Ebstein, R. B., Huettel, S. A., Kable, J. W., Karmarkar, U. R., Kitayama, S., Knutson, B., Liberzon, I., Lohrenz, T., Stallen, M., Yoon, C., Lett, M., Boksem, M. A. S., Hsu, M., Sanfey, A. G., Stallen, : M, … Huettel, S. A. (2014). *Advancing consumer neuroscience*. https://doi.org/10.1007/s11002-014-9306-1

Sun, F. T., Miller, L. M., & D'Esposito, M. (2004). Measuring interregional functional connectivity using coherence and partial coherence analyses of fMRI data. *NeuroImage*, *21*(2), 647–658. https://doi.org/10.1016/J.NEUROIMAGE.2003.09.056

Sundby, K. K., Jana, S., & Aron, A. R. (2021). Double-blind disruption of right inferior frontal cortex with TMS reduces right frontal beta power for action stopping. *Journal of Neurophysiology*, *125*(1), 140–153. https://doi.org/10.1152/JN.00459.2020,

The MathWorks Inc. (2024). *MATLAB version 24.2.0.2833386 (R2024b)*. The MathWorks Inc.

Uddin, L. Q., Kelly, A. M. C., Biswal, B. B., Castellanos, F. X., & Milham, M. P. (2008). Functional connectivity of default mode network components: Correlation, anticorrelation, and causality. *Human Brain Mapping*, *30*(2), 625. https://doi.org/10.1002/HBM.20531

Vecchiato, G., Astolfi, L., Fallani, F. D. V., Cincotti, F., Mattia, D., Salinari, S., Soranzo, R., & Babiloni, F. (2010). Changes in brain activity during the observation of TV commercials by using EEG, GSR and HR measurements. *Brain Topography*, *23*(2), 165–179. https://doi.org/10.1007/S10548-009-0127-0

Venkatraman, V., Payne, J. W., Bettman, J. R., Luce, M. F., & Huettel, S. A. (2009). Separate Neural Mechanisms Underlie Choices and Strategic Preferences in Risky Decision Making. *Neuron*, *62*(4), 593–602. https://doi.org/10.1016/j.neuron.2009.04.007

Vysata, O., Kukal, J., Valis, M., Pazdera, L., Hort, J., & Prochazka, A. (2014). Lag synchronisation in the human brain: Evidence from 17,722 healthy subjects' EEG analyses. *NeuroQuantology*, *12*(1), 40–45. https://doi.org/10.14704/NQ.2014.12.1.700

Walsh, C., Tait, L., Garrido, M. G., Brown, J. T., & Ridler, T. (2025). Transient cortical beta-frequency oscillations associated with contextual novelty in high density mouse EEG. *Scientific Reports*, *15*(1). https://doi.org/10.1038/S41598-025-86008-9

Yoon, C., Gonzalez, R., Bechara, A., Berns, G. S., Dagher, A. A., Dubé, L., Huettel, S. A., Kable, J. W., Liberzon, I., Plassmann, H., Smidts, A., & Spence, C. (2012). Decision neuroscience and consumer decision making. *Marketing Letters*, *23*(2), 473–485. https://doi.org/10.1007/s11002-012-9188-z

Yu, J., Nickens, T., Liu, D., & Vincenzi, D. A. (2023). Decision-making under crisis conditions: A training and simulation perspective. *Human Factors in Simulation and Training: Application and Practice*, 209–224. https://doi.org/10.1201/9781003401353-7/DECISION-MAKING-CRISIS-CONDITIONS-JIAHAO-YU-TIFFANY-NICKENS-DAHAI-LIU-DENNIS-VINCENZI

Zilles, K. (2004). Architecture of the Human Cerebral Cortex: Regional and Laminar Organization. *The Human Nervous System: Second Edition*, 997–1055. https://doi.org/10.1016/B978-012547626-3/50028-4

Supplementary Material 1

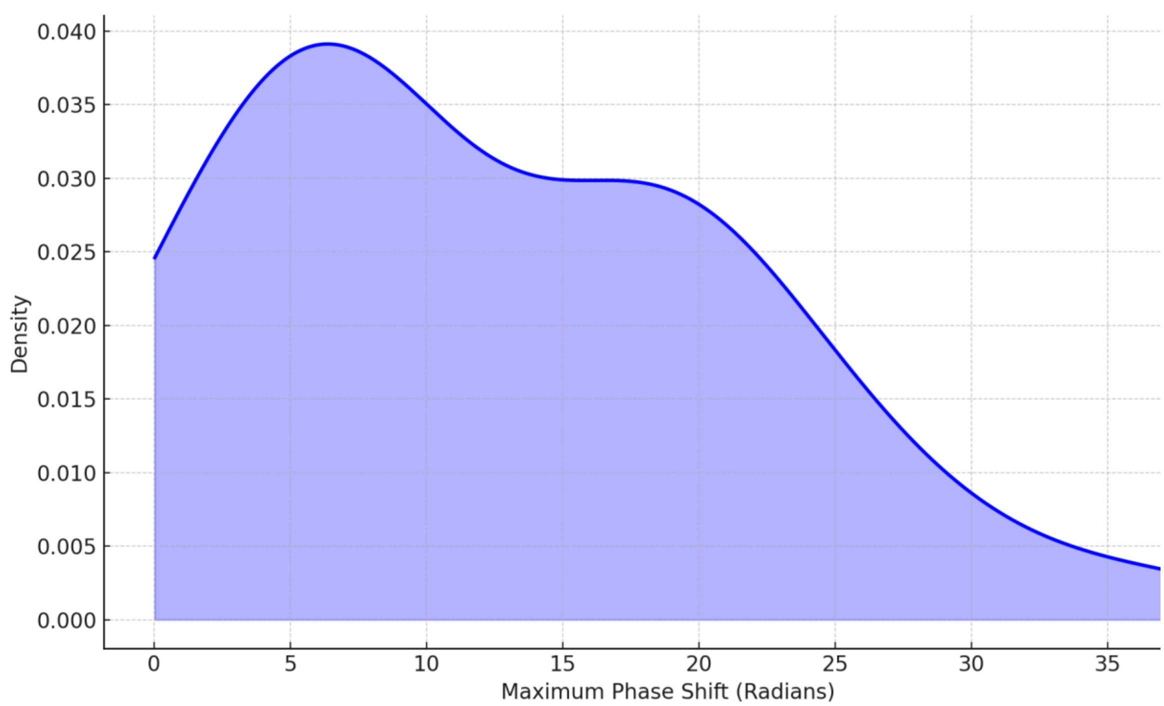
Supplementary Material 1.xlsx

Supplementary Material - Pre-Processing justification

Analysis of the pre-processed NeuMa database demonstrated some frailties in the pre-processing pipeline used. It was possible to see that some subjects still displayed some artefacts. Three standard deviations is a common threshold in statistical artefact detection. This prompted us to return to the raw data provided by the authors. Some preliminary results, significantly higher Beta band power within the viewing of not bought products introduced the hypothesis that there could be some phase shift in the signals, introduced by the filtering. As such it was decided that the filtering would be applied to the raw signals and the phase response would be compared with the raw signals. The third order Butterworth filter utilized by the authors seemed to introduce phase shift in a majority of the subjects as can be seen in the density plot shown in Figure 1. However, the filter applied by the authors did seem to remove noise from the stopband, a standard which is important to maintain. It was also ascertained that the filter applied by the authors did not fully remove the powerline noise (50-60 Hz), as can be seen in Figure 2.

Figure 1

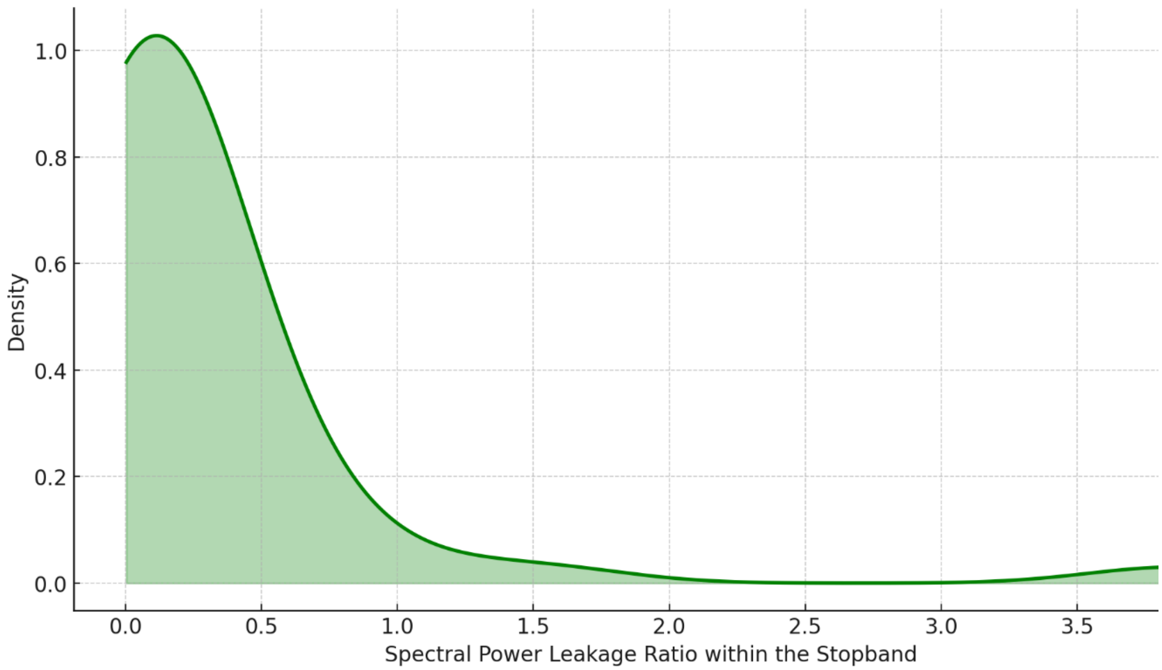
Maximum Phase Shift in Third Order Butterworth



Note. Probability Density Plot for the Maximum Phase Shift when using the Third order Butterworth filter utilized by the authors of the Neuma database. It is possible to see that this filter introduces a substantial amount of Phase Shift which compromises time-sensitive analysis of EEG data.

Figure 2

Ratio of Spectral Leakage within the Stopband Distribution in Third Order Butteworth (0.5-45Hz)



Note. Spectral Leakage Ratio within the Stopband while using the third order Butterworth filter (0.5-45 Hz). The Butterworth did, however demonstrate good attenuation of the stopband with very low values of power leakage within the stopband.

Several filters were attempted, namely a first and second order Butterworth filter, and several different order FIR filters with Blackman Harris windowing applied. The best results were achieved with a Blackman-Harris FIR filter, which maximized the number of subjects with a an acceptable phase lag of under 0.5 radians, and a good stopband leakage ratio. Zero-phase filtering was achieved though MATLAB's filtfilt function.

This paper focuses on an analysis of the multiband source localized functional connectivity of segments where subjects were viewing a product which was bought and the same for products which were not bought. This analysis looks at all frequency bands of interest in the EEG signal, namely the delta (1-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta

(12-30 Hz) and gamma (30-40 Hz) bands. Therefore, it was imperative that these bands are intact within the pre-processed signal. This guided the choice of filter bandpass. The pass band of 0.8 to 45 Hz successfully removes the low frequency drift and high frequency noise within the signal, suitably removing known source of noise, for example the powerline noise (50-60 Hz). Unfortunately, filtering without phase lag was not achieved uniformly across the dataset, and some subjects maintained unsuitable phase lag, with over 6 radians of phase distortion found in some subjects. Due to the failure to find a suitable filter for all subjects it was decided to utilize the order 500 FIR filter with a Blackman-Harris window and a bandpass of 0.8 to 45 Hz, as this provided the best result for the majority of subjects. 21 out of 41 subjects were kept, while 20 subjects were rejected due to substandard phase response to all filters. It was decided not to use different filtering methods for the rejected subjects as this may introduce bias.

For the analysis herein described it is of utmost importance to suitably removed artefacts from the signal. As such, after bandpass filtering, artefact correction was performed via ICA. It was decided not to use FORCe, as the original authors did, as this does not allow manual inspection of artefacts, it was decided that this was a necessary condition, to ensure no brain activity was removed as the result of a failed run of FORCe. This process was, therefore, conducted using EEGLab. This choice was made due to its inclusion of the runica function, and the ICLabel plugin. Prior to ICA decomposition it was verified that the length of signals was adequate for ICA, the rule of thumb of $20 * number\ of\ channels^2$ served as a guide, then the signals were average re-referenced. runica was then utilized to decompose the signals, as there are 19 channels in every channel in the dataset, 18 components were allowed. After ICA decomposition the topographical plots of components were inspected. Special attention was placed on components ailing from frontal regions of the EEG, due to the high likelihood that eye-blink and lateral eye movement components are located in these regions. Additionally, components ailing from distal regions of the scalp were considered as these may represent muscle artefacts. Components identified through inspection of the topographical maps were then inspected further to see their temporal distribution and their power spectral density. Once manual evaluation of components was finished, ICLabel was applied. Only components identified both through visual inspection and by ICLabel as eye and muscle components were removed. Any components where the presence of brain activity was questioned were kept, components identified as artefacts were removed and the signal was reconstructed. Remaining artefacts (+ 3 *SD*) were eliminated from the signal.

Once satisfied with artefact correction and rejection, the signals were mean centered and root mean squared normalized. Centering and normalization are key and mandatory steps in signal processing as they make signals originating from non-linear signals such as the brain comparable.

Supplementary Materials 2 – Voxel-wise Buy/No Buy contrasts per map

Figure 1

Contrast between Alpha 1 activation in bought and not bought products

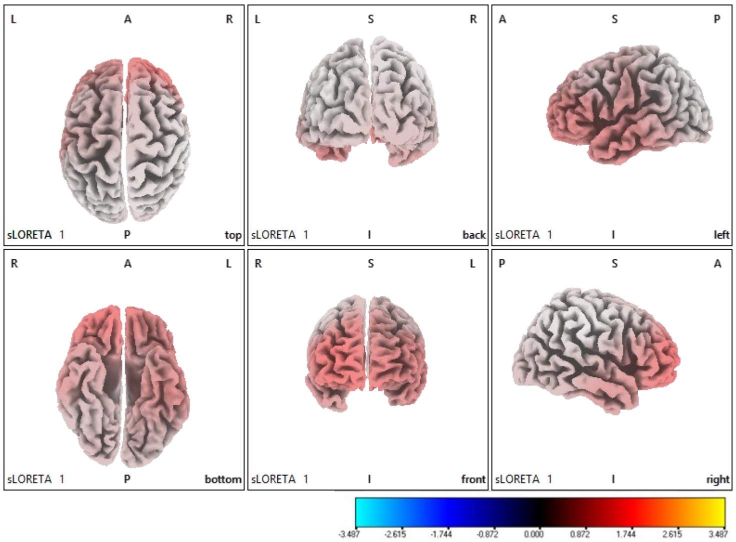


Figure 2

Contrast between Alpha 2 activation in bought and not bought products

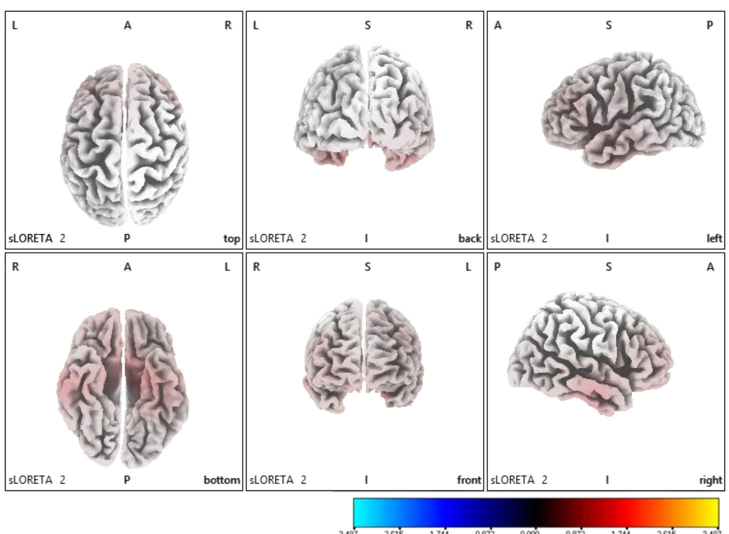


Figure 3

Contrast between Beta 1 activation in bought and not bought products

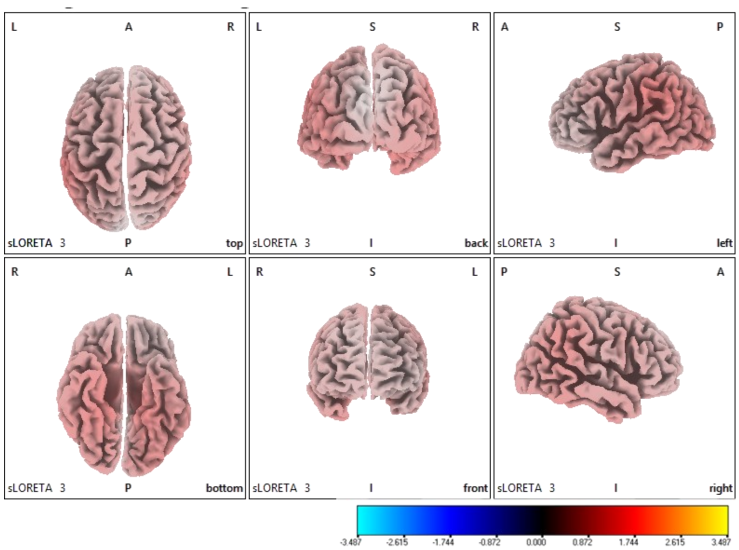


Figure 4

Contrast between Beta 1 activation in bought and not bought products

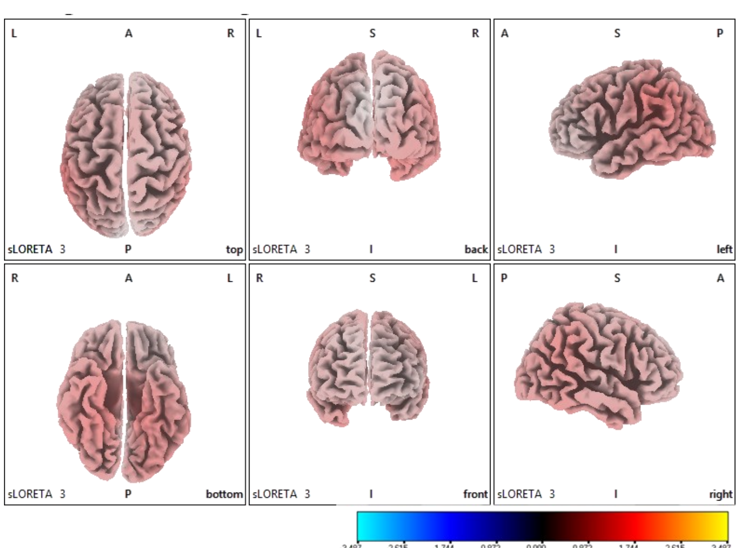
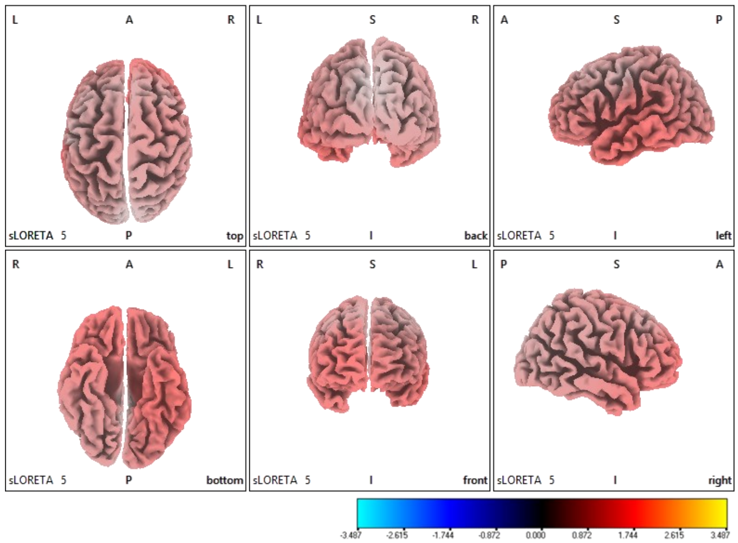


Figure 5

Contrast between Beta 3 activation in bought and not bought products



Supplementary Material 3

Supplementary Material 3.xlsx

Chapter 4: Segmenting Sustainable Textile Consumers: Evidence from a Latent Class Analysis (Study 3)

Segmenting Sustainable Textile Consumers: Evidence from a Latent Class Analysis

Submitted for Publication in Sustainability: Science, Practice and Policy; Taylor & Francis

Presently awaiting Editor Approval

Pedro Rodrigues Ribeiro[1,2,3] | prribeiro@ucp.pt | ORCID: 0000-0003-0496-0634

Ana F. Moreno [1,2,3] | amoreno@ucp.pt | ORCID: 0000-0003-1377-2360

Ted Scharf [4] | scharf.ted@gmail.com | ORCID: 0000-0003-1377-2360

Ignacio Cifre [2] | ignaciocl@blanquerna.url.edu | ORCID: 0000-0003-0644-6022

Bahar Tunçgenç[3] | bahar.tuncgenc@ntu.ac.uk | ORCID: 0000-0002-1135-1004

Patrícia Oliveira-Silva [1] | posilva@ucp.pt | ORCID: 0000-0001-6550-3790

4. Human Neurobehavioral Laboratory, Research Centre for Human Development, Faculty of Education and Psychology, Universidade Católica Portuguesa, Porto, Portugal
5. School of Psychology, Education and Sport Science, Blanquerna Ramon Llull University, Barcelona, Spain
6. Department of Psychology, Nottingham Trent University, Nottingham, United Kingdom
7. National Institute for Occupational Safety and Health, (1992-2023, retired), Cincinnati, Ohio, USA

Abstract

The textile industry is a major contributor to environmental and social sustainability challenges, placing consumers at the center of the transition towards more responsible practices. Their adoption of sustainable modes of acquisition, more rigid and structured modes of maintenance and responsible disposal represents a critical lever for change. The be@t questionnaire was designed to capture this complexity by assessing, values, attitudes and behaviors across the full spectrum of a product's lifecycle, from its acquisition to its disposal at end of life. In this study, the data gathered from this survey was analyzed by combining Latent Class Analysis (LCA) and Exploratory Factor Analysis (EFA). LCA identified four distinct consumers profiles, the Knowledgeable consumers, the Conscientious but Uninformed Consumers, the Value maximizers, and the Broadly Sustainable consumers. EFA reduced the dimensionality of the data from over a hundred variables to eight interpretable factors, describing product knowledge, concern for item sustainability, care practices and alternative modes of consumption. The study adopted an exploratory approach, aiming to reveal latent patterns of consumer knowledge, attitudes, and practices in sustainable textile consumption. The findings reveal that sustainable consumption is not a monolithic construct but rather heterogenous and multidimensional, shaped by varying levels of knowledge, attitudes and contextual practices. This study offers a theoretical and practical contribution by advancing understanding of consumers engage with sustainability and by providing guidance for refining interventions and future measurement tools.

Keywords: Latent Class Analysis; Exploratory Factor Analysis; Consumer Segmentation; Sustainable Consumption; Circular Economy.

Introduction

Sustainability is currently a prominent topic of debate, yet it has maintained paramount importance over the past several decades. It carries implications across the social, environmental an economic domains, as well as responsibilities for current and future public health. The United Nations has set out a number of goals for sustainable development (*SD*Gs) (UNDESA, 2024) which require action in multiple plains, be they political, academic, industrial or community. The fashion industry has an undeniable impact on sustainability, affecting not only environmental but also social dimensions. The environmental impact is particularly evident, as annual clothing production has more than doubled since the year 2000, with effects observed across every step of the supply chain, from agricultural and petrochemical inputs to manufacturing and logistics (Niinimäki et al., 2020). The worrying amount of textile waste that has been produced by this rapid growth in production is driven by fast fashion consumption patterns, underscoring the urgent need for changes in consumption modes if the *SD*Gs are to be achieved (Radhakrishnan, 2020).

In this context, understanding the consumer becomes particularly important (Voola et al., 2022). Consumers' behavior is critical in sustainable fashion, as their choices and behaviors directly influence the high rates of consumption and disposal in this industry (Castano Garcia et al., 2021). It is necessary to empower consumers with the knowledge they need, but consumers are not monolithic, and their lifestyles and identities lead them to hold different levels of knowledge across different dimensions of sustainability. Therefore, understanding their specific patterns of behavior and what aspects they prioritize is essential for effective consumer education.

Within the context of this study, a key driver in the sustainability of the fashion industry is achieving circularity, reducing the amount of raw material extracted by reusing material recovered from products at the end of their lifecycle, closing the loop (Geisendorf & Pietrulla, 2018; Stanescu, 2021). Ultimately, the aim is to move the fashion industry away from the traditional model of "take, make, dispose", and for this consumers are essential, as they are required to adopt disciplined practices in clothing use, maintenance and disposal, and to embrace new modes of product consumption, like renting and second-hand shopping (Zamani & Boniadi Naieni, 2020).

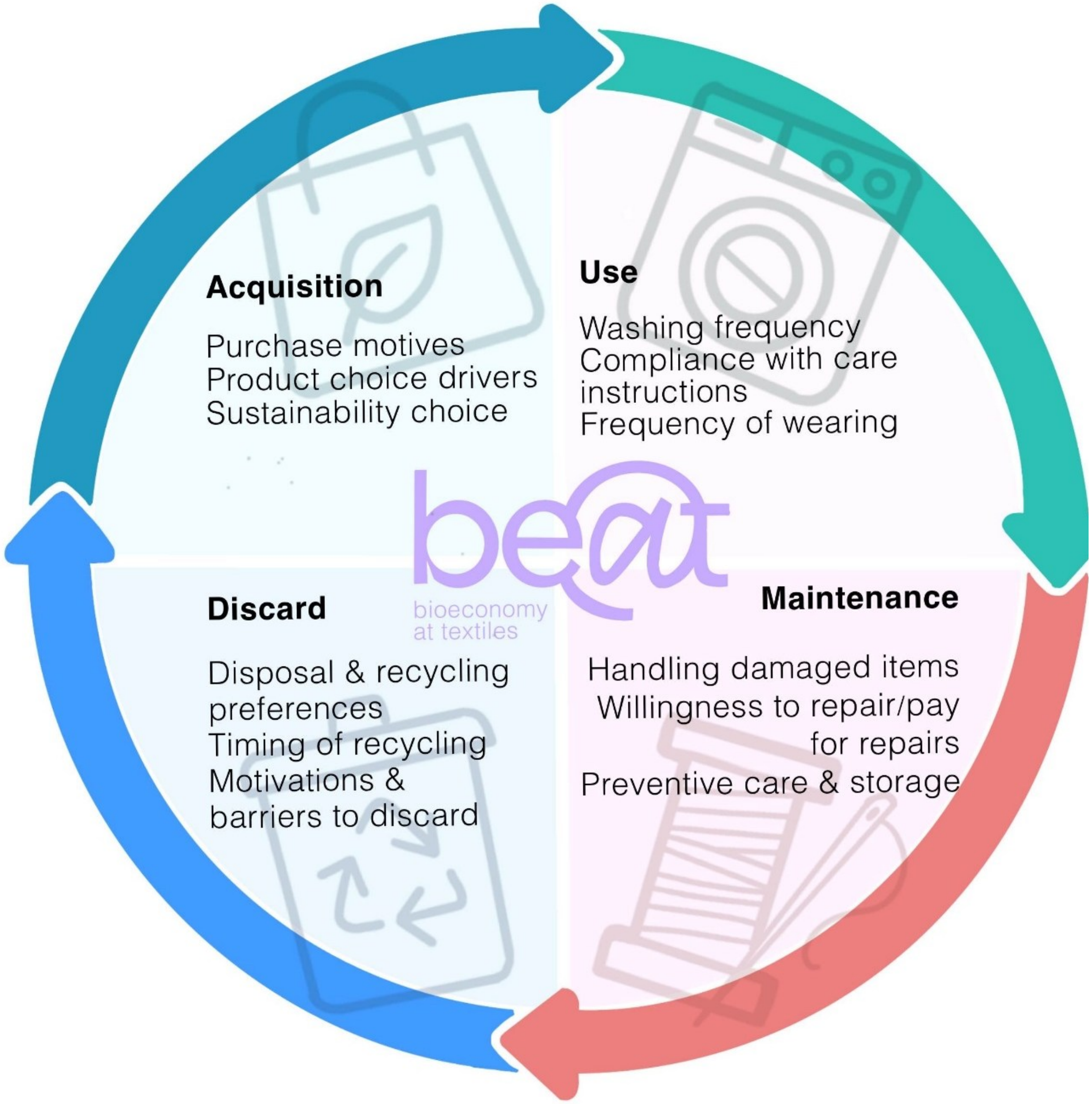
Studies have broadly placed consumers along different latent constructs in the past, an example of this was Milfont and Duckitt's (2010) Environmental Attitudes Inventory, an instrument aiming to quantify a consumer's level of cognitive bias towards preservationist and utilizationist attitudes. In fact, the divides amongst consumers and peoples are so well known that many studies, including within the field of sustainability, have devoted considerable attention to explaining the reasons why consumers cluster together. For example, Tajfel (1978), in his theory of social identity introduced the idea that our values, attitudes and personal norms are intrinsically tied to our positive outlook toward our own in-groups, and an antagonistic view toward our out-groups. Bichieri (2005) and Cialdini(Goldstein et al., 2008; Schultz et al., 2007) go further in explaining this "social effect" through the introduction of social norms, the idea that we learn behaviors by watching how our own social groups and influential people in our communities, and we learn what is and isn't an acceptable behavior and attitude to hold in much the same way.

Of course, as there is a social layer of how we form our behavior, personal motivations, and beliefs also contribute. The most well accepted and leveraged theory exposing this would be Ajzen’s (Ajzen, 1985, 2020; Bosnjak et al., 2020) theory of planned behavior. Ajzen considered Bheavior to be directly predicted by intention, which in itself is predicted by attitude towards the behavior, by personal subjective norms, which may be shaped by social stimuli, and a perception of control over the behavior, or whether a person feels like they themselves are solely accountable for their behavior.

These pre-existent groupings, as well as one’s own identity ensure that different consumers have different levels of engagement with different sustainable and unsustainable behaviors. These behaviors were questioned intensively within the be@t questionnaire (Ribeiro et al., 2023). This instrument divided textile consumption behavior in four large dimensions: Acquisition, Use, Maintenance and Discard. These dimensions adhere to the lifecycle of a clothing item, it is produced, purchased, then used for a period of time which depends strongly on whether the product is well maintained, maintained when damaged, and discarded when unwanted or too damaged to repair. Each of these dimensions contain different concerns, attitudes and behaviors, which are further described in Figure 1. Different pathways within this cycle determine the circular or finite flow of the materials used to produce the clothing (Geisendorf & Pietrulla, 2018).

Figure 1

Structure of the be@t questionnaire



Note. Adapted from (Ribeiro et al., 2023)

This study follows up on Ribeiro and colleagues (2023), who conducted a large-scale survey using a newly built instrument, the be@t questionnaire. The descriptive analysis presented in that study led to questions regarding how the different pathways of consumption, collective attitudes and behaviors, and levels of engagement with forms of sustainable action segmented the sample. Accordingly, this present study explores the latent classes of textile consumers revealed by the be@t questionnaire and describes these classes through latent dimensions identified via Exploratory Factor Analysis. While other studies have mapped sustainability attitudes on specific behaviors, this work goes beyond, attempting to categorize consumer classes along the latent dimensions of sustainable clothing consumption, through an intensive product lifecycle-based survey built with the assistance of industry experts. Therefore, the aim of this study is to identify latent classes of textile consumers based on the be@t questionnaire and to describe them through latent dimensions using a combined LCA and EFA approach. This dual approach allows us to capture the heterogeneity of consumer profiles and the underlying latent dimensions that connect knowledge, attitudes and practices in sustainability. In doing so, the study advances the literature by providing a framework that can inform targeted interventions, consumer education strategies, and policy initiatives, while also offering methodological innovation in the analysis of complex sustainability datasets.

Following this introduction, the next section will detail the methodological approach employed, including the design of the be@t questionnaire and the analytic strategy combining LCA and EFA. This is followed by a presentation of the results, where the identified consumer classes and latent dimensions are described. Finally, the discussion interprets this finding highlighting relevant literature and their implications for consumer research, and policy design.

Methods

Sample

The present study is based on a sample of 1,056 Portuguese residents. Participants were recruited through convenience sampling via social media and direct contact through promotional e-mails. Data were collected between March and May 2023. Respondents who provided consent but did not answer any survey items were removed to ensure sample integrity, yielding a final sample of 1,026. All participants provided informed consent. Data collection was anonymous and performed in conformity with the Declaration of Helsinki (World Medical Association, 2001).

The final sample was predominantly female (~68%), with the majority aged 26 to 60 years (~83%). Around 81% of respondents reported holding a higher education degree. Most respondents reported living in urban or metropolitan areas, with the majority of respondents participating from the North of Portugal. Further, most participants indicated that their household income allowed them to live comfortably or cover expenses. A complete distribution of sociodemographic characteristics for the entire population and stratified by the four latent classes is presented in Table 1.

Table 1

Distribution of sociodemographic variables per latent class

Variable	Options	Class 1	Class 2	Class 3	Class 4	Population
Age	18-25	12.5	13.2	14.5	14.0	13.7
	26-35	27.5	27.3	23.2	37.2	29.8
	36-45	23.8	25.5	26.8	25.6	25.6
	46-60	33.8	28.6	31.5	21.0	27.5
	Over 60	2.5	5.5	3.0	2.2	3.4
Gender	Male	23.8	20.5	37.3	36.4	31.3
	Female	76.3	79.6	62.7	63.3	68.7
	I prefer not to answer				0.27	0.1
Education	1st Cycle of Basic Education (up to 4th year)	0.6			0.5	0.3
	2nd Cycle of Basic Education (up to 6th year)			1.5		0.4
	3rd Cycle of Basic Education (up to 9th year)		0.9	3.6	1.4	1.7
	Secondary Education (up to 12th grade)	11.3	10.0	23.2	18.3	16.8
	Pre-Graduate Higher Education (Bachelor's Degree)	38.1	30.9	38.0	29.7	33.5
	Postgraduate Higher Education (Postgraduate, Master's, Doctorate)	50	58.2	33.7	50.1	47.4
	Rural	13.1	15.0	20.3	16.2	16.6

Type of living area	Urban	61.3	55.9	57.3	63.3	59.8
	Big City	25.6	29.1	22.1	20.5	23.6
	Missing			0.36		0.1
Region	North	76.9	64.6	77.9	76.6	74.4
	Centre	5.6	7.3	5.8	4.3	5.6
	Alentejo		0.5			0.1
	Algarve	0.6	0.5		0.5	0.4
	Azores Autonomous Region	0.6			0.5	0.3
	Madeira Autonomous Region		0.5	0.4		0.2
	Greater Lisbon Area	5.6	13.6	5.4	5.4	7.2
	Greater Porto Area	10.6	13.2	10.5	12.7	11.9
Number of dependents	0	53.1	62.3	46.0	56.8	54.5
	1	16.3	20.0	26.1	21.8	21.7
	2	25.6	16.4	21.0	16.2	19.0
	3	3.1	0.9	3.3	3.5	2.8
	Over 3	1.3	0.5	3.6	1.6	1.9
	Missing	0.6				0.1
Comfort with income	The current income allows me to live comfortably	41.9	45.9	30.4	34.0	36.8
	The current income allows me to pay the expenses	44.4	42.7	49.6	49.1	47.1
	It's hard to live with your current income	8.1	8.6	12.3	10.5	10.2
	It is very difficult to live with the current income	0.6	0.5	3.6	2.2	2.0

I don't know how to judge/ I prefer not to answer	4.4	2.3	4.0	4.3	3.8
Missing	0.6				0.1

*Note***.** Table presents the percentage of item choice per sociodemographic variable displayed per LCA class and for the entire sample.

Survey

The be@t questionnaire was developed by the research team in collaboration with industry partners and is structured around four phases of textile consumption — 1) Acquisition, 2) Use, 3) Maintenance/Repair, and 4) Discard. The instrument also includes sociodemographic items, comprising dichotomous, multiple-choice, and 5-point Likert-response items. A detailed description of the instrument and descriptive results was published previously and is referenced here (Ribeiro et al., 2023).

Data Analysis

The data were analyzed using R (version 4.4.2 Pile of leaves (R Core Team, 2024)) and Jamovi (version 2.6.26; jamovi, 2025). The snowRMM package (Seol, 2025) was used for LCA, and the psych package for Exploratory Factor Analysis (Revelle, 2025). A Bayesian mixed model was tested to see if sociodemographic variables are significant predictors of class membership. Package "brms" was used for this purpose (Bürkner, 2017).

Before analyses, variables corresponding to multiple choice questions (e.g. "What are the key factors you take into consideration when buying an item?") were one-hot encoded, with each option corresponding to one dichotomous variable (1 = yes, 0 = no). For gated questions, i.e., those questions only accessible based on a positive response to a previous question (e.g. "If you answered "Yes", select which sustainable factors you take into account:"), were corrected with Missing responses, i.e., where the participant skipped a question based on the response to a prior "gate", were noted as a non-selection of the "gated" options. The gated questions present in this study are noted with the prefix "SF". All scale variables were treated as ordinal variables. Every non-sociodemographic variable in the survey was included for latent class analysis (LCA). A large number of dropouts at different stages of the survey were found, this can be attributed to the long length of the survey at ~44 questions. However, only participants who did not answer any questions were excluded from the study.

We estimated models for k classes, up to the maximum number of nine classes allowed by the software. Model fit was evaluated using the Bayesian Information Criterion (BIC) (Neath & Cavanaugh, 2012), and Akaike Information Criterion (AIC) (Cavanaugh et al., 2019), as well as Shannon's entropy (Saraiva, 2023). Ranking of model fit was based on the lowest BIC, with the AIC and entropy serving as confirmatory criteria. After suitable candidates were found from the model fit metrics, the class sizes were checked to ensure that no class accounted for less than 5% of the sample, as this would indicate fragmentation, meaning that a new class has been created without adding information. Finally, the remaining candidate classes were analyzed qualitatively to ensure a cohesive thread existed that made class separation logically defensible.

After class identification, a Chi-square test (McHugh, 2013) was used to check which variables significantly distinguished the classes, with Cramér's V (Allen, 2017) having been calculated as a measure of effect size. Because these variables contributed to class formation, these tests are descriptive rather than inferential.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974), based on the polychoric correlation matrix was 0.42, falling below the conventional threshold of 0.50, indicating limited shared variance across the items. Batlett's test (Bartlett, 1937) was significant, $\chi^2(780) = 193{,}849.6$, $p < .001$, confirming that the correlation matrix was not an identity matrix. Despite the low KMO, factor analysis was conducted given the strong theoretical basis of the be@t questionnaire and interpretability of factors, especially as the purpose of this paper was not to validate a psychometric instrument, but to uncover hidden classes that may be present in our sample.

To identify latent dimensions which may help categorize classes further in a more structured manner, Exploratory Factor Analysis was undertaken. As items comprised mixed nominal and ordinal categorical variables, the EFA procedures began with a polychoric correlation matrix (Rigdon & Carl E. Ferguson, 1991). Maximum likelihood with oblique rotation (oblimin) was employed to extract the factors. Structures with 2 to 12 factors were considered. Eight factors were retained due to a close match with the structure of LCA classes, and the theoretical reasoning for questionnaire construction. Items were assigned to factors if they loaded ≥ 0.3. No cross-loadings at this threshold.

Factor scores were computed for each subject, then averaged per class. For each factor, scores were computed by summing the score for each item, for Likert scale-based items, the raw score of the scale was used, for dichotomous variable selection of the item added one point, non-selection added none. For negative loaded items, the score for the item was multiplied by -1, for positively loaded items, the score was multiplied by +1. Composite scores were then averaged by class.

Results

For the LCA, models were estimated, separately, with 2-through-9 classes (T*able 2*; *Figure 1*). Model fit was evaluated through the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and the Sample-size Adjusted Bayesian Information Criterion (SABIC). The AIC mostly decreased, with some reversals, as classes were added, despite the BIC and SABIC reaching their minimum at the 4-class solution and increasing after. Entropy values were consistently high ($0.836 < E < 0.917$), with the 4-class solution achieving an entropy of 0.907, which indicates adequate classification quality. Based on the presented fit indices, parsimony, and interpretability, the 4-class solution was chosen, producing interpretable profiles. The model yielded class membership proportions of 12.6%, 35.5%, 25.7% and 21.1%. The estimated class proportions came to 94.9% rather than 100%. This is expected as snowRMM reports class sizes as posterior-weighted averages rather than deterministic counts and rounding introduces further minor discrepancy. In practice, the proportions approximate 100% and reflect the relative size of each class.

Table 2

Fit statistics for 2-9 class solutions

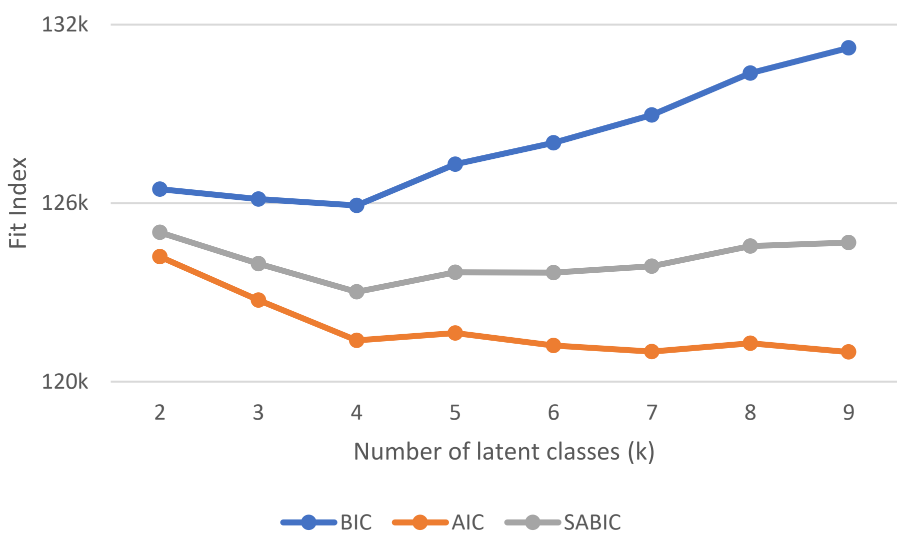
Number of classes	AIC	BIC	SABIC	Entropy
2	124,199	126,467	125,015	0.84
3	122,737	126,141	123,962	0.89

4	**121,381**	**125,921**	**123,015**	**0.91**
5	121,634	127,311	123,678	0.87
6	121,211	128,024	123,663	0.91
7	121,014	128,963	123,875	0.92
8	121,288	130,374	124,558	0.91
9	120,994	131,217	124,674	0.91

Note. Final solution presented in bold. Adapted from Jamovi (version 2.6.26; jamovi, 2025) output.

Figure 1

Fit indices across 2-9 class solutions.



Note. The 4-class solution achieved the lowest BIC and SABIC values and one of the highest entropy scores, supporting its selection as the optimal model.

It is possible to define and name each class profile. Class 1 is characterized by strong knowledge of sustainability, particularly regarding labels, which makes them capable and proactive sustainable actors. They are therefore referred to as the "Knowledgeable Consumers." Class 2 is characterized by a strong willingness to learn and an emerging concern for sustainability. They focus closely on materials and durability. In addition, members of Class 2 are particularly diligent in maintaining their clothing and show strong concern for ensuring responsible product end-of-life. Respondents in this group are therefore referred to as the "Conscientious but Uninformed Consumers." Class 3 does not display any outstanding characteristics in the acquisition or discard of products, but they show a great deal of care with respect to their clothing, i.e., ensuring their clothes are washed properly. These consumers read the manufacturers' instructions and use the appropriate laundry programs to wash each piece of clothing. They are therefore referred to as the "Value Maximizer Consumers." Class 4 is not particularly knowledgeable, but they display the most comprehensive sustainability orientation, not only weighing multiple sustainability factors, but also paying attention to many different facets of sustainability, like economic (i.e. sustainability of production processes) and social sustainability, i.e. valuing the existence of a social score indicating fairness of social conditions involved in product production (e.g. penalizing poor conditions for factory workers or rewarding conditions where workers receive a living wage and suitable benefits), making them the most holistic in terms of acquisition-related sustainability. Respondents in this group are therefore referred to as the "Broadly Sustainable Consumers".

Table 3

Class profile summary

Class	Name	Size	Defining Characteristics
1	Knowledgeable Consumers	12.6%	Highly knowledgeable, able to interpret labels and act sustainably in purchases.
2	Conscientious but Uninformed Consumers	**35.5%**	Care specifically about materials and durability, highly willing to learn, emphasize a responsible end-of-life for their clothing, lack knowledge and ability to maintain products.
3	Value Maximizer Consumers	25.7%	Strong care for products, informed by manufacturers' instructions, little concern at purchase, but maximize value post-acquisition.
4	Broadly Sustainable Consumers	21.1%	Moderately knowledgeable, but aggregate the broadest range of

		sustainability concerns, including environmental and social dimensions.

To understand the demographic inclinations of each class, a Bayesian multinomial logistic regression model was created wherein the dependent variable was the class membership, and the independent variables were the demographic variables. The criterion for significance was the Credible Interval (*CI*) not including 0 (± 0.1).

In this model, the Broadly Sustainable Consumers (#4) were selected as the reference class. The Knowledgeable Consumers (#1) had 1.73 times the odds of being within the age range of 46 to 60 ($\beta = 0.55$, *CI* = [-0.02, 1.11]) and 1.77 times the odds of belonging to the female gender ($\beta = 0.57$, *CI* = [0.17, 0.98]). The Conscientious but Uninformed class (#2) had 2.20 times the odds of being in the above 60 age range ($\beta = 0.79$, *CI* = [-0.004, 1.58]), 2.16 times the odds of being of the female gender ($\beta = 0.77$, *CI* = [0.38, 1.15]), and 1.80 times the odds of living in the greater Lisbon area ($\beta = 0.59$, *CI* = [0.03, 1.17]). All other variables did not significantly predict class membership. The full model summary is presented in Supplementary Table 1. A breakdown of sociodemographic variables per class is presented in Table 1.

Chi-square difference testing of variables between each class revealed two types of contrasts: variables with significant differences between every class and variables with significant differences between pairs of classes. Each of these contrasts was analyzed. Below we present the top five variables for each contrast in terms of significance (p-value). Table 4 describes these variables. Remaining significant variables, as well as Chi-square results, are presented in supplementary material 1.

Table 4

Disambiguation of top five variables for every contrast

Variable	Contrasts	Description
SF – Sustainable Materials	All variables.	Indicates whether participants consider the sustainability of materials in purchasing decisions

Read labels	All variables.	Indicates whether participants habitually read product labels before purchase
SF – Durability	All variables.	Indicates whether participants consider the durability of products when purchasing.
Use of specialized washing programs	All variables; 1*3; 2*3; 3*4.	Frequency of using specialized washing programs (e.g., lingerie, home textiles, etc.)
Willingness to pay	All variables.	Willingness to pay a premium for sustainable textiles (Likert scale)
Knowledge of labels	1*2, 1*3, 1*4, 3*4.	Indicates knowledge of sustainability labels
Willingness to learn	1*2; 2*3; 2*4.	Indicates willingness to learn more about sustainability (Likert scale)
Responsible end of life	1*2.	Indicates whether participants value clothing collection programs that ensure responsible end-of-life
Buy sustainable materials	1*2.	Indicates willingness to buy products made from sustainable materials
PF – Sustainable materials	1*3; 1*4; 2*3.	Indicates whether material sustainability is a factor in purchasing decisions
PF – Durability	1*3; 2*3.	Indicates whether durability is a factor in purchasing decisions
PF – Environmental impact	1*4; 2*4.	Indicates whether environmental impact is a factor in purchasing decisions.
SF – Sustainability of production processes	1*4; 2*4; 3*4.	Indicates whether participants consider production process sustainability
Frequency of washing home textiles	2*3.	Indicates frequency of washing home textiles (Likert scale)
Social sustainability	2*4.	Indicates whether participants consider social sustainability (e.g., fair wages, safe conditions, labor rights)

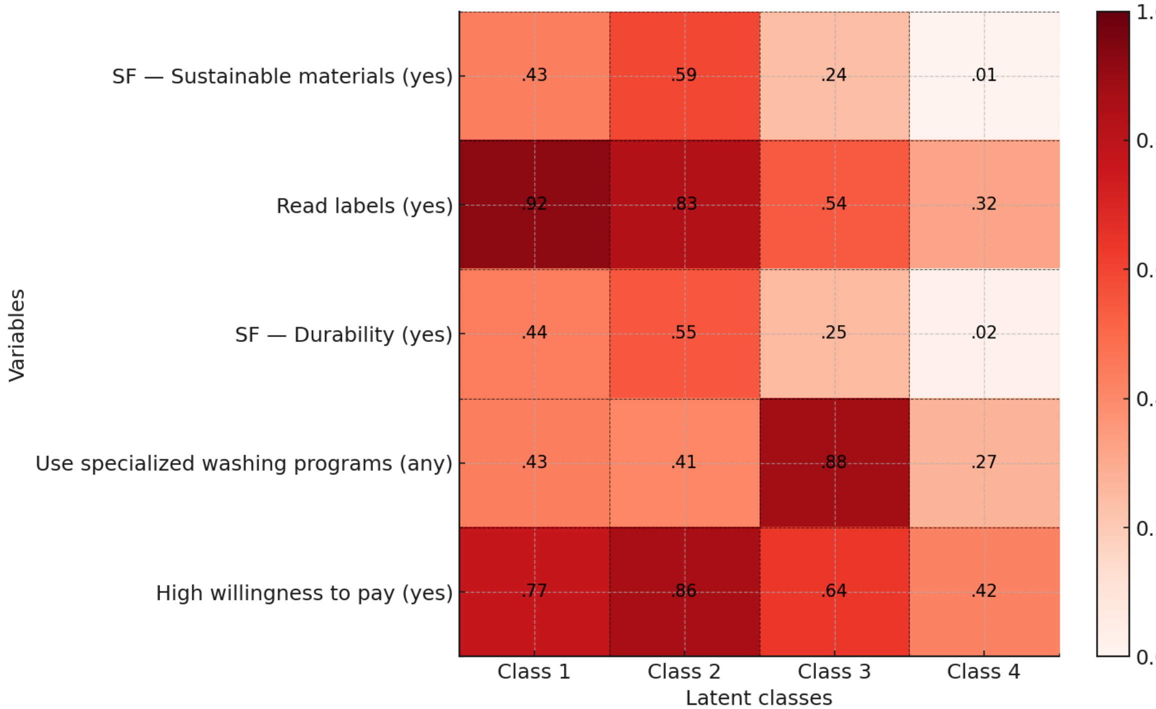
SF – Sustainability certificates	2*4.	Indicates whether participants consider sustainability certifications when evaluating products
Follows care instructions	3*4	Indicates whether participants follow manufacturer care instructions when washing their clothing
Discards products to trash bin	3*4.	Indicates whether participants dispose of textile products in the common trash bin

Note. This table reports selected survey items included in the be@t questionnaire. Variables are organized by questionnaire dimension and coding reference (e.g., 2*4, 3*4). Each description indicates the specific consumer behavior or consideration captured by the item.

All classes displayed distinct response patterns. Class 1 displayed a moderate concern for the sustainability of materials in the clothing items purchased and the durability of said items (.43 and .44, respectively), showing a very high likelihood of reading product labels (.92). Class 2 displayed a similarly moderate, while displaying slightly higher probabilities of caring for the sustainability of materials and durability of purchased items (.59 and .55, respectively), they also displayed a high likelihood of reading product labels, despite being significantly lower than Class 1 (.83), and showing the highest willingness to pay for sustainable products (.86). Class 3 displayed a low concern for the sustainability of materials and the durability of clothing items (.24 and .25, respectively), all the while displaying the highest probability of using specialized washing programs by a very large margin (.87). Class 4 displayed low concern for the sustainability of materials and durability of the clothing they purchased (.01 and .02, respectively), while also displaying a negative attitude towards reading labels (.32) and using specialized washing programs (.26). Figure 2 presents the item-response probabilities for these five variables.

Figure 2

Item response probabilities for the five most discriminating variables across all classes

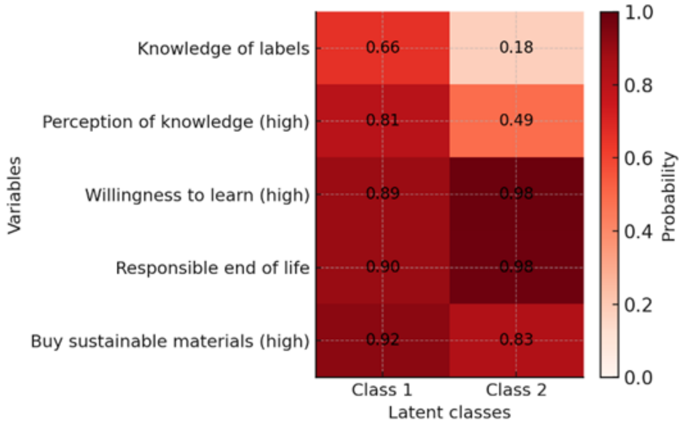


Note. The Knowledgeable Consumers (#1) showed higher probabilities of reading labels, considering sustainable materials and product durability, and reporting greater general knowledge, and Conscientious but Uninformed (#2) consumers displayed a high willingness to pay, while The Value Maximizers (#3) showed the highest use of specialized washing programs. "SF" indicates sustainable factors reported as purchase considerations; "PF" indicates general purchase factors. For "Use specialized washing programs," *any* refers to any reported frequency above zero. For contrasts between classes, values for multi-item variables such as "Knowledge of labels" and "Use specialized washing programs" may vary, as not every item within these variables shows significant differences across all comparisons; only items with statistically significant differences were retained for each relevant contrast.

When we compare The Knowledgeable Consumers (1) and Conscientious but Uninformed (2) consumers, we find marked contrasts on several variables, the significant top five which are displayed in Figure 3. The Knowledgeable Consumers (1) displayed a far greater knowledge of labels (average knowledge score of .66) and to perceive themselves as more knowledgeable (.81 vs. .49). They were also somewhat more willing to buy products made out of sustainable products (.92 vs. .83). The Conscientious but Uninformed class (2) reported being more willing to learn (.99 vs. .89) and was more likely to attempt to provide a responsible end of life for their products (.98 vs. .90).

Figure 3

Item-response probabilities for the top five contrasting variables between Class 1 and Class 2

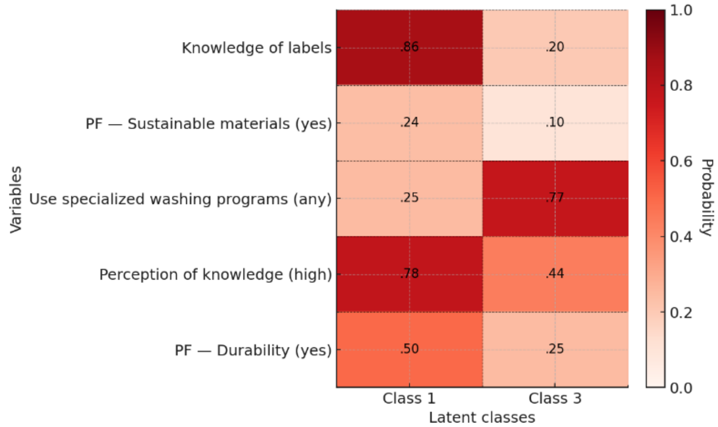


Note. Class 1 showed a higher probability of knowing sustainability labels, perceiving themselves as knowledgeable, and expressing willingness to buy sustainable materials. In contrast, Class 2 showed greater willingness to learn and a stronger likelihood of ensuring a responsible end of life for products. “Buy sustainable materials (high)” refers to a high (top two options in Likert scale) willingness to buy sustainable materials, Responsible end of life refers to whether they consider it important for a clothing collection program provides a responsible disposal pathway for products.

In comparison to the Value Maximizers (#3), the Knowledgeable Consumers (#1) holds a higher probability of recognizing labels indicating an item’s sustainable characteristics (0.86 vs. 0.20), a higher likelihood of considering both sustainable materials and the durability of an item during purchase (0.24 vs. 0.10 and 0.50 vs. 0.25, respectively) and reporting a higher perception of knowledge regarding sustainability (0.78 vs. 0.44). However, the Value Maximizers (3) show a much higher probability of using specialized washing programs with any frequency (0.77 vs. 0.25), showing that this class is more tuned to making their products last through careful maintenance.

Figure 4

Item-response probabilities for the top five contrasting variables between Class 1 and 3

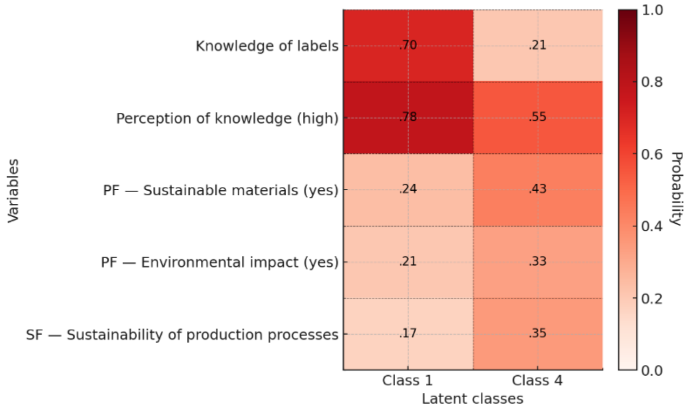


Note. Class 1 showed higher probability of knowing sustainability labels, considering sustainable materials and product durability in purchase decisions, and perceiving themselves as more knowledgeable. In contrast, Class 3 showed the highest overall use of specialized washing programs. "SF" indicates sustainable factors reported as purchase considerations; "PF" indicates general purchase factors. For "Use specialized washing programs," *any* refers to any reported frequency above zero.

When comparing the Knowledgeable Consumers (1) and the Broadly Sustainable Consumers (4), it is possible to see that the Knowledgeable Consumers (#1) stand out in label knowledge (0.70 vs. 0.21), perception of knowledge (0.78 vs. 0.55). However, the Broadly Sustainable Consumers (#4) stand out in terms of the consideration for the sustainability of materials in the products they purchase (0.43 vs. 0.24), the consideration for the environmental impact of these products (0.33 vs. 0.21), and for their consideration of the sustainability of the production processes of the products they purchase (0.17 vs. 0.35).

Figure 5

Item-response probabilities for the top five contrasting variables between Class 1 and 4

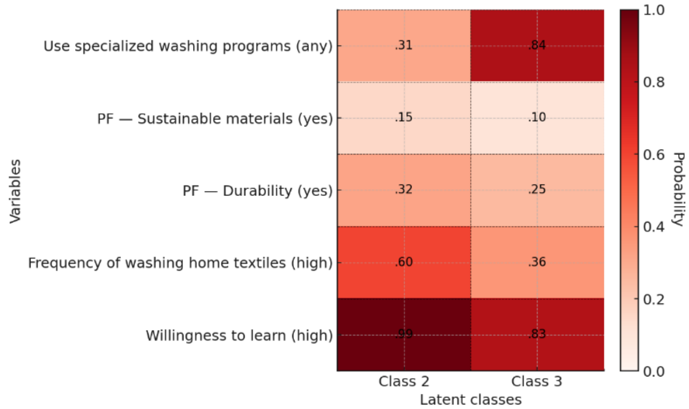


Note. Class 1 showed higher probabilities of knowing sustainability labels, perceiving themselves as knowledgeable, and considering the sustainability of production processes. In contrast, Class 4 placed greater emphasis on the sustainability of materials and the environmental impact of purchased products. “SF” indicates sustainable factors reported as purchase considerations; “PF” indicates general purchase factors.

When comparing the Conscientious but Uninformed (#2) class and the Value Maximizers (#3), it is possible to see that the Value Maximizers (#3) are much more careful in the maintenance of their clothing, preferring less frequent washes (0.36 vs. 0.60) where possible, and using specialized washing programs more frequently (0.84 vs. 0.31), also self-reporting more willingness to learn (0.83 vs. 0.80). The Conscientious but Uninformed (#2) consumers seem more attuned to the sustainable characteristics of products they buy, the sustainability of materials (0.15 vs. 0.10) and durability of products (0.32 vs. 0.25).

Figure 6

Item-response probabilities for the top five contrasting variables between Class 2 and 3

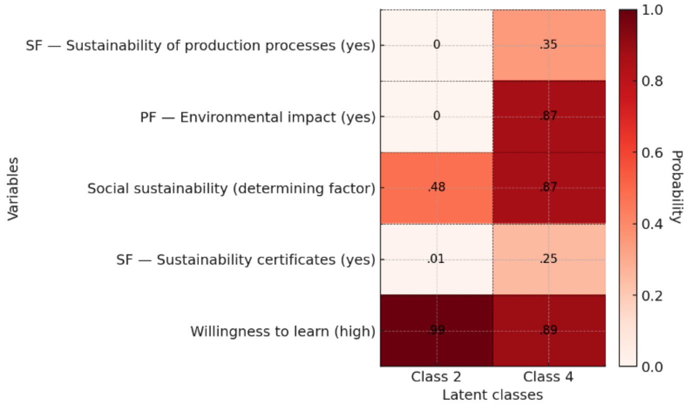


Note. The Value Maximizers (#3) class displayed a more frequent use of specialized washing programs and a lower willingness to learn, while the Conscientious but Uninformed class (#2) showed greater awareness of the sustainability of materials and durability of purchased clothing, as well as higher frequency of washing home textiles. "SF" indicates sustainable factors reported as purchase considerations; "PF" indicates general purchase factors. For "Use specialized washing programs," *any* refers to any reported frequency above zero.

When comparing the Conscientious but Uninformed (#2) and the Broadly Sustainable Consumers (#4) classes, it is possible to uncover the Broadly Sustainable Consumers' (#4) higher tendency towards considering both sustainable factors, like the sustainability of processes (0.35 vs. ~0), the consideration for a product's environmental impact (0.33 vs 0), and consideration for sustainability certificates (0.25 vs. 0.01), along with a paramount concern for social sustainability of products they purchase (0.87 vs. 0.48). The Broadly Sustainable Consumers (#4) also displayed a high willingness to learn (0.98 vs. 0.80).

Figure 7

Item-response probabilities for the top five contrasting variables between Class 2 and 4

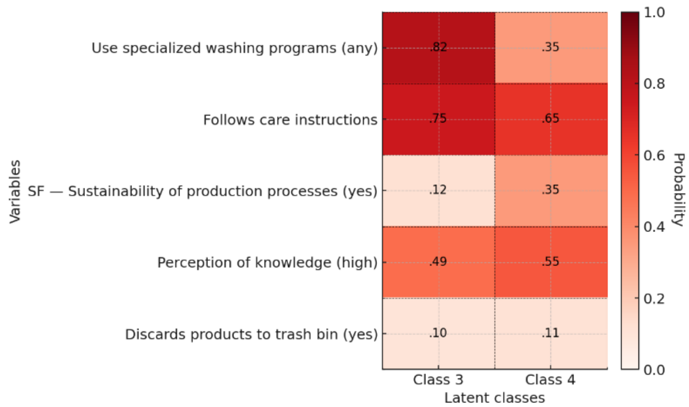


Note. Class 4 displayed a higher probability of considering environmental impact and the social sustainability of clothing items, while Class 2 demonstrated greater attention to the sustainability of materials and durability of purchased clothing, as well as higher frequency of washing home textiles, and willingness to learn. “SF” indicates sustainable factors reported as purchase considerations; “PF” indicates general purchase factors. For “Use specialized washing programs,” *any* refers to any reported frequency above zero.

When comparing classes 3 and 4, a pattern emerges, class 4 appears as the somewhat knowledgeable and concerned consumer, who tends to pay attention to the production (0.35 vs. 0.12) of their clothing, and accompanies this concern with a high perception of knowledge (0.55 vs. 0.49). Meanwhile, class 3 emerges as the class who aims to extract the most value out of their products, taking good care of them using specialized washing programs (0.82 vs. 0.35) and paying attention to manufacturer instructions (0.75 vs. 0.65)

Figure 8

Item-response probabilities for the top five contrasting variables between Class 3 and 4



Note. Class 4 displayed greater concern for the sustainability of purchased products and reported a higher perception of knowledge, while Class 3 aimed to maximize product use by taking good care of items and following manufacturer instructions. "SF" indicates sustainable factors reported as purchase considerations; "PF" indicates general purchase factors. For "Use specialized washing programs," *any* refers to any reported frequency above zero.

Exploratory factor analysis uncovered eight meaningful factors, capturing different aspects of consumer behavior. These included: (1) product knowledge, (2) concern for item sustainability, (3) care practices, and (4) alternative modes of consumption. The disambiguation of the structure is presented in Table 4, while the full factor loadings displaying a color-coded factor structure are presented in Supplementary Table 2.

Table 4

Factor Structure Disambiguation

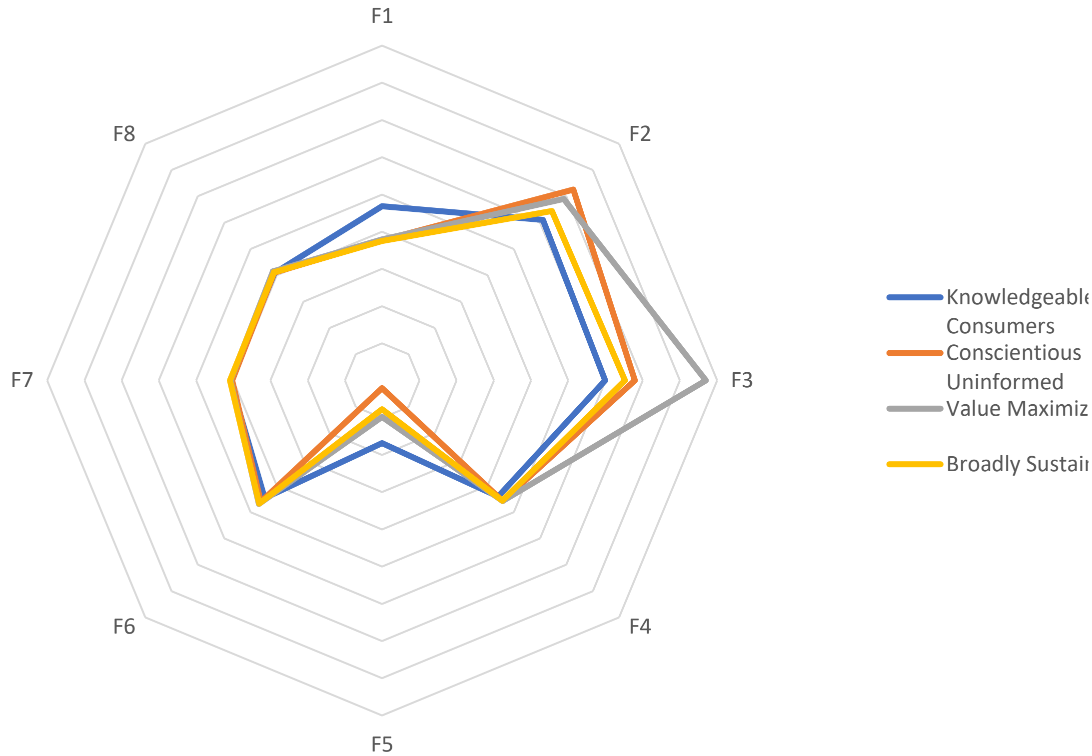
Factor ID	Factor title	Factor description	# items
1	Knowledge vs. Recognition	Captures perceived knowledge and recognition of sustainability labels	16
2	Embracing Sustainability	Encompasses sustainable purchase considerations, willingness to learn, reading labels, and attention social sustainability	15
3	Use of Specialized Washing Programs	Reflects use of specialized washing programs to extend clothing lifespan	11
4	Renting Behaviors	Captures consumer tendencies to rent clothing as an alternative ownership	2
5	Average frequency of washing each type of clothing	Represents the frequency of washing across different clothing types	6
6	2^{nd} Hand Shopping Behaviors	Refers to purchasing and reselling second hand clothing as a form of circularity	4
7	Alternative Consumption Models	Involves the use of professional or third-party laundry providers	4
8	Use of Clothing Repair Services;	Represents reliance on clothing repair services to extend garment life	3

Despite this paper not being a validation effort, Cronbach's alpha was computed for each factor. Internal consistency was generally good to excellent across factors (α ranging from .856 to .944), except for Factor 5 ($\alpha = .679$) and Factor 8 ($\alpha = .406$). These two factors, while showing lower reliability in this sample, represent theoretically meaningful constructs and were therefore retained. In particular, we note that Factor 8, which relates to the use of clothing repair services, may present higher variability and reliability in populations with more technical expertise in clothing repair.

To better understand how each factor distinguishes the latent classes, we computed factor scores for each participant, averaging these scores per class. Figure 9 displays these mean scores on a radar plot, and Table 6 presents the values themselves, allowing for a visual comparison of the sustainability profiles across classes. This process confirms that the Knowledgeable Consumer class scores highest in the Knowledge vs. Recognition class, also scoring the highest in the Frequency of Washing Items Factor. The Conscientious but Uninformed class stands out in the Embracing Sustainability Factor on account of its generally high score in willingness to learn. The Value Maximizers class, as expected, scored highest in the use of specialized washing programs factor. The Broadly Sustainable Consumers class scored high in Embracing Sustainability, due to its wide range of endorsed concerns, but also in Renting and 2^{nd} Hand Shopping behaviors, also scoring high in the use of Third-Party Washing Services, which displays a degree of concern for making their items last longer. The plot justifies the class profiles well, showing both their distinctiveness and the similarities, for example, every class but class 1 displays quite a similar outlook on renting and secondhand shopping behaviors, and every class shows an elevated use of clothing repair services.

Figure 9

Radar plot of latent class profiles across eight sustainability-related factors



Note. Factors F1: Knowledge vs. Recognition; F2: Embracing Sustainability; F3: Use of Specialized Washing Programs; F4: Renting Behaviors; F5: Average frequency of washing each type of clothing; F6: 2nd Hand Shopping Behaviors; F7: Third Party Laundry Services; F8: Use of Clothing Repair Services. Individual plots of each class are presented in Supplementary Figure 1.

Table 6

Mean factor scores per class

Factor	Knowledgeable Consumers	Conscientious but Uninformed	Value Maximizers	Broadly Sustainable Consumers
Knowledge vs. Recognition	3.42	-1.15	-1.05	-1.23
Embracing Sustainability	10.51	16.28	14.51	12.22
Use of Specialized Washing Programs	9.95	13.94	23.48	12.61
Renting Behaviors	2.06	2.88	2.91	2.81
Frequency of washing clothing items	-11.60	-18.98	-15.11	-16.14
2nd Hand Shopping Behaviors	2.34	3.05	3.45	3.38
Third Party Laundry Services	0.41	0.15	0.37	0.45
Use of Clothing Repair Services	0.47	0.50	0.73	0.57

Discussion

This study combined LCA with EFA to analyze patterns of sustainable textile consumption behaviors captured within the be@t questionnaire (Ribeiro et al., 2023). LCA allowed for the identification of distinct classes of consumers based on observed behavioral and attitudinal variables, while EFA provided means to reduce the high dimensionality of the dataset, forming theoretically meaningful factors. Although the survey's psychometric properties were not optimal, reflected in low KMO values and only moderate internal consistency for certain factors, the analysis was not intended as an instrument validation.

Rather, the study was explicitly exploratory, aiming to identify meaningful latent classes of textile consumers' engagements with sustainable actions and to characterize the underlying dimensions that differentiate these behaviors and decisions. While this approach was inevitably constrained by the survey's structure and the complexity of the data, it nevertheless provided valuable insights by linking patterns of sustainable behavior to theoretically grounded constructs and by highlighting directions for refinement in future versions of the instrument. Revisions to the be@t instrument are deferred to future study. For the LCA, a four-class solution was identified as the most robust, minimizing the BIC, achieving acceptable entropy, and maintaining class sizes above 5% threshold. This model was also the most interpretable, allowing us to proceed with a detailed analysis of each class.

LCA identified four distinct consumer profiles reflecting different ways of engaging with sustainable textile consumption. Knowledgeable Consumers stand out for their strong familiarity with labels indicating sustainable characteristics and self-perceive a degree of expertise, although their actions do not always match their knowledge. Despite this, the class fell short of other classes in terms of actual action, particularly in product care and endorsement of alternative consumption vehicles. Conscientious but Uninformed Consumers show a willingness to learn and a strong engagement with sustainability, but their limited knowledge constrains their impact. Value Maximizers are less concerned with sustainability in product purchase but excel in extending the lifespan of their products by carefully following care instructions and making use of specialized washing programs for each type of clothing. Finally, Broadly Sustainable Consumers display the most holistic concern by integrating environmental, economic and social sustainability into their reasoning, while also engaging with alternative modes of consumption like second-hand shopping and renting. Together, these classes highlight a multifaceted view of sustainability in textile consumption, with different groups motivated by distinct considerations of knowledge, values, and practices. These profiles echo prior typologies of sustainable consumers (e.g., green activists, indifferent consumers, convenience-driven buyers) but refine them by anchoring behaviors in the full product lifecycle.

In the Knowledgeable Consumer class (#1), we see a good example of the intention-behavior gap, in a group of people who are knowledgeable regarding sustainability. Considering Ajzen's (1991) model in the Theory of Planned Behavior, where Subjective Norms, Attitudes and Perception of Control predict intention, which motivates behavior, this would signal that this class holds an intention for sustainable action. However, this class falls short in relation to other classes with less subject knowledge, indicating an intention-behavior gap (Tomkins et al., 2018). While it is difficult to speculate about the reasons, the likely candidates may include a concern for price or budgetary constraints (Bocti et al., 2021). Price did not come out as a significant predictor of any class. However, it is possible to enlist several candidates: 1) perhaps a lack of access to a laundry service, 2) a store selling suitable products, 3) a place to adequately discard clothing (Schiaroli et al., 2024), or 4) a social circle with a negative attitude towards sustainable action (Silintowe & Sukresna, 2023). Tajfel's (1978) and Bicchieri's (2005) models would support this hypothesis, this lack of action on the part of this class could indicate that they are included in an in-group who does not frequently engage with sustainability, or live in an environment where the social norm is against their intention, for example if they live in a community that values new clothing as a matter of social standing. The preceding are possible explanations for the discrepancy between classes.

The Knowledgeable Consumer class (#1) also showed to have a demographic bias, with greater odds of including middle-aged women. Studies show women tend to be more attuned to sustainability (Idalgo-Crespo et al., 2022; Phillips & Englis, 2022), which helps to explain why this class shows a larger tendency to be knowledgeable about sustainability in general. However, Xia and Li (2023) have also noted a trend in how gender roles manifest in sustainable action, with men being more overt about their behavior and acting within the public sphere, while women tend to prefer keeping their sustainable action within the private sphere. This may offer an explanation for the lack of sustainable action when this class is compared to others, perhaps the survey simply wasn't able to capture enough of private sphere behaviors and focused too much on over-behaviors related to shopping and use of external services. This may, however, be disputed, as the study did include a class (the Value Maximizers (#3)) described by their care of products, which happens mostly in the private sphere. As such it is a possibility that gender does not explain this behavior.

Knowledge is an empowering tool, and it contributes effectively to one's perception of control (Ajzen, 1991). A lack of knowledge in the Conscientious but Uninformed class (#2) could explain their limited sustainable action in comparison to other classes. Grunert and colleagues (2014) saw this in the context of food labels. In their study, consumers did display concern and willingness to learn but lacked a specific desire to use the information provided in the context of food choices. In fact, lack of knowledge leads to skepticism, which has been directly linked to a lack of purchase intention (Kim & Oh, 2020).

The Conscientious but uninformed class (#2) again presented some bias towards females over the age of 60. Just as studies showed a trend for women displaying more sustainable conscientiousness, Studies have consistently shown that older people tend to have a stronger connection to the environment (Liobikienė & Minelgaitė, 2021; Rajapaksa et al., 2018), while also being more active in sustainable action (Wang et al., 2021). This could explain why this class, even though not as well informed as the Knowledgeable Consumers (#2), presents as more active and concerned. Another factor that may aid in this group's sustainable action is that there is a greater odd of them living in the Greater Lisbon area, close to a Big City with a large amount of amenities and access to the tools and services required for a lot of types of sustainable action, in particular in the acquisition phase, as the opportunity for choice is a lot greater than in a smaller city or a rural area. As such, it is far easier for this class to have access to stores catering to their interest in sustainable materials, or durable materials. Again, Tajfel's (1978) and Bicchieri's (Bicchieri, 2005) models prove relevant, as living in an area like Greater Lisbon also means that there are a lot more public spaces for sustainable action, like bike lanes, a higher density of recycling containers, repair shops, and clothing donation centers, which make it easier to note overt action that create descriptive norms, and in turn it also makes it easier to identify with an in-group holding sustainable values.

The Value Maximizers (#3) class describes a group of people without a particularly large concern for the products they buy in terms of sustainability, but with a deep concern for getting the most out of what they buy. Wilkens and colleagues describe a similar behavior in the context of purchase and willingness to pay (2018). In Wilkens' case, agents aim to get as much value as possible for their budget. Despite us not finding any specific links to concern for price in this class when compared to others, we do see a pattern where consumers buy a product without any specific expectations for its quality or durability, only to treat it to premium care throughout its lifecycle, effectively making it last for a longer time. Consumers have a number of concerns when purchasing a product or endorsing a behavior, be they epistemic, social, emotional, or functional (Tanrikulu, 2021). It is possible to suggest that these consumers look for a more functional product with respect to its ability to last for a long time. This class presented no sociodemographic bias.

Broadly Sustainable class (#4) was shown to hold a broad range of concerns and to act on them effectively. While not the most well-informed of consumers, they understand what is important in the field of sustainability and seem to pursue those concerns. This class endorses alternative modes of consumption like renting and buying second-hand, and accessing third-party services when they lack technical knowledge. Chi and colleagues (2023) found similar tendencies, reporting attitude and knowledge as positive predictors of apparel renting behavior. They also reported personal effectiveness and past behavior as possible predictors, which would match well with the Theory of Planned Behavior's Perception of Personal Control (Ajzen, 1991). Although these predictors were not included in the be@t questionnaire, it would be interesting to study Broadly Sustainable Consumers in the context of their habits and their own perceived effectiveness. As they seem to hold a large number of sustainability concerns, as well as understand the different facets of sustainability, it will be important to study them in their social context. These consumers may be products of an in-group with large sustainability concerns and knowledge, or they themselves may be a driver for their group's sustainability habits (Allcott, 2011; Bicchieri, 2005; Legros & Cislaghi, 2020; Tajfel, 1978).

It is important to recognize that both the structure of the survey and the high dimensionality of the data posed substantial challenges for this work. The extended duration of the instrument raised concerns and was a likely driver of participant dropout. Since missingness could not be assumed random, imputation would have introduced bias and was therefore avoided. From the outset, we considered whether dropout patterns themselves might emerge as meaningful classes in the LCA; however, we ultimately chose to exclude only those participants who discontinued during the sociodemographic section, thereby retaining as many valid responses as possible for analysis. To address this, we adopted a consistent rule for recoding missing values as rejection options when appropriate. For example, SF items were only displayed when a subject had previously indicated concern with sustainability aspects during product purchase. Accordingly, participants who might have been eligible to see the question but were not presented with it had their responses recoded from missing to "No." This strategy preserved items that proved informative in the LCA, as several contributed to significant differences between classes. A revised version of this survey will be designed to address these structural limitations and to capture more systematically the dimensions suggested by the present findings. Also, given the highly educated, urban Portuguese sample, these classes may not generalize directly to other national or socioeconomic contexts. Replication across diverse populations will be essential.

A low KMO in factor analysis indicates that inter-item correlations may not be optimal for factor analysis. However, the interpretability and theoretical foundation of the factors uncovered justify their inclusion, while in future studies including a new sample could attempt Confirmatory Factor Analysis to replicate and validate this factor structure. Parallel analysis was not used in this analysis as the goal for factor analysis was theory driven interpretation of the data. The decision to maintain these items and factors which may be considered statistically inappropriate is also based upon the reasoning for this analysis. The idea behind factor analysis was to try to cope with the high dimensionality of the survey by reducing the many variables of different types that seemed to differentiate between classes into a few dimensions that could provide a summary of each class. The factor analysis fulfilled its purpose with great effect, producing factors well aligned with the main differences found in LCA, as well as with the theory. In fact, not only did EFA aid in representing the data in a simpler way, it also produced what we consider to be a theoretically significant contribution, as it fit remarkably well to some of the dimensions thought up when developing the survey, such as: 1) engagement with sustainability, 2) knowledge of sustainability, 3) product care, and 4) alternative consumption patterns, among others. These findings hint at the importance of these constructs moving outside of the theoretical domain into the practical realm. Future studies should also consider the role of self-report and social desirability bias, as sustainability behaviors are socially valued and may be over-reported. The current results may contribute to an understanding regarding how consumers engage with sustainability.

Ultimately, this study aimed to map the patterns of textile consumption through an instrument built with a focus on sustainability. Although exploratory in approach, the analyses followed a rigid methodology, with decisions accurately documented. From this study, we were able to map four significantly different classes of sustainable consumers: Knowledgeable Consumers, Conscientious but Uninformed Consumers, Value Maximizers, and Broadly Sustainable Consumers. These classes then mapped into eight latent factors aptly named 1) Knowledge vs. Recognition, 2) Embracing Sustainability, 3) Use of Specialized Washing Programs, 4) Renting Behaviors, 5) Frequency of washing clothing items, 6) 2nd

Hand Shopping Behaviors, 7) Third Party Laundry Services, and 8) Use of Clothing Repair Services.

One clear output of this paper is demonstrating that different groups of consumers engage differently in textile sustainability, across different phases of consumption. This study shows that consumers hold different motivations towards sustainable actions, and face different barriers. It is necessary to reiterate the need to invest in removing the barriers to sustainable consumption which lead to intention failing to translate into behavior. This paper examines a sample that is generally well educated, financially comfortable and engages with sustainable consumption in varying degrees. Segmentation may be different when including a more diverse sample from different socioeconomic backgrounds. Nevertheless, the findings underscore the importance of further study to identify the drives of each class, their strengths and the barriers that limit engagement with sustainability. Doing so would provide evidence to guide both new policies that facilitate sustainable consumption and new educational approaches tailored to each segment.

The next step in this research line is to redesign the survey by focusing on the items and dimensions that proved significant in the LCA and loaded onto one of the eight factors. The revised instrument will eliminate "gated" questions and replace multiple-choice items allowing several selections with ranked-choice formats, thereby increasing the proportion of ordinal variables and enabling more balanced factor scoring.

Conclusion

This study provides novel insights into the heterogeneity of sustainable textile consumption by combining LCA and EFA. Four distinct consumer profiles were identified: Knowledgeable Consumers, Conscientious but Uninformed Consumers, Value Maximizers, and Broadly Sustainable Consumers, each characterized by specific motivations, practices and limitations. The emergence of eight latent factors further demonstrated that sustainability engagement is a multidimensional construct that extends across the entire product lifecycle, from acquisition to discard.

Beyond mapping consumer behavior, these findings underscore the importance of moving away from binary definitions of "sustainable" versus "non-sustainable" consumers. Different groups are driven by unique combinations of knowledge, values and practices. Recognizing this diversity is crucial for designing more effective interventions. Policies, educational strategies and industry initiatives can be better targeted by addressing the knowledge gaps, barriers and strengths specific to each segment, whether by fostering informed purchasing, encouraging repair and maintenance, or supporting access to alternative consumption models.

Methodologically, this study illustrates the utility of integrating LCA and EFA to untangle complex consumer data, despite the challenges posed by survey structure and psychometric limitations. Future research should refine and validate the be@t questionnaire, replicate these analyses across more diverse populations, and test the stability of the identified classes over time. Doing so will advance the development of a robust instrument for assessing sustainable consumption, while also generating actionable evidence to guide systemic change in the fashion industry.

References

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In *Action Control* (pp. 11–39). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2020). The theory of planned behavior: Frequently asked questions. *Human Behavior and Emerging Technologies*, *2*(4), 314–324. https://doi.org/10.1002/hbe2.195

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*, *95*(9–10), 1082–1095. https://doi.org/10.1016/j.jpubeco.2011.03.003

Allen, M. (2017). Cramér's V. *The SAGE Encyclopedia of Communication Research Methods*. https://doi.org/10.4135/9781483381411.N107

Bartlett, M. S. (1937). Properties of sufficiency and statistical tests. *Proceedings of the Royal Society of London. Series A - Mathematical and Physical Sciences*, *160*(901), 268–282. https://doi.org/10.1098/rspa.1937.0109

Bicchieri, C. (2005). *The Grammar of Society*. Cambridge University Press. https://doi.org/10.1017/CBO9780511616037

Bocti, M., Zein, S. A. El, & Giannini, R. (2021). Exploring Antecedents to the Attitude-Behavior Gap for Sustainable Fashion Consumption in Germany. *Journal of Sustainable Marketing*, *2*(2), 32–46. https://doi.org/10.51300/JSM-2021-39

Bosnjak, M., Ajzen, I., & Schmidt, P. (2020). The theory of planned behavior: Selected recent advances and applications. *Europe's Journal of Psychology*, *16*(3), 352–356. https://doi.org/10.5964/ejop.v16i3.3107

Bürkner, P. C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. *Journal of Statistical Software*, *80*, 1–28. https://doi.org/10.18637/JSS.V080.I01

Castano Garcia, A., Ambrose, A., Hawkins, A., & Parkes, S. (2021). High consumption, an unsustainable habit that needs more attention. *Energy Research & Social Science*, *80*, 102241. https://doi.org/10.1016/j.erss.2021.102241

Cavanaugh, J. E., Neath, A. A., & Joseph Cavanaugh, C. E. (2019). The Akaike information criterion: Background, derivation, properties, application, interpretation, and refinements. *Wiley Interdisciplinary Reviews: Computational Statistics*, *11*(3), e1460. https://doi.org/10.1002/WICS.1460

Chi, T., Adesanya, O., Liu, H., Anderson, R., & Zhao, Z. (2023). Renting than Buying Apparel: U.S. Consumer Collaborative Consumption for Sustainability. *Sustainability 2023, Vol. 15, Page 4926*, *15*(6), 4926. https://doi.org/10.3390/SU15064926

Geisendorf, S., & Pietrulla, F. (2018). The circular economy and circular economic concepts-a literature analysis and redefinition. *Thunderbird International Business Review*, *60*(5), 771–782. https://doi.org/10.1002/tie.21924

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels. *Journal of Consumer Research*, *35*(3), 472–482. https://doi.org/10.1086/586910

Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. *Food Policy*, *44*, 177–189. https://doi.org/10.1016/J.FOODPOL.2013.12.001

Idalgo-Crespo, J., Benítez-Troya, F., Amaya-Rivas, J. L., Soto, M., Terán-Alvarado, A. F., & Hidalgo-Crespo, A. (2022). Does gender influence a person's environmental concern and pro-environmental behaviours? In L. P. M. M, J. Texier, A. Pena, & J. A. S. Viloria (Eds.), *Proceedings of the LACCEI international Multi-conference for Engineering,* *Education and Technology* (Vols. 2022-July). Latin American and Caribbean Consortium of Engineering Institutions. https://doi.org/10.18687/LACCEI2022.1.1.673

jamovi. (2025). The jamovi project. In *https://www.jamovi.org*. jamovi.

Kaiser, H. F. (1974). An Index of Factorial Simplicity. *Psychometrika*, *39*(1), 31–36. https://doi.org/10.1007/BF02291575

Kim, Y., & Oh, K. W. (2020). Effects of Perceived Sustainability Level of Sportswear Product on Purchase Intention: Exploring the Roles of Perceived Skepticism and Perceived Brand Reputation. *Sustainability 2020, Vol. 12, Page 8650*, *12*(20), 8650. https://doi.org/10.3390/SU12208650

Legros, S., & Cislaghi, B. (2020). Mapping the Social-Norms Literature: An Overview of Reviews. *Perspectives on Psychological Science*, *15*(1), 62–80. https://doi.org/10.1177/1745691619866455

Liobikienė, G., & Minelgaitė, A. (2021). Energy and resource-saving behaviours in European Union countries: The Campbell paradigm and goal framing theory approaches. *Science of the Total Environment*, *750*. https://doi.org/10.1016/j.scitotenv.2020.141745

McHugh, M. L. (2013). The Chi-square test of independence. *Biochemia Medica*, *23*(2), 143. https://doi.org/10.11613/BM.2013.018

Milfont, T. L. (2010). The psychological meaning of preservation and utilization attitudes: A study using the natural semantic network technique. *Psyecology*, *1*(1), 123–136. https://doi.org/10.1174/217119710790709559

Milfont, T. L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, *30*(1), 80–94. https://doi.org/10.1016/j.jenvp.2009.09.001

Neath, A. A., & Cavanaugh, J. E. (2012). The Bayesian information criterion: background, derivation, and applications. *Wiley Interdisciplinary Reviews: Computational Statistics*, *4*(2), 199–203. https://doi.org/10.1002/WICS.199

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment*, *1*(4), 189–200. https://doi.org/10.1038/s43017-020-0039-9

Phillips, D. M., & Englis, B. G. (2022). Green consumption is both feminine and masculine—Just ask the androgynous consumer. *Journal of Consumer Behaviour*, *21*(5), 1028–1039. https://doi.org/10.1002/cb.2052

R Core Team. (2024). _R: A Language and Environment for Statistical Computing_. In *https://www.R-project.org/*. R Foundation for Statistical Computing.

Radhakrishnan, S. (2020). Sustainable Consumption and Production Patterns in Fashion. In M. A. Gardetti & S. S. Muthu (Eds.), *The UN Sustainable Development Goals for the Textile and Fashion Industry* (1st ed., Vol. 1, pp. 59–75). Springer Singapore. https://doi.org/10.1007/978-981-13-8787-6_4

Rajapaksa, D., Islam, M., & Managi, S. (2018). Pro-Environmental Behavior: The Role of Public Perception in Infrastructure and the Social Factors for Sustainable Development. *Sustainability*, *10*(4), 937. https://doi.org/10.3390/su10040937

Revelle, W. (2025). psych: Procedures for Psychological, Psychometric, and Personality Research. In *https://CRAN.R-project.org/package=psych*. Northwestern University.

Ribeiro, P. R., Batista, P., Mendes-Palma, F., Pintado, M., & Oliveira-Silva, P. (2023). Consumers' Engagement and Perspectives on Sustainable Textile Consumption. *Sustainability*, *15*(22), 15812. https://doi.org/10.3390/su152215812

Rigdon, E. E., & Carl E. Ferguson, JR. (1991). The Performance of the Polychoric Correlation Coefficient and Selected Fitting Functions in Confirmatory Factor Analysis with Ordinal Data. *Journal of Marketing Research*, *28*(4), 491–497. https://doi.org/10.1177/002224379102800412

Saraiva, P. (2023). On Shannon entropy and its applications. *Kuwait Journal of Science*, *50*(3), 194–199. https://doi.org/10.1016/J.KJS.2023.05.004

Schiaroli, V., Fraccascia, L., & Dangelico, R. M. (2024). How can consumers behave sustainably in the fashion industry? A systematic literature review of determinants, drivers, and barriers across the consumption phases. *Journal of Cleaner Production*, *483*, 144232. https://doi.org/10.1016/J.JCLEPRO.2024.144232

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The Constructive, Destructive, and Reconstructive Power of Social Norms. *Psychological Science*, *18*(5), 429–434. https://doi.org/10.1111/j.1467-9280.2007.01917.x

Seol, H. (2025). snowRMM. In *https://github.com/hyunsooseol/snowRMM*.

Silintowe, Y. B. R., & Sukresna, I. M. (2023). Understanding Green Self-identity: Does It Affect Green Buying Behavior? Social Identity Theory Perspective. *Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration*, *31*(1). https://doi.org/10.46585/sp31011624

Stanescu, M. D. (2021). State of the art of post-consumer textile waste upcycling to reach the zero waste milestone. *Environmental Science and Pollution Research*, *28*(12), 14253–14270. https://doi.org/10.1007/s11356-021-12416-9

Tajfel, H. (1978). Social Categorization, Social Identity and Social Comparison. In *Differentiation between Social Groups: Studies in the Social Psychology of Intergroup Relations* (pp. 61–76).

Tanrikulu, C. (2021). Theory of consumption values in consumer behaviour research: A review and future research agenda. *International Journal of Consumer Studies*, *45*(6), 1176–1197. https://doi.org/10.1111/IJCS.12687

Tomkins, S., London, B., Isley, S., & Getoor, L. (2018). Sustainability at scale: Towards bridging the intention-behavior gap with sustainable recommendations. *RecSys 2018 - 12th ACM Conference on Recommender Systems*, 214–218. https://doi.org/10.1145/3240323.3240411/SUPPL_FILE/P214-TOMKINS.MP4

United Nations Department of Economic and Social Affairs (UNDESA). (2024). *The Sustainable Development Goals Report 2024*. https://unstats.un.org/*SD*gs/report/2024/

Voola, R., Bandyopadhyay, C., Azmat, F., Ray, S., & Nayak, L. (2022). How are consumer behavior and marketing strategy researchers incorporating the *SD*Gs? A review and opportunities for future research. *Australasian Marketing Journal*, *30*(2), 119–130. https://doi.org/10.1177/14413582221079431

Wang, Y., Hao, F., & Liu, Y. (2021). Pro-Environmental Behavior in an Aging World: Evidence from 31 Countries. *International Journal of Environmental Research and Public Health*, *18*(4), 1748. https://doi.org/10.3390/IJERPH18041748

Wilkens, C. A., Cavallo, R., Niazadeh, R., Taggart, S., Technologies, T., & Research, Y. (2018). *Mechanism Design for Value Maximizers*.

World Medical Association. (2001). World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. *Bulletin of the World Health Organization*, *79*(4), 373–374. https://doi.org/doi:10.1001/jama.2013.281053

Xia, W., & Li, L. M. W. (2023). Societal gender role beliefs moderate the pattern of gender differences in public- and private-sphere pro-environmental behaviors. *Journal of Environmental Psychology*, *92*. https://doi.org/10.1016/j.jenvp.2023.102158

Zamani, J., & Boniadi Naieni, A. (2020). Best Feature Extraction and Classification Algorithms for EEG Signals in Neuromarketing. *Frontiers in Biomedical Technologies*. https://doi.org/10.18502/fbt.v7i3.4621

Supplementary material 1: Significant contrasts between variables

Supplementary material 1.docx

Supplementary Table 1

Supplementary Table 1

Full Socio-demographics model summary

Parameter (Class ID_Predictor)	Estimate	Est.Error	l-95% *CI*	u-95% *CI*
Class 1 - Age 26-35	-0.15	0.27	-0.69	0.39
Class 1 - Age 36-45	0.04	0.29	-0.53	0.61
Class 1 - Age 46-60	**0.55**	**0.29**	**-0.02**	**1.11**
Class 1 - Age Over 60	0.13	0.47	-0.82	1.04
Class 1 - Gender Female	**0.58**	**0.21**	**0.17**	**0.98**
Class 1 - Gender Prefer not to answer	-0.07	0.68	-1.39	1.26
Class 1 - Education 2nd cycle of basic education	-0.14	0.68	-1.49	1.19
Class 1 - Education 3rd cycle of basic education	-0.51	0.60	-1.70	0.65
Class 1 - Education High school	-0.32	0.42	-1.14	0.51
Class 1 - Education Undergraduate degree	0.37	0.40	-0.39	1.15
Class 1 - Education Postgraduate degree	0.29	0.40	-0.48	1.07
Class 1 - Area Classification Urban	0.13	0.25	-0.36	0.64
Class 1 - Area Classification Big City	0.45	0.30	-0.13	1.04
Class 1 - Region Centre	0.14	0.37	-0.60	0.84
Class 1 - Region Alentejo	-0.06	0.69	-1.41	1.27
Class 1 - Region Algarve	0.13	0.63	-1.11	1.36
Class 1 - Region Madeira Autonomous Region	0.14	0.64	-1.12	1.38
Class 1 - Region Azores Autonomous Region	-0.14	0.66	-1.46	1.12
Class 1 - Region Greater Lisbon Area	-0.28	0.37	-1.01	0.42
Class 1 - Region Greater Porto Area	-0.33	0.29	-0.91	0.23
Class 1 - Number of dependents 1	-0.29	0.26	-0.80	0.20
Class 1 - Number of dependents 2	0.36	0.25	-0.13	0.85
Class 1 - Number of dependents 3	-0.19	0.43	-1.06	0.64
Class 1 - Number of dependents over 3	-0.16	0.52	-1.21	0.84

Class 1 - Budget Covers expenses	-0.23	0.20	-0.62	0.16
Class 1 - Budget Difficult to live	-0.20	0.32	-0.85	0.42
Class 1 - Budget Very difficult to live	-0.37	0.55	-1.49	0.67
Class 1 - Budget Can't judge/Prefer not to answer	0.01	0.40	-0.79	0.78
Class 2 - Age 26-35	-0.39	0.25	-0.87	0.09
Class 2 - Age 36-45	0.05	0.26	-0.46	0.56
Class 2 - Age 46-60	0.39	0.27	-0.13	0.92
Class 2 - Age Over 60	**0.80**	**0.40**	**0.00**	**1.58**
Class 2 - Gender Female	**0.77**	**0.19**	**0.39**	**1.15**
Class 2 - Gender Prefer not to answer	-0.08	0.68	-1.41	1.24
Class 2 - Education 2nd cycle of basic education	-0.14	0.67	-1.48	1.15
Class 2 - Education 3rd cycle of basic education	-0.06	0.56	-1.18	1.04
Class 2 - Education High school	-0.28	0.41	-1.09	0.52
Class 2 - Education Undergraduate degree	0.24	0.39	-0.52	1.00
Class 2 - Education Postgraduate degree	0.52	0.38	-0.22	1.28
Class 2 - Area Classification Urban	-0.12	0.23	-0.56	0.33
Class 2 - Area Classification Big City	0.20	0.27	-0.33	0.73
Class 2 - Region Centre	0.46	0.33	-0.19	1.10
Class 2 - Region Alentejo	0.34	0.67	-0.99	1.64
Class 2 - Region Algarve	0.05	0.61	-1.15	1.24
Class 2 - Region Madeira Autonomous Region	-0.18	0.66	-1.49	1.09
Class 2 - Region Azores Autonomous Region	0.27	0.65	-1.01	1.55
Class 2 - Region Greater Lisbon Area	**0.60**	**0.29**	**0.03**	**1.17**
Class 2 - Region Greater Porto Area	0.02	0.26	-0.48	0.52
Class 2 - Number of dependents 1	-0.16	0.23	-0.61	0.28
Class 2 - Number of dependents 2	-0.13	0.25	-0.62	0.35
Class 2 - Number of dependents 3	-0.93	0.47	-1.88	-0.03
Class 2 - Number of dependents over 3	-0.69	0.53	-1.75	0.30
Class 2 - Budget Covers expenses	-0.29	0.18	-0.65	0.06

Class 2 - Budget Difficult to live	-0.14	0.30	-0.72	0.45
Class 2 - Budget Very difficult to live	-0.62	0.52	-1.67	0.37
Class 2 - Budget Can’t judge/Prefer not to answer	-0.66	0.41	-1.48	0.12
Class 3 - Age 26-35	-0.43	0.24	-0.89	0.04
Class 3 - Age 36-45	-0.12	0.25	-0.61	0.37
Class 3 - Age 46-60	0.12	0.25	-0.37	0.61
Class 3 - Age Over 60	0.08	0.39	-0.68	0.84
Class 3 - Gender Female	-0.03	0.16	-0.35	0.29
Class 3 - Gender Prefer not to answer	-0.08	0.68	-1.41	1.24
Class 3 - Education 2nd cycle of basic education	0.76	0.60	-0.41	1.95
Class 3 - Education 3rd cycle of basic education	0.49	0.48	-0.45	1.45
Class 3 - Education High school	-0.10	0.37	-0.82	0.62
Class 3 - Education Undergraduate degree	-0.10	0.36	-0.81	0.61
Class 3 - Education Postgraduate degree	-0.56	0.36	-1.28	0.15
Class 3 - Area Classification Urban	-0.27	0.20	-0.66	0.13
Class 3 - Area Classification Big City	-0.01	0.25	-0.50	0.48
Class 3 - Region Centre	0.03	0.32	-0.61	0.67
Class 3 - Region Alentejo	-0.08	0.67	-1.40	1.21
Class 3 - Region Algarve	-0.37	0.63	-1.63	0.83
Class 3 - Region Madeira Autonomous Region	-0.34	0.63	-1.59	0.88
Class 3 - Region Azores Autonomous Region	0.19	0.64	-1.08	1.44
Class 3 - Region Greater Lisbon Area	-0.07	0.33	-0.71	0.55
Class 3 - Region Greater Porto Area	-0.24	0.25	-0.74	0.25
Class 3 - Number of dependents 1	0.16	0.21	-0.25	0.56
Class 3 - Number of dependents 2	0.22	0.22	-0.22	0.66
Class 3 - Number of dependents 3	-0.02	0.39	-0.80	0.73
Class 3 - Number of dependents over 3	0.59	0.43	-0.25	1.42
Class 3 - Budget Covers expenses	0.09	0.18	-0.25	0.44
Class 3 - Budget Difficult to live	0.14	0.27	-0.38	0.67

Class 3 - Budget Very difficult to live	0.57	0.42	-0.26	1.39
Class 3 - Budget Can't judge/Prefer not to answer	0.13	0.36	-0.59	0.84

Note. Significant variables are in bold.

Supplementary Table 2
Full factor loadings for final Exploratory Factor Analysis

Item	Knowledge vs. Recognition	Embracing Sustainability	Use of Specialized Washing Programs	Renting Behaviors	Frequency of Washing Clothing Items	2^{nd} Hand Shopping Behavior	Use of Third Party Washing Services	Use of Repair Services
Updates wardrobe	0.15	0.10	-0.02	-0.04	0.01	-0.22	0.11	-0.02
Takes Advantage of Discounts	0.03	0.15	-0.09	-0.03	0.02	-0.10	0.05	0.00
Replace old and worn out	-0.06	-0.03	0.02	-0.04	0.14	0.16	-0.04	0.03
Clothing for occasions	0.02	0.01	-0.06	-0.04	0.15	-0.14	0.00	0.01
Necessity	0.00	0.02	0.02	-0.03	0.00	-0.13	0.00	0.01
Other reasons for purchase	-0.06	-0.04	-0.02	0.01	-0.04	-0.08	0.04	-0.05
Average purchases	-0.05	-0.05	0.12	-0.04	0.06	0.21	-0.05	0.06
Considers price in purchase	0.01	0.21	0.10	0.00	0.07	-0.18	-0.02	-0.04
Considers quality and functionality in purchase	0.04	-0.17	0.08	-0.04	0.14	0.12	0.03	0.05
Considers fashion trends in purchase	0.15	0.09	-0.04	0.03	-0.01	-0.12	0.10	0.01
Considers Environmental	0.06	-0.52	-0.06	0.02	0.09	-0.12	0.02	0.00

impact in purchase								
Considers style in purchase	0.04	0.17	0.00	-0.02	0.25	-0.24	0.05	-0.05
Considers durability in purchase	0.08	-0.19	0.06	0.03	0.19	-0.09	0.05	-0.03
Considers comfort in purchase	0.05	0.03	0.01	-0.02	0.17	-0.04	0.02	0.01
Considers brand-reputation in purchase	0.07	-0.02	-0.04	-0.05	0.21	-0.17	0.13	0.00
Considers ease of purchase	0.00	0.07	0.01	0.03	0.19	-0.10	0.04	0.00
Considers sustainable practices in purchases	-0.05	-0.43	-0.07	0.02	0.08	-0.16	0.03	-0.01
Considers sustainable materials in purchase	0.03	-0.57	0.08	0.00	0.01	-0.10	0.02	-0.04
Considers fair labor practices in purchase	-0.06	-0.37	-0.04	0.02	0.07	-0.13	0.04	-0.01
Considers other factors in purchase	0.05	0.01	0.06	0.01	0.01	-0.09	-0.05	0.04
Sustainable factors sustainable materials	-0.01	0.67	0.01	-0.01	-0.02	0.01	-0.02	-0.01

Sustainable factors sustainable sustainable processes	-0.03	0.55	0.05	-0.01	-0.07	0.05	0.03	0.04
Sustainable factors sustainable Durability	-0.02	0.61	0.03	-0.01	-0.02	0.01	0.04	0.07
Sustainable factors sustainable packaging	0.01	0.31	0.06	-0.03	-0.06	0.22	-0.04	0.00
Sustainable factors sustainable certificates	-0.06	0.46	0.03	0.00	-0.02	0.03	0.01	0.01
Sustainable factors sustainable other	0.00	0.03	-0.05	-0.01	0.01	0.14	0.01	0.03
Willingness to change	0.08	0.45	-0.04	0.01	0.08	-0.05	0.08	-0.01
Willingness to pay	0.01	0.49	0.00	0.01	-0.04	-0.12	0.00	-0.04
Willingness to buy sustainable materials	0.05	0.40	-0.07	0.00	-0.06	-0.03	-0.03	0.02
Perception of knowledge	-0.32	0.27	0.06	-0.03	0.18	0.06	0.00	0.05
Willingness to learn	0.07	0.42	-0.05	0.04	0.03	0.03	-0.01	-0.03
Social score influence	-0.04	-0.38	-0.01	-0.04	-0.03	0.08	-0.02	-0.01
Read labels	0.16	-0.49	0.08	0.02	-0.11	0.06	0.01	0.06
GOTS	0.54	-0.10	-0.01	0.02	-0.16	0.02	0.01	0.05

GRS	0.67	-0.01	0.01	0.02	-0.04	0.04	-0.01	-0.03
RCS	0.66	0.03	0.03	0.01	-0.03	0.00	-0.08	0.00
OCS	0.57	-0.06	0.03	0.01	-0.05	0.02	-0.07	-0.05
RWS	0.61	-0.03	0.02	-0.09	0.03	-0.05	-0.01	-0.05
RDS	0.58	0.00	-0.01	-0.13	0.02	-0.03	-0.03	0.02
OEKOTEX100	0.42	-0.01	0.07	0.03	-0.11	-0.01	0.02	0.05
OEKOTEXGreen	0.46	0.00	-0.01	0.02	-0.10	0.04	0.03	0.04
BCI	0.69	-0.01	-0.02	0.02	-0.01	0.00	0.05	0.00
C2C	0.37	-0.04	0.09	0.02	0.23	-0.08	0.09	-0.02
EUFLAX	0.56	0.06	-0.11	0.02	0.02	0.03	0.07	0.05
FTCOTTON	0.39	-0.10	0.00	0.02	0.24	0.00	-0.03	-0.01
Bluesign	0.60	0.08	-0.02	0.01	0.02	0.03	-0.03	-0.02
CmiA	0.57	0.06	0.00	0.01	0.09	-0.01	0.01	0.03
EUECOLABEL	0.30	-0.17	0.10	0.01	0.09	0.00	0.02	0.00
FSC	0.42	-0.07	0.10	0.02	0.14	-0.07	0.03	-0.01
Other certificates	-0.20	0.16	-0.03	0.02	0.13	-0.01	-0.06	-0.07
Information purveyor	-0.03	-0.06	-0.06	-0.05	0.09	0.28	-0.08	0.01
Prefered information channel	-0.14	0.08	-0.04	-0.03	0.00	0.07	-0.04	-0.05
Share with family	0.02	0.16	0.06	-0.04	0.07	0.21	0.05	-0.03
Share with known people	0.03	0.16	0.03	-0.03	0.00	0.21	-0.06	-0.05
Share with unknown people	0.03	0.10	-0.01	-0.02	0.10	0.21	-0.05	0.00
Types of rent outerwear	0.01	-0.05	-0.02	-0.01	-0.03	0.12	0.04	-0.01
Types of rent common wear	0.00	0.00	-0.01	1.00	0.01	-0.01	-0.01	-0.01

Types of rent cerimony wear	0.02	-0.05	0.06	-0.02	-0.05	0.16	-0.02	0.02
Types of rent footwear	0.00	0.00	-0.01	1.00	0.01	-0.01	-0.01	-0.01
Types of rent accessories	0.00	-0.02	0.10	0.70	-0.03	0.04	0.02	0.06
2nd hand plaforms facebook	-0.03	-0.06	0.04	-0.04	0.07	0.35	0.04	0.07
2nd hand plaforms vinted	0.03	0.08	-0.02	0.02	0.08	0.61	0.02	-0.06
2nd hand plaforms olx	0.03	0.01	-0.01	0.09	0.04	0.44	0.03	0.01
2nd hand plaforms ebay	0.00	0.03	-0.01	0.29	-0.01	0.18	0.07	-0.04
2nd hand plaforms poshmark	0.03	0.07	0.02	-0.01	-0.02	0.14	-0.02	0.04
2nd hand plaforms thredup	0.02	0.02	0.01	-0.01	0.07	0.11	-0.04	0.00
2nd hand plaforms physical store	0.04	0.16	0.02	-0.03	-0.10	0.32	0.06	0.00
Times using textile	-0.03	0.00	-0.11	-0.07	-0.16	-0.07	0.01	-0.05
Item longevity	0.01	0.07	-0.12	0.03	-0.14	-0.04	0.07	0.01
Avg frequency of wash t-shirt	0.07	0.05	0.15	-0.03	-0.45	-0.01	0.03	-0.02
Avg frequency of wash wools weater	0.02	0.08	0.02	0.00	-0.58	-0.11	0.01	0.03

Avg frequency of wash denim	0.06	0.05	-0.10	0.01	-0.59	0.01	0.05	0.00
Avg frequency of wash ceremonial wear	0.03	-0.02	0.01	-0.01	-0.32	-0.07	0.06	0.03
Avg frequency of wash motherhood clothing	0.00	-0.04	-0.04	0.02	-0.47	-0.03	0.01	-0.03
Avg frequency of wash underwear	-0.03	-0.04	0.12	-0.02	-0.18	0.03	0.01	-0.02
Avg frequency of wash home textiles	-0.06	-0.03	-0.08	-0.03	-0.43	0.00	-0.02	-0.01
Read labels instructions wash	0.01	-0.29	-0.16	-0.04	-0.10	0.19	0.06	0.03
Use of washing program cotton	-0.09	0.05	0.47	-0.04	0.06	-0.04	-0.03	-0.04
Use of washing program synthetic	0.02	0.03	0.52	0.04	0.01	-0.05	-0.01	-0.01
Use of washing program fastmix	0.05	-0.10	0.32	-0.01	-0.02	0.11	-0.01	0.01
Use of washing program delicates	-0.02	0.06	0.64	0.01	-0.02	-0.03	-0.06	-0.04
Use of washing program wool	-0.01	0.04	0.73	0.02	-0.04	-0.01	-0.01	0.00
Use of washing program rinse	-0.05	-0.07	0.61	0.01	-0.01	-0.03	-0.04	0.02
Use of washing program dark colors	0.02	0.00	0.66	-0.01	0.05	-0.01	0.00	0.02

Use of washing program lingerie	0.02	0.01	0.74	-0.01	0.04	0.03	-0.01	-0.01
Use of washing program mixed fabrics	0.01	-0.06	0.62	-0.01	0.04	0.04	0.00	-0.01
Use of washing program easy	0.01	-0.03	0.72	0.01	-0.03	0.01	0.09	0.02
Use of washing program duvet	0.02	0.02	0.65	0.01	-0.02	-0.03	0.04	0.00
Chemicals use softener	0.03	0.10	-0.10	0.00	-0.04	-0.06	0.04	-0.01
Chemicals use detergent	0.02	0.12	0.16	-0.02	-0.06	0.09	0.02	0.04
Chemicals use soap	-0.01	-0.12	-0.13	0.02	0.03	-0.05	-0.03	0.01
Chemicals use chemical free washball	0.00	-0.08	0.00	0.00	0.04	0.01	0.00	-0.07
Chemicals use None	-0.03	0.01	-0.08	0.01	0.09	0.02	-0.02	-0.05
Chemicals use other	0.00	-0.07	0.08	0.01	0.05	-0.15	-0.01	0.03
Third party washing cost	-0.03	0.10	-0.01	-0.01	0.01	-0.03	0.64	-0.02
Third party washing environmental impact	0.00	-0.22	-0.12	0.02	0.05	-0.03	0.15	0.01
Third party washing proximity	0.07	-0.01	0.03	-0.03	0.09	-0.06	0.56	-0.08

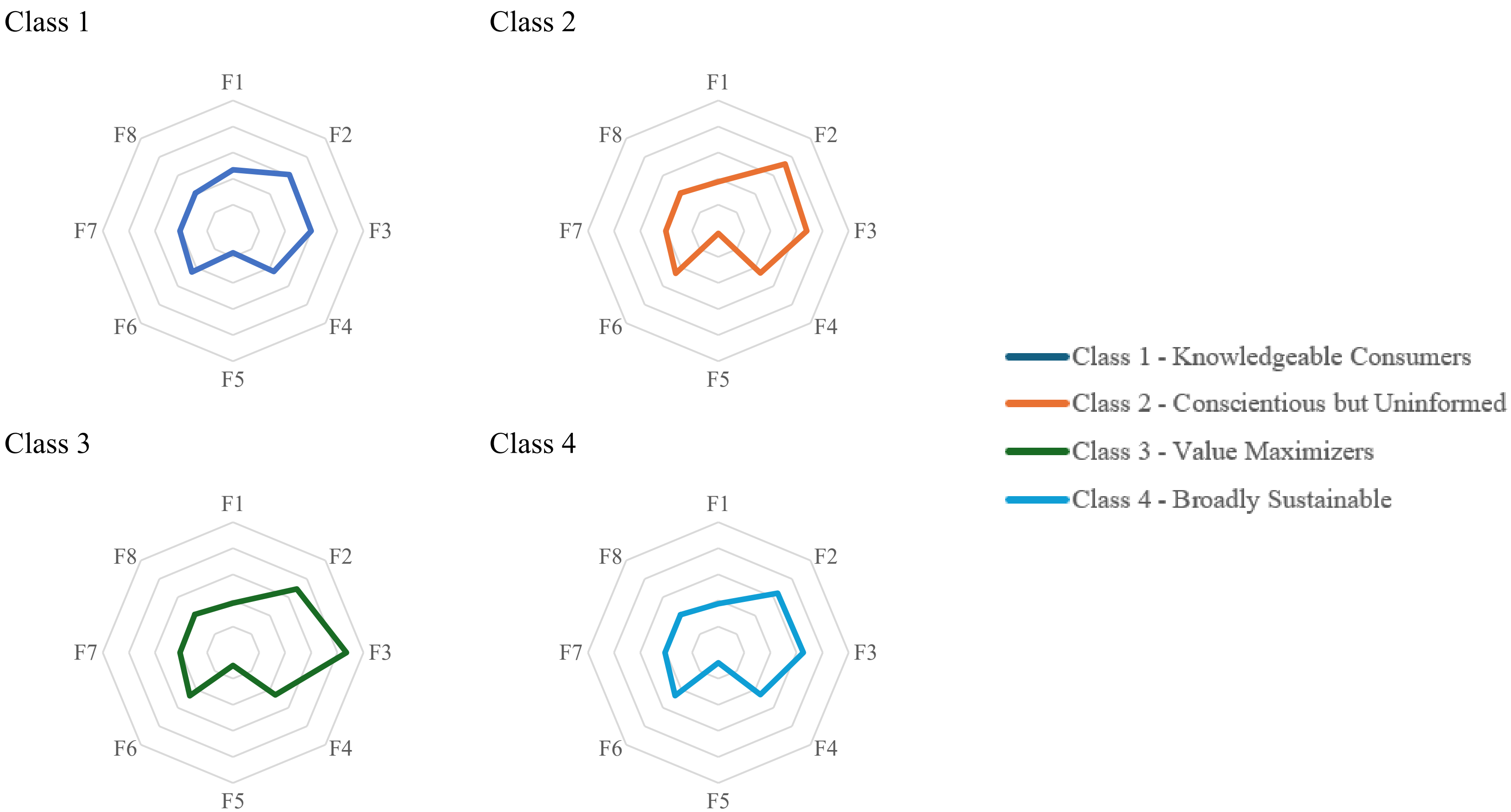
Third party washing quality	-0.01	-0.06	0.02	-0.03	0.01	-0.02	0.58	0.04
Third party washing special treatment	-0.03	-0.06	-0.02	0.02	0.05	0.02	0.24	0.06
Third party washing Don't use	0.02	0.01	0.00	-0.01	0.04	-0.03	-0.95	-0.01
Care for article type when washing	-0.02	-0.12	-0.12	-0.04	-0.14	-0.03	0.29	0.00
Drying items	-0.11	-0.09	-0.01	-0.02	0.07	0.06	-0.09	-0.01
Treatment of damaged items garbage bin	-0.01	0.24	0.03	0.03	0.07	-0.08	0.08	-0.03
Treatment of damaged items repair services	0.13	0.01	0.05	0.03	0.12	-0.07	0.06	0.06
Treatment of damaged items repair by myself	0.00	-0.19	-0.04	0.04	0.16	-0.17	0.01	0.02
Treatment of damaged items alternative uses	-0.02	-0.07	0.05	0.05	0.16	-0.15	-0.01	0.05
Treatment of damaged items donation recycling	0.09	-0.14	0.01	-0.03	0.00	0.03	-0.01	0.03
WIllingness to pay repair	0.08	0.01	0.02	0.02	0.13	0.03	0.15	0.12

Use of repair services Seamstress	0.01	0.00	0.00	0.00	0.03	0.00	0.01	1.00
Use of repair services Thirdparty	0.05	-0.04	0.04	0.00	0.11	0.10	0.11	-0.59
Use of repair services Brand repair	0.05	-0.01	-0.11	-0.14	0.02	-0.12	0.03	-0.13
Use of repair services Other	-0.03	-0.04	0.01	0.01	-0.04	-0.13	-0.11	-0.47
Discard Donation	0.04	-0.10	-0.02	0.07	0.03	-0.05	0.03	0.05
Discard Recycling containers	-0.04	-0.07	0.06	0.04	0.02	0.06	0.08	0.04
Discard Store recycling	0.04	-0.16	0.04	0.02	0.03	-0.21	0.00	-0.05
Discard Resale	-0.01	-0.05	0.07	-0.03	-0.01	-0.56	0.00	0.04
Discard Creative use	0.03	-0.13	-0.07	0.03	0.08	-0.16	0.00	-0.04
Discard Garbage bin	0.04	0.27	0.06	0.03	0.17	-0.10	0.06	-0.01
Discard other	0.01	-0.06	0.05	0.00	-0.01	-0.06	-0.04	0.03
When discard	0.03	0.14	0.02	0.02	0.10	0.07	-0.06	0.02
Reasons for recycling responsible end of life	-0.09	-0.26	0.14	-0.04	0.02	0.11	-0.04	-0.03
Reasons for recycling Brand receives	0.07	0.01	0.00	0.02	0.09	-0.12	0.06	0.02

Reasons for recycling reward	0.11	0.25	-0.04	0.05	0.09	-0.19	0.07	-0.01
What would lead to recycle	-0.01	0.05	0.04	-0.01	0.07	0.00	0.04	-0.06
Items discarded per year	0.03	0.00	-0.01	0.00	0.16	0.16	-0.06	0.05

Supplementary Figure 1

Radar plots per class



Chapter 5: Discussion and Conclusion

5.1. Discussion of Contributions

5.1.1 Study 1: The Social Circle Effect

Study 1, titled "The Social Circle Effect" tackled two main gaps. The first gap addressed is the lack of studies linking social norms and identity to theories directly to environmental attitudes. While plenty of studies have shown how important the social aspect is to the formation of attitudes and by extension, intentions (see Section 1.2), no work has been developed connecting these to the important construct of environmental attitudes, which has been a key concept of environmental psychology literature. Environmental attitudes are a key part of how we engage with pro-environmentalism. A more utilitarian person has less of a natural connection and concern for the natural environment, while a more preservationist holds a natural bias towards the preservation of nature.

The second gap addressed is the lack of studies looking into the proximal social circle using structured instruments. The study of this social dimension typically relies on self-report through non-psychometric methods. This approach has well known biases, such as social desirability. Therefore, the creation of an instrument like our EAI_s is of vital importance in pushing for the more structured and psychometrically valid measurement for the perception of the close social circle's engagement with specific constructs.

The Social EAI was derived from the Environmental Attitudes Inventory, adapting high-loading items to capture perceived rather than self-endorsed attitudes. We took the highest factor loading item for each first-level latent construct, allowing us to calculate the scores for our constructs of interests, Preservation and Utilization, the instruments second-level constructs. These items were reworded to shift focus from the self to the proximal social circle. The resulting instrument was the Social EAI, directly linked to participants' perception of social circle Environmental attitudes. This allowed us to reliably model the relationship between the social circle to individual attitudinal pathways.

This study held the secondary objective to answer to the ubiquitous calls from literature for ecologically valid consumer research (see Section 1.3). As such, we made the effort to recruit participants at point-of-sale locations – shopping centers, neighborhood markets and touristic markets. This allowed us to reach participants in the first place where they must exert sustainable action.

As a tertiary objective, we intended to show that environmental attitude varies by national context. We attempted to test this effect within the Iberian Peninsula. This contrast was chosen as Spain and Portugal traversed distinct paths in important dimensions, like environmental policy, educational policy, and general culture dimensions.

Finally, as a fourth objective, we intended to bridge the gap between demographic and social segmentation models further, by demonstrating that there are interaction effects between demographic variables and the social circle's perceptions.

This methodology allowed us to gather suitable theoretical outcomes. The first and foremost outcome, responding to our principal objective, was the notion that the perceptions of close social circles strongly predicted individual environmental attitudes. Our results also confirmed long-standing effects reported in literature regarding political orientation and gender's role in building pro-environmental attitudes. We attempted to show there are interaction effects between social circle perceptions and demographic variables. No significant interactions were found. No cross-cultural effects were observed; despite this we were able to demonstrate that the social circle was a significant predictor steadily across both national contexts.

This study presents methodological contributions beyond the development of the EAI_s, in the form of the instrument development process itself. Our approach is replicable to multiple study problems. This means that it is possible to measure social circle perceptions regarding psychometrized constructs in a structured and sound way. This approach may even be transferable to other domains beyond consumer research. Additionally, given the calls coming from multiple fields of research for the introduction of Bayesian modelling, our work stands at the bleeding edge. This study may serve as further proof of concept of Bayesian methodology and aims to contribute to its widespread adoption.

Limitations can be found within this study in the modest sample size and the reliance on convenience sampling. The cross-sectional design can also be seen as a limitation as it does not allow us to demonstrate the probable temporal dynamics of social influence. Additionally, the lack of inclusion of true behavioral measures means we are not able to observe whether the socially constructed environmental attitude truly converts into pro-environmental action. Finally, our conclusions are subject to the homology alternative – it is possible that rather than the close social circle shaping the attitudes of the participants, the attitudes themselves lead them to search for a social circle holding similar values.

5.1.2 Study 2: How Do You Buy Without Constraints?

Study 2, titled "How You Buy Without Constraints?", aimed to address a primarily methodological gap, to demonstrate the feasibility and theoretical added value of applying mechanistic EEG analyses to naturalistic decision-making contexts. Recent reviews have revealed the field of neuromarketing has suffered from an overreliance in what pertains to its use of EEG technology, with a vast majority of studies based on band-power heuristics and laboratory based, unnatural tasks, far apart from the purchase experience. This leads to a lack of mechanistic insight which comes from more complex methodologies intended for mapping brain networks involved in decision making.

The release of the NeuMa dataset, which aimed to leverage EEG and Eye-tracking multimodality in exploring a naturalistic paradigm of unconstrained purchasing decision-making, allowed us to address the calls for naturalistic paradigms. The unconstrained context, which engaged participants in a purchasing process without the consideration of time or budget, was initially thought of only as a limitation, as it reduces generalizability of the results. However, it presented the opportunity to compare this phenomenon to previous works which explored constrained purchasing and led us to suggest further works which may prove transformative in the study of consumer decision making.

We intended to address these gaps by applying underused methodologies in the field – sLORETA-based source localization, which allows us to overcome EEG's spatial limitations, and functional connectivity analyses, identifying brain networks used in the decision-making process, not just relying on isolated activations. Rather than employing broad frequency bands, we explored fine-grained analysis of Alpha and Beta sub-bands, allowing us to capture nuanced processes. In this work, we again employed Bayesian modelling, in the form of Bayesian logistic regression for predictive modelling of purchase vs. rejection. While not being unique in the application of source-localized connectivity, this is one of the first applications in the field of consumer neuroscience, looking to set a precedent for future studies to employ mechanism-focused methods.

The application of this method allowed us to identify two distinct neural mechanisms. The purchase pathway revealed a reliance on mnemonic valuation through parahippocampal activity, connected to the posterior cingulate, and eliciting activity in the medial frontal cortex. The rejection pathway revealed a pattern of inhibitory control and attention redirecting through the activation of the anterior cingulate, the left middle frontal, the inferior parietal and precuneus. From this output we were able to propose a dual-path model of consumer choice in an unconstrained setting, the Retrieve-Value-Act, or purchase, path, and the Filter-Reorient-Inhibit, or rejection, path. This analysis was anchored by the node centrality of the dorsolateral prefrontal in every functional network, indicating the system's reliance on inhibition, even in an unconstrained setting. The principal outcome of this study is the notion that inhibitory control processes are engaged even in unconstrained shopping, challenging the idea that such processes only matter under budget/time pressure. The observed inhibitory processes may represent the neural substrate of self-regulatory mechanisms that mediate the intention–behavior gap discussed in Section 1.2, linking neural evidence to higher-level models of consumer decision-making.

Methodologically, this study contributed in showing that naturalistic unconstrained paradigms hold value in revealing structured neural processes. We aimed to validate the feasibility of combining ecological validity with advanced analysis methods. We reinforced the case for Bayesian inference in neuroscience.

This study is not without limitations. The relatively small sample of 21 participants constrains both statistical power and generalizability of the findings. As mentioned earlier, the unconstrained nature of the purchasing task is not reflective of real-world shopping constraints, therefore generalizability requires retesting with an adapted method to include normal purchasing constraints, like budget and time. sLORETA extends the EEG's spatial definition, however it is not as sound as the use of multimodal fMRI for source localization. This was a secondary dataset, not tailored to our specific hypotheses, limiting the flexibility of experimental design.

5.1.3 Study 3: Classifying Portuguese Textile Consumers

Study 3, titled "Classifying Portuguese Textile Consumers", aimed to tackle the gap in the segmentation of consumer behavior. Most prior work in this area relied on demographics or broad "green vs. non-green" categories. However, sustainable consumption is not monolithic, there is heterogeneity in behavioral patterns across a product's lifecycle. As such, the field required methods that could capture latent consumer classes.

This study leveraged the be@t questionnaire, an instrument co-developed with industry partners, structured around the full textile product lifecycle, from acquisition, to use, to maintenance, and finally product discard. We leveraged Latent Class Analysis (LCA) to identify hidden consumer classes. We combined this approach with EFA to reduce the complexity of the large survey into interpretable dimensions. We, again, leveraged Bayesian mixed modelling to test sociodemographic predictors of class membership.

This methodology allowed us to identify four latent class, 1) Knowledgeable consumers, 2) Conscientious but uninformed consumers, 3) Value maximizers, 4) Broadly sustainable consumers. We also uncovered an 8 factor structure to the survey: F1) Knowledge vs. Recognition; 2) Embracing Sustainability; 3) Use of Specialized Washing Programs; 4) Renting Behaviors; 5) Average frequency of washing each type of clothing; 6) 2nd Hand Shopping Behaviors; 7) Third Party Laundry Services; 8) Use of Clothing Repair Services. This demonstrated that sustainable consumption is not heterogenous, and not a single linear construct. Through the combination of LCA and EFA allowed us to clearly highlight knowledge, care practices, and attitudes in shaping pathways toward sustainability. Our results show that textile sustainability is a multidimensional, lifecycle-based phenomenon, not reducible to a single behavior, like recycling. This work extends consumer psychology by showing that segmentation and lifecycle framing can provide rich insights.

This study introduces a replicable approach through the creation of a survey based upon product lifecycles and the combination of LCA and EFA to explore consumer behavioral patterns. This provides a blueprint that can be applied to multiple industries, like food, energy, or electronics. We also provide a detailed explanation of the process for selecting key variables for class description and comparison through difference testing and EFA. We also showed the feasibility of working at the intersection of academia and industry.

This study presents limitations, mainly due to the survey structure. The overreliance on multiple choice questions caused low KMO values, which reduced the psychometric strength of some factors, while the long length of the survey led to dropouts, potentially biasing toward more sustainability-engaged respondents. LCA and EFA are exploratory tools, not confirmatory, as such results should be treated as a basis for further testing, not definitive segmentation. A reliance on convenience sampling in Portugal limited cross-cultural generalizability.

5.2. General Limitations

Some overarching limitations should be acknowledged. Sampling constraints affected all studies. The reliance on convenience samples, particularly in Study 1 and Study 3, may have biased participation toward individuals with greater leisure time or pre-existing interest in sustainability, while the small sample in Study 2 limited statistical power. Moreover, most participants were based in Portugal, with only a small proportion from Spain, restricting the cultural scope and representativeness of the findings.

Efforts to enhance ecological validity, especially in Studies 1 and 2, necessarily reduced experimental control. Data collection in public settings may have amplified contextual and self-presentation biases, while the focus on in-person shopping excluded online-only consumers. The unconstrained paradigm of Study 2, though naturalistic, introduced variability in task engagement and decision context.

Methodological limitations were also present. In Study 3, the length and format of the survey contributed to dropouts and lower psychometric robustness, whereas in Study 2, the spatial limitations of EEG, only partially mitigated by sLORETA, remained inferior to multimodal imaging.

Finally, the thesis investigated distinct dimensions of consumer behavior (attitudinal, neural, and behavioral) but did not fully integrate them within a single empirical framework. As such, the findings should be viewed as complementary pathways rather than definitive causal models, offering a foundation for future triangulated research.

5.3. Practical Contributions for Society

This thesis presented results with wide-reaching implications across different sectors of society. It is possible to extract contributions relevant to the development of interventions within the political sphere, targeting both community and peer-based policies. Within the industrial sphere it is possible to leverage both methodological and theoretical contributions to gift a greater understanding of the consumer base and design better more effective social marketing campaigns. Within the personal sphere, it is possible to use these outcomes to inform the consumer regarding their own impact and about aspects of sustainability they were perhaps unaware they are party to.

Within the political sector, study one demonstrates that close social circles strongly shape environmental attitudes. This finding has clear implications for policy. Traditional approaches typically treat individuals as isolated entities and focus primarily on incentives, penalties, or broad informational campaigns. While these approaches have a place, they may overlook the power of social norms and peer influence in guiding pro-environmental behavior.

Community and peer-based interventions may offer an effective alternative. Policies capable of incentivizing collective engagement, for example neighborhood recycling initiatives, community-led repair hubs and workshops, peer-to-peer education, may amplify the social circle effect. Rather than relying simply on top-down messaging and trickle-down information campaigns, policy makers can design programs and ease regulations to make such initiatives possible. Effectively, such actions could create social norms through policy.

Moreover, since the influence of social circle was found to hold up in Portugal and Spain, despite divergent trajectories in sustainability, this approach may represent a transferable mechanism. This finding suggests these interventions could be robust across cultural contexts.

Study 3's evidence of a multidimensional sustainability panorama, with multiple possible behavioral and motivational patterns, means that policy can be targeted to specific consumer classes. Instead of assuming a uniform public that responds equally to generic sustainability, policy makers should consider that different segments of consumers have their own strengths, weaknesses, and barriers when it comes to sustainable practices. Studying specific segments in detail will reveal specific initiatives that may break down barriers or move consumers to a more holistic engagement with sustainable practices.

For example, multiple classes within our work revealed poor knowledge of eco-labels. This indicates that it is not possible to rely on mediums of information with a high bar of entry. Perhaps, in this case, specific policy creating more easily readable and self-exploratory labels may break down this barrier. Policies may also look to capitalize on specific motivations, for example, Value maximizers are driven to extend the lifecycle of their products as far as possible, so providing them the tools to do so through tax credits, and by ensuring repair services are readily available may help increase their impact.

By acknowledging heterogeneity, policymakers can move beyond one-size-fits-all initiatives and adopt a portfolio of interventions designed to meet consumers where they are.

This segmentation-based approach is not only more efficient but also more equitable and respectful to differences in knowledge, resources and motivations.

Study 2 suggests that consumers engage inhibitory control even when unconstrained. This suggests rejection of a product is not a passive outcome, but rather an active cognitive process involving inhibitory and attentional networks. Consumers are naturally predisposed to evaluate, filter and inhibit choices.

This insight indicates that policies can make use of choice architecture to nudge the consumer to the more sustainable choice through eco-labels, sustainable defaults, or warning systems for high-impact products. Since inhibitory control processes are already active, interventions can assert clear and salient cues at the point of decision. An example of this could be a clear repair vs. replace option for consumer electronics that does not demand the adoption of radically different behaviors.

This challenges the assumption that consumers act on impulse or habit, which has often served to justify restrictive regulatory measures. Overly restrictive regulatory approaches may overlook consumers' cognitive capacities for self-regulation, suggesting that subtle, evidence-based interventions could be equally or more effective in promoting sustainable choices. On the other side, by using subtle well targeted clues, policy makers can capitalize on the consumers' innate inhibitory processes.

Beyond the policy sphere, industries also stand to gain from these findings. Industries can benefit from the insights derived by the method in study 3 to segment their consumer bases and design targeted products and services. Taking as an example our four classes, a company could help the Value Maximizers by providing a low-cost repair service, complying with right to repair directives, or creating more durable products, another may provide a self-explanatory visual index for Conscientious but Uninformed to indicate sustainable characteristics of their products. The same approach can be taken for social marketing. A company may find that they have a large segment of their consumer base avoiding a more sustainable product line due to not understanding its benefits, which may create skepticism, creating educational campaigns alongside the products would help customers make more informed decisions and increase buy-in.

The same way policy makers can make use of inhibitory mechanisms, so can industries. A consumer can be cued towards sustainable action by cuing the inhibitory system at point of purchase. For example, a website could have sustainable packaging as a default opt out option, a store layout could be set up to point the customer at the most sustainable option. Providing good experiences purchasing sustainable products or engaging in sustainable action may activate positive mnemonic valuation.

Companies may also engage in social farming by placing ads emphasizing peer and family approval of more sustainable options, rather than marketing to the individual. Similarly, social marketing campaigns could be directed at individuals who already engage frequently in sustainable behavior encouraging them to be vocal within their social circles and engage within the public sphere, promoting positive social norms. These options could leverage the social circle effect to guide customers to sustainable products or campaigns. An example could be a sale where the purchase of a product in a sustainable line with a friend could provide a free product or a discount for the friend.

This ripples towards the personal sphere. A consumer made aware of these findings may start perceiving themselves as more than a passive part, but as a role model for sustainability within their own social circles. Awareness of this influence is capable of empowering individuals to make more deliberate choices, knowing they can inspire others to do the same. People's choices ripple outward, other's perceptions of their attitudes and what others see them do creates descriptive and injunctive norms that will guide behavioral change.

Consumers already possess the mental tools to say no to unsustainable or unnecessary products. Encouraging individuals to be aware of how they consume, to pause and reflect, activates their own inhibitory system to align their actions with their values. External tools like budgeting apps, checklists or simple self-prompts can strengthen the process. A practical exercise that can be derived from this output is to wait 24 hours before making any purchase they may think may be unnecessary, this will likely be enough time for inhibitory control to act.

Consumers are not passive recipients of policy or industry change, they are active agents shaping sustainability through choices, actions and words. Small consistent personal action can compound effects over time. Talking to peers may develop social norms, reinforcing demand for sustainable products signals the need for change to industry, being vocal about what each consumer does for sustainability signals policy makers about their values. These applications confirm that understanding consumer behavior through a pluralistic, multi-level lens provides academic insight and tangible pathways for fostering sustainable societies.

5.4. General Next Steps

The findings present in this thesis represent an important step towards the expansion of the methodological toolkit for consumer research, but they are not the endpoint. The following directions indicate future work may build upon and extend the contributions of this thesis.

The creation of the EAI_s provides an important methodological blueprint for future studies involving the proximal social circle. However, the instrument itself holds value as it allows for the modelling of social environmental attitudes. Therefore, full validation should be the next concern. Confirmatory Factor Analysis should be undertaken on a sample of appropriate size. This will ensure psychometric robustness across cultures and contexts. After validation the instrument will be made publicly available in open access.

Similarly, we believe the be@t questionnaire holds promise as an appropriate psychometric instrument directed at measuring attitudes and behaviors across a product's lifecycle. However, a new version must be created to improve upon the original, especially to deal with the large amount of dropouts by shortening the survey, and to reduce the number of nominal variables by turning multiple choice questions in the "elect all that apply" format into rank order choice. New data should be collected with this new version of the instrument with a more representative sample across socioeconomic strata. The new version of the instrument will be submitted to a new round of EFA, before a necessary confirmatory step.

The NeuMa protocol holds promise due to its naturalistic context but falls short due to the unconstrained setting which fails to represent the reality of shopping for a vast portion of the population who may have monetary or time constraints. As such the paradigm should be extended to include time and budgetary constraints, and the two conditions should be retested with samples of suitable size for statistical power, in order to confirm our dual-pathway model.

5.5. Conclusion

This thesis primarily sought to expand the methodological toolkit for consumer research by introducing novel instruments, applying advanced neuroscientific methods, and developing new segmentation approaches. We believe we were successful in this endeavor, having proposed effective blueprints for new research to follow mechanistic approaches, and more structured measurements of key constructs. Overall, the thesis makes a meaningful contribution to the consumer research literature within its stated objectives.

Each study presented theoretical and methodological contributions. Study 1 demonstrated the influence of proximal social circles on environmental attitudes through the creation of the EAI_s. Study two proposed a dual-pathway model for purchase vs rejection decision making using fine grained spectral source localized functional connectivity. Study 3 revealed consumer heterogeneity in textile sustainability practices while providing key understanding for the development of a new psychometric instrument, through the use of LCA segmentation and EFA. Together these studies highlight the value of methodological pluralism, bridging psychology, neuroscience, and consumer research.

The findings hold relevance for policy, industry and consumers. They provide a framework for designing future sustainability interventions informed by social influence, cognitive mechanisms of decision-making, and recognition that sustainable consumption is a multidimensional construct shaped by attitudes, motivations and behaviors. By developing replicable instruments, refining psychometric tools, and extending naturalistic paradigms, this thesis lays the groundwork for future research that is both methodologically rigorous and societally impactful.

6. Unified list of References

Adams, N. E., Sherfey, J. S., Kopell, N. J., Whittington, M. A., & LeBeau, F. E. N. (2017). Hetereogeneity in neuronal intrinsic properties: A possible mechanism for hub-like properties of the rat anterior cingulate cortex during network activity. eNeuro, 4(1). https://doi.org/10.1523/ENEURO.0313-16.2017

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In Action Control (pp. 11–39). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2020). The theory of planned behavior: Frequently asked questions. Human Behavior and Emerging Technologies, 2(4), 314–324. https://doi.org/10.1002/hbe2.195

Akram, F., Gill, A. R., Haq, M. A. U., Arshad, A., & Malik, H. A. M. (2023). Barriers to Enduring Pro-Environmental Habits among Urban Residents. Applied Sciences, 13(4), 2497.

Allcott, H. (2011). Social norms and energy conservation. Journal of Public Economics, 95(9–10), 1082–1095. https://doi.org/10.1016/j.jpubeco.2011.03.003

Allen, M. (2017). Cramér's V. In The SAGE Encyclopedia of Communication Research Methods. https://doi.org/10.4135/9781483381411.N107

Allouch, S., Yochum, M., Kabbara, A., Duprez, J., Khalil, M., Wendling, F., Hassan, M., & Modolo, J. (2022). Mean-Field Modeling of Brain-Scale Dynamics for the Evaluation of EEG Source-Space Networks. Brain Topography, 35(1), 54–65. https://doi.org/10.1007/S10548-021-00859-9

Anderson, D. J., & Krettenauer, T. (2021). Connectedness to Nature and Pro-Environmental Behaviour from Early Adolescence to Adulthood: A Comparison of Urban and Rural Canada. Sustainability, 13(7). https://doi.org/10.3390/su13073655

Aponik-Gremillion, L., Chen, Y. Y., Bartoli, E., Koslov, S. R., Rey, H. G., Weiner, K. S., Yoshor, D., Hayden, B. Y., Sheth, S. A., & Foster, B. L. (2022). Distinct population and single-neuron selectivity for executive and episodic processing in human dorsal posterior cingulate. eLife, 11. https://doi.org/10.7554/ELIFE.80722

Aron, A. R. (2010). From reactive to proactive and selective control: developing a richer model for stopping inappropriate responses. Biological Psychiatry, 69(12), e55. https://doi.org/10.1016/J.BIOPSYCH.2010.07.024

Astolfi, L., De Vico Fallani, F., Cincotti, F., Mattia, D., Bianchi, L., Marciani, M. G., Salinari, S., Colosimo, A., Tocci, A., Soranzo, R., & Babiloni, F. (2008). Neural basis for brain responses to TV commercials: A high-resolution EEG study. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 16(6), 522–531. https://doi.org/10.1109/TNSRE.2008.2009784

Babu Henry Samuel, I., Wang, C., Hu, Z., & Ding, M. (2018). The frequency of alpha oscillations: Task-dependent modulation and its functional significance. NeuroImage, 183, 897–906. https://doi.org/10.1016/J.NEUROIMAGE.2018.08.063

Bartlett, M. S. (1937). Properties of sufficiency and statistical tests. Proceedings of the Royal Society of London. Series A - Mathematical and Physical Sciences, 160(901), 268–282. https://doi.org/10.1098/rspa.1937.0109

Basha, D., Kalia, S. K., Hodaie, M., Lopez Rios, A. L., Lozano, A. M., & Hutchison, W. D. (2023). Beta band oscillations in the motor thalamus are modulated by visuomotor coordination in essential tremor patients. Frontiers in Human Neuroscience, 17. https://doi.org/10.3389/FNHUM.2023.1082196

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. Science, 275(5304), 1293–1295. https://doi.org/10.1126/SCIENCE.275.5304.1293

Belavadi, S., & Hogg, M. A. (2021). Social Identity and Intergroup Competition. In The Oxford Handbook of the Psychology of Competition (pp. 476–495). Oxford University Press.

Bettman, J. R., Luce, M. F., & Payne, J. W. (1998). Constructive Consumer Choice Processes. Journal of Consumer Research, 25(3), 187–217. https://doi.org/10.1086/209535

Bicchieri, C. (2005). The Grammar of Society. Cambridge University Press. https://doi.org/10.1017/CBO9780511616037

Bocti, M., Zein, S. A. El, & Giannini, R. (2021). Exploring Antecedents to the Attitude-Behavior Gap for Sustainable Fashion Consumption in Germany. Journal of Sustainable Marketing, 2(2), 32–46. https://doi.org/10.51300/JSM-2021-39

Bonnefond, M., & Jensen, O. (2013). The role of gamma and alpha oscillations for blocking out distraction. Communicative and Integrative Biology, 6(1). https://doi.org/10.4161/CIB.22702

Bosnjak, M., Ajzen, I., & Schmidt, P. (2020). The theory of planned behavior: Selected recent advances and applications. Europe's Journal of Psychology, 16(3), 352–356. https://doi.org/10.5964/ejop.v16i3.3107

Boyacı, T., Canyakmaz, C., & de Véricourt, F. (2024). Human and Machine: The Impact of Machine Input on Decision Making Under Cognitive Limitations. Management Science, 70(2), 1258–1275. https://doi.org/10.1287/MNSC.2023.4744

Brand, J. P. (2022). The Beginnings of Psychological Assessment in Spain and Portugal. In International Histories of Psychological Assessment (pp. 134–150). Cambridge University Press. https://doi.org/10.1017/9781108755078.009

Brundtland, G. H. (1987). Our Common Future. Oxford University Press.

Bürkner, P. C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. Journal of Statistical Software, 80, 1–28. https://doi.org/10.18637/JSS.V080.I01

Burn, S. M. (1991). Social Psychology and the Stimulation of Recycling Behaviors: The Block Leader Approach. Journal of Applied Social Psychology, 21(8), 611–629.

Carrington, M. J., Neville, B. A., & Whitwell, G. J. (2010). Why Ethical Consumers Don't Walk Their Talk: Towards a Framework for Understanding the Gap Between the Ethical Purchase Intentions and Actual Buying Behaviour of Ethically Minded Consumers. Journal of Business Ethics, 97(1), 139–158. https://doi.org/10.1007/s10551-010-0501-6

Castano Garcia, A., Ambrose, A., Hawkins, A., & Parkes, S. (2021). High consumption, an unsustainable habit that needs more attention. Energy Research & Social Science, 80, 102241. https://doi.org/10.1016/j.erss.2021.102241

Cavanaugh, J. E., Neath, A. A., & Joseph Cavanaugh, C. E. (2019). The Akaike information criterion: Background, derivation, properties, application, interpretation, and refinements. Wiley Interdisciplinary Reviews: Computational Statistics, 11(3), e1460. https://doi.org/10.1002/WICS.1460

Chandon, P., Hutchinson, J. W., Bradlow, E. T., & Young, S. H. (2009). Does in-store marketing work? Effects of the number and position of shelf facings on brand attention and evaluation at the point of purchase. Journal of Marketing, 73(6), 1–17. https://doi.org/10.1509/JMKG.73.6.1

Chen, M.-F., & Tung, P.-J. (2014). Developing an extended Theory of Planned Behavior model to predict consumers' intention to visit green hotels. International Journal of Hospitality Management, 36, 221–230. https://doi.org/10.1016/j.ijhm.2013.09.006

Chi, T., Adesanya, O., Liu, H., Anderson, R., & Zhao, Z. (2023). Renting than Buying Apparel: U.S. Consumer Collaborative Consumption for Sustainability. Sustainability, 15(6), 4926. https://doi.org/10.3390/SU15064926

Cho, S. S., Pellecchia, G., Ko, J. H., Ray, N., Obeso, I., Houle, S., & Strafella, A. P. (2012). Effect of continuous theta burst stimulation of the right dorsolateral prefrontal cortex on cerebral blood flow changes during decision making. Brain Stimulation, 5(2), 116. https://doi.org/10.1016/J.BRS.2012.03.007

Collado, S., Staats, H., & Sancho, P. (2019). Normative Influences on Adolescents' Self-Reported Pro-Environmental Behaviors: The Role of Parents and Friends. Environment and Behavior, 51(3), 288–314. https://doi.org/10.1177/0013916517744591

Collins, R. (2015). Keeping It in the Family? Re-Focusing Household Sustainability. Geoforum, 60, 22–32. https://doi.org/10.1016/j.geoforum.2015.01.006

Corbetta, M., Patel, G., & Shulman, G. L. (2008). The Reorienting System of the Human Brain: From Environment to Theory of Mind. Neuron, 58(3), 306. https://doi.org/10.1016/J.NEURON.2008.04.017

Costers, L., Van Schependom, J., Laton, J., Baijot, J., Sjøgård, M., Wens, V., De Tiège, X., Goldman, S., D'Haeseleer, M., D'hooghe, M. B., Woolrich, M., & Nagels, G. (2020). Spatiotemporal and spectral dynamics of multi-item working memory as revealed by the n-back task using MEG. Human Brain Mapping, 41(9), 2431–2446. https://doi.org/10.1002/HBM.24955

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 351(1346), 1413–1420. https://doi.org/10.1098/RSTB.1996.0125

De Vico Fallani, F., Astolfi, L., Cincotti, F., Mattia, D., Marciani, M. G., Gao, S., Salinari, S., Soranzo, R., Colosimo, A., & Babiloni, F. (2008). Structure of the cortical networks during successful memory encoding in TV commercials. Clinical Neurophysiology, 119(10), 2231–2237. https://doi.org/10.1016/J.CLINPH.2008.06.018

Delorme, A., Makeig, S., Humphries, C., Enghoff, S., Jung, T.-P., Bell, T., Lee, T.-W., & Finelli, L. (2025). EEGLab version 2025.0.0. Swartz Center for Computational Neuroscience, Institute for Neural Computation, University of California.

Demeter, E., Hernandez-Garcia, L., Sarter, M., & Lustig, C. (2011). Challenges to attention: A continuous arterial spin labeling (ASL) study of the effects of distraction on sustained attention. NeuroImage, 54(2), 1518–1529. https://doi.org/10.1016/J.NEUROIMAGE.2010.09.026

Deutchman, P. (2023). People Update Their Injunctive Norm Beliefs and Moral Judgements after Receiving Descriptive Norm Information.

Dixon, M. L., & Dweck, C. S. (2021). The Amygdala and the Prefrontal Cortex: The Co-construction of Intelligent Decision-Making. Psychological Review, 129(6), 1414–1441. https://doi.org/10.1037/REV0000339

Domingues, R. B., & Gonçalves, G. (2020). Assessing Environmental Attitudes in Portugal Using a New Short Version of the Environmental Attitudes Inventory. Current Psychology, 39(2), 629–639.

Dunbar, R. (2021). Friends: Understanding the Power of Our Most Important Relationships. Little Brown.

Duron-Ramos, M. F., Collado, S., García-Vázquez, F. I., & Bello-Echeverria, M. (2020). The Role of Urban/Rural Environments on Mexican Children's Connection to Nature and Pro-Environmental Behavior. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.00514

Dzhebrailova, T. D., & Korobeĭnikova, I. I. (2013). Spatial organization of the beta2 EEG frequency band and effectiveness of the intellectual activity in humans. Zhurnal Vyssheĭ Nervnoĭ Deiatelnosti Imeni I P Pavlova, 63(6), 667–676. https://doi.org/10.7868/S004446771306004X

East, R. (2016). Bias in the Evaluation of Research Methods. Marketing Theory, 16(2), 219–231. https://doi.org/10.1177/1470593115609797

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. Energy Policy, 48, 717–729. https://doi.org/10.1016/j.enpol.2012.06.009

Ejelöv, E., Bergquist, M., Hansla, A., & Nilsson, A. (2022). Why Are They Eco-Friendly? Attributing Eco-Friendly Descriptive Norms to Intrinsic Motivation Increases pro-Environmental Purchase Intention. PLOS ONE, 17(10), e0265839.

Elordi, C. (2000). Ideology, Assessing Its Impact and Political Choices. Public Perspective, 34–36.

Engelmann, J. B., & Tamir, D. (2009). Individual differences in risk preference predict neural responses during financial decision-making. Brain Research, 1290, 28–51. https://doi.org/10.1016/j.brainres.2009.06.078

Feldman, S. (1988). Structure and Consistency in Public Opinion: The Role of Core Beliefs and Values. American Journal of Political Science, 32(2), 416.

Feng, C., Liu, Q., Huang, C., Li, T., Wang, L., Liu, F., Eickhoff, S. B., & Qu, C. (2024). Common neural dysfunction of economic decision-making across psychiatric conditions. NeuroImage, 294. https://doi.org/10.1016/J.NEUROIMAGE.2024.120641

Ferreira, M. A., & Santana, S. (2021). Low-Income People and Pro-Environmental Behavior: Beyond Money Issues, A Literature Review. Millenium: Journal of Education, Technologies, and Health, 2021(14), 71–78.

Fink, L., Strassner, C., & Ploeger, A. (2021). Exploring External Factors Affecting the Intention-Behavior Gap When Trying to Adopt a Sustainable Diet: A Think Aloud Study. Frontiers in Nutrition, 8, 511412. https://doi.org/10.3389/FNUT.2021.511412/FULL

Fishman, R. M., & Lizardo, O. (2013). How Macro-Historical Change Shapes Cultural Taste. American Sociological Review, 78(2), 213–239.

Foley, R. W., Wiek, A., Kay, B., & Rushforth, R. (2017). Ideal and reality of multi-stakeholder collaboration on sustainability problems: a case study on a large-scale industrial contamination in Phoenix, Arizona. Sustainability Science, 12(1), 123–136. https://doi.org/10.1007/S11625-016-0393-1/TABLES/1

Fox, K. F. A., & Kotler, P. (1980). The Marketing of Social Causes: The First 10 Years. Journal of Marketing, 44(4), 24–33. https://doi.org/10.1177/002224298004400404

Geisendorf, S., & Pietrulla, F. (2018). The circular economy and circular economic concepts-a literature analysis and redefinition. Thunderbird International Business Review, 60(5), 771–782. https://doi.org/10.1002/tie.21924

Georgiadis, K., Kalaganis, F. P., Riskos, K., Matta, E., Oikonomou, V. P., Yfantidou, I., Chantziaras, D., Pantouvakis, K., Nikolopoulos, S., Laskaris, N. A., & Kompatsiaris, I. (2023). NeuMa - the absolute Neuromarketing dataset en route to an holistic understanding of consumer behaviour. Scientific Data, 10(1). https://doi.org/10.1038/s41597-023-02392-9

Gillingham, K., & Bollinger, B. (2020). Social Learning and Solar Photovoltaic Adoption. SSRN Electronic Journal.

Gluth, S., Sommer, T., Rieskamp, J., & Büchel, C. (2015). Effective Connectivity between Hippocampus and Ventromedial Prefrontal Cortex Controls Preferential Choices from Memory. Neuron, 86(4), 1078–1090. https://doi.org/10.1016/j.neuron.2015.04.023

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels. Journal of Consumer Research, 35(3), 472–482. https://doi.org/10.1086/586910

Gould, I. C., Rushworth, M. F., & Nobre, A. C. (2011). Indexing the graded allocation of visuospatial attention using anticipatory alpha oscillations. Journal of Neurophysiology, 105(3), 1318–1326. https://doi.org/10.1152/JN.00653.2010

Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. Food Policy, 44, 177–189. https://doi.org/10.1016/J.FOODPOL.2013.12.001

Guerreiro, L., Jörgens, H., & Alves, V. (2022). Energy Governance in Portugal. In Handbook of Energy Governance in Europe (pp. 959–991). Springer International Publishing.

Gul, F., & Pesendorfer, W. (2008). The Case for Mindless Economics. In The Foundations of Positive and Normative Economics (pp. 2–40). Oxford University Press.

Gupta, R., Koscik, T. R., Bechara, A., & Tranel, D. (2011). The amygdala and decision-making. Neuropsychologia, 49(4), 760–766. https://doi.org/10.1016/j.neuropsychologia.2010.09.029

Haddock-Fraser, J. E., & Tourelle, M. (2010). Corporate motivations for environmental sustainable development: exploring the role of consumers in stakeholder engagement. Business Strategy and the Environment, 19(8), 527–542. https://doi.org/10.1002/bse.663

Hall, M. G., Higgins, I. C. A., Grummon, A. H., Lazard, A. J., Prestemon, C. E., Mendel Sheldon, J., & Taillie, L. S. (2021). Using a Naturalistic Store Laboratory for Clinical Trials of Point-of-Sale Nutrition Policies and Interventions: A Feasibility and Validation

Study. International Journal of Environmental Research and Public Health, 18(16). https://doi.org/10.3390/ijerph18168764

Han, G. (2023). Relationships between Outdoor Recreation-Associated Flow, Pro-Environmental Attitude, and Pro-Environmental Behavioral Intention. Sustainability, 15(13), 10581.

Hare, T. A., Camerer, C. F., & Rangel, A. (2009). Self-control in decision-making involves modulation of the vmPFC valuation system. Science, 324(5927), 646–648. https://doi.org/10.1126/SCIENCE.1168450

Hartwich, L., & Becker, J. C. (2023). The Role of Ideological and Intergroup Mechanisms in Predicting Opposition to Redistribution and Discrimination Against the Lower Social Class. Journal of Social and Political Psychology, 11(1), 167–181.

He, L., & Filimonau, V. (2020). The Effect of National Culture on Pro-Environmental Behavioural Intentions of Tourists in the UK and China. Tourism Management Perspectives, 35. https://doi.org/10.1016/j.tmp.2020.100716

Hocke, L. M., Cayetano, K., Tong, Y., & Frederick, B. (2015). Optimized multimodal functional magnetic resonance imaging/near-infrared spectroscopy probe for ultrahigh-resolution mapping. Neurophotonics, 2(4), 045004. https://doi.org/10.1117/1.NPH.2.4.045004

Hogan, P. S., Galaro, J. K., & Chib, V. S. (2018). Roles of Ventromedial Prefrontal Cortex and Anterior Cingulate in Subjective Valuation of Prospective Effort. Cerebral Cortex, 29(10), 4277. https://doi.org/10.1093/CERCOR/BHY310

Huang, J., Li, W., Cheng, X., & Cui, K. (2024). What's the Difference between Factors Influencing Household Waste Management and Energy-Saving Behavior? A Meta-Analysis. Management of Environmental Quality. https://doi.org/10.1108/MEQ-03-2024-0103

Idalgo-Crespo, J., Benítez-Troya, F., Amaya-Rivas, J. L., Soto, M., Terán-Alvarado, A. F., & Hidalgo-Crespo, A. (2022). Does Gender Influence a Person's Environmental Concern and pro-Environmental Behaviours? In Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology. https://doi.org/10.18687/LACCEI2022.1.1.673

IPCC. (2021). IPCC AR6 Working Group 1: Summary for Policymakers | Climate Change 2021: The Physical Science Basis.

Ivković, D., & Mandić, A. (2024). Psychological and Socio-Demographic Drivers of pro-Environmental Behaviour in Generation Z. In Tourism in a VUCA World: Managing the Future of Tourism (pp. 119–141). Emerald Publishing. https://doi.org/10.1108/978-1-83753-674-020241009

jamovi. (2025). The jamovi project. https://www.jamovi.org

Jans, L., & Fielding, K. (2018). The Role of Group Processes in Environmental Issues, Attitudes, and Behaviours. In Environmental Psychology: An Introduction (pp. 228–237). Wiley. https://doi.org/10.1002/9781119241072.ch23

Jatoi, M. A., Kamel, N., Malik, A. S., Faye, I., Bornot, J. M., & Begum, T. (2016). EEG-based brain source localization using visual stimuli. International Journal of Imaging Systems and Technology, 26(1), 55–64. https://doi.org/10.1002/IMA.22157

Joshua, J. (2017). The Environmental Effects of Overconsumption. In The Economics of Addictive Behaviours Volume IV (pp. 67–73). https://doi.org/10.1007/978-3-319-62536-2_9

Kable, J. W., & Glimcher, P. W. (2010). An "As Soon As Possible" Effect in Human Intertemporal Decision Making: Behavioral Evidence and Neural Mechanisms. Journal of Neurophysiology, 103(5), 2513–2531. https://doi.org/10.1152/jn.00177.2009

Kahneman, D., & Tversky, A. (1984). Choices, values, and frames. American Psychologist, 39(4), 341–350. https://doi.org/10.1037/0003-066X.39.4.341

Kaiser, H. F. (1974). An Index of Factorial Simplicity. Psychometrika, 39(1), 31–36. https://doi.org/10.1007/BF02291575

Khondakar, M. F. K., Sarowar, M. H., Chowdhury, M. H., Majumder, S., Hossain, M. A., Dewan, M. A. A., & Hossain, Q. D. (2024). A systematic review on EEG-based neuromarketing: recent trends and analyzing techniques. Brain Informatics, 11(1), 1–25. https://doi.org/10.1186/S40708-024-00229-8

Khurana, V., Gahalawat, M., Kumar, P., Roy, P. P., Dogra, D. P., Scheme, E., & Soleymani, M. (2021). A Survey on Neuromarketing Using EEG Signals. IEEE Transactions on Cognitive and Developmental Systems, 13(4), 732–749. https://doi.org/10.1109/TCDS.2021.3065200

Khushaba, R. N., Wise, C., Kodagoda, S., Louviere, J., Kahn, B. E., & Townsend, C. (2013). Consumer neuroscience: Assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking. Expert Systems with Applications, 40(9), 3803–3812. https://doi.org/10.1016/j.eswa.2012.12.095

Kim, Y., & Oh, K. W. (2020). Effects of Perceived Sustainability Level of Sportswear Product on Purchase Intention: Exploring the Roles of Perceived Skepticism and Perceived Brand Reputation. Sustainability, 12(20), 8650. https://doi.org/10.3390/SU12208650

Kohno, M., Morales, A. M., Guttman, Z., & London, E. D. (2017). A neural network that links brain function, white-matter structure and risky behavior. NeuroImage, 149, 15–22. https://doi.org/10.1016/j.neuroimage.2017.01.058

Kopelman, M. D., Bright, P., Buckman, J., Fradera, A., Yoshimasu, H., Jacobson, C., & Colchester, A. C. F. (2007). Recall and recognition memory in amnesia: Patients with hippocampal, medial temporal, temporal lobe or frontal pathology. Neuropsychologia, 45(6), 1232–1246. https://doi.org/10.1016/j.neuropsychologia.2006.10.005

Kotler, P. (1978). Marketing for nonprofit organizations (1st ed.). Atlas.

Kotler, P., & Anderson, A. (1987). Strategic Marketing for Non-profit Organizations.

Kotler, P., & Lee, N. (2008). Corporate social responsibility: Doing the most good for your company and your cause. John Wiley & Sons.

Krain, A. L., Wilson, A. M., Arbuckle, R., Castellanos, F. X., & Milhama, M. P. (2006). Distinct neural mechanisms of risk and ambiguity: A meta-analysis of decision-making. NeuroImage, 32(1), 477–484. https://doi.org/10.1016/j.neuroimage.2006.02.047

Krettenauer, T. (2017). Pro-Environmental Behavior and Adolescent Moral Development. Journal of Research on Adolescence, 27(3), 581–593. https://doi.org/10.1111/jora.12300

La Foresta, F., Morabito, F. C., Marino, S., & Dattola, S. (2019). High-Density EEG Signal Processing Based on Active-Source Reconstruction for Brain Network Analysis in Alzheimer's Disease. Electronics, 8(9), 1031. https://doi.org/10.3390/ELECTRONICS8091031

Legros, S., & Cislaghi, B. (2020). Mapping the Social-Norms Literature: An Overview of Reviews. Perspectives on Psychological Science, 15(1), 62–80.

Lester, J. C. (1994). The Evolution of the Political Compass (and Why Libertarianism Is Not Right-Wing). Journal of Social and Evolutionary Systems, 17(3), 231–241.

Levek, A., Benazzi, A. C., Arnone, J., Seguin, J., & Gerhardt, T. (2002). A responsabilidade social e sua interface com o marketing social. Revista Da FAE, 5(2), 15–25.

Liobikienė, G., & Minelgaitė, A. (2021). Energy and resource-saving behaviours in European Union countries: The Campbell paradigm and goal framing theory approaches. Science of the Total Environment, 750. https://doi.org/10.1016/j.scitotenv.2020.141745

Liobikienė, G., & Poškus, M. S. (2019). The Importance of Environmental Knowledge for Private and Public Sphere Pro-Environmental Behavior: Modifying the Value-Belief-Norm Theory. Sustainability, 11(12), 3324.

Liu, Y., Bengson, J., Huang, H., Mangun, G. R., & Ding, M. (2016). Top-down Modulation of Neural Activity in Anticipatory Visual Attention: Control Mechanisms Revealed by Simultaneous EEG-fMRI. Cerebral Cortex, 26(2), 517–529. https://doi.org/10.1093/CERCOR/BHU204

López-Novo, J., & Morata, F. (2019). The Implementation of IEAs in Spain: From National Energy Considerations to EU Environmental Constraints. In International Environmental Agreements and Domestic Politics (pp. 313–340). Routledge.

Lou, X., & Li, L. M. W. (2022). The Mediating Role of Self-Enhancement Value on the Relationship of Power Distance and Individualism with Pro-Environmental Attitudes: Evidence from Multilevel Mediation Analysis with 52 Societies. Cross-Cultural Research, 56(5), 445–466. https://doi.org/10.1177/10693971221093122

Maitre-Ekern, E. (2021). Re-thinking producer responsibility for a sustainable circular economy from extended producer responsibility to pre-market producer responsibility. Journal of Cleaner Production, 286, 125454. https://doi.org/10.1016/J.JCLEPRO.2020.125454

Maleki, S., Naeimi, A., Bijani, M., & Salahi Moghadam, N. (2025). Comparing predictive power of planned behavior and social cognition theories on students' pro-environmental behaviors: The case of University of Zanjan, Iran. Journal of Cleaner Production, 486, 144386. https://doi.org/10.1016/J.JCLEPRO.2024.144386

Malekmohammadi, A., Ehrlich, S. K., Rauschecker, J. P., & Cheng, G. (2023). Listening to familiar music induces continuous inhibition of alpha and low-beta power. Journal of Neurophysiology, 129(6), 1344–1358. https://doi.org/10.1152/JN.00269.2022

Marinescu, R. V., Eshaghi, A., Alexander, D. C., & Golland, P. (2019). BrainPainter: A software for the visualisation of brain structures, biomarkers and associated pathological processes. Multimodal Brain Image Analysis..., 11846, 112. https://doi.org/10.1007/978-3-030-33226-6_13

Marsh, A. A., Blair, K. S., Vythilingam, M., Busis, S., & Blair, R. J. R. (2007). Response options and expectations of reward in decision-making: The differential roles of dorsal and rostral anterior cingulate cortex. NeuroImage, 35(2), 979. https://doi.org/10.1016/J.NEUROIMAGE.2006.11.044

McGregor, S. (2005). Sustainable consumer empowerment through critical consumer education: a typology of consumer education approaches. International Journal of Consumer Studies, 29(5), 437–447. https://doi.org/10.1111/j.1470-6431.2005.00467.x

McGregor, S. L. T. (2016). Framing consumer education conceptual innovations as consumer activism. International Journal of Consumer Studies, 40(1), 35–47. https://doi.org/10.1111/ijcs.12208

McHugh, M. L. (2013). The Chi-square test of independence. Biochemia Medica, 23(2), 143. https://doi.org/10.11613/BM.2013.018

Milfont, T. L. (2010). The psychological meaning of preservation and utilization attitudes: A study using the natural semantic network technique. Psyecology, 1(1), 123–136. https://doi.org/10.1174/217119710790709559

Milfont, T. L., & Duckitt, J. (2010). The Environmental Attitudes Inventory: A Valid and Reliable Measure to Assess the Structure of Environmental Attitudes. Journal of Environmental Psychology, 30(1), 80–94. https://doi.org/10.1016/j.jenvp.2009.09.001

Morren, M., & Grinstein, A. (2016). Explaining Environmental Behavior across Borders: A Meta-Analysis. Journal of Environmental Psychology, 47, 91–106.

Nakai, R. (2024). Nationalism and Environmentalism from the Global Perspective: A Comparative Survey Analysis of Eco-nationalism. Nations and Nationalism.

Naskar, S. T., & Lindahl, J. M. M. (2025). Forty years of the theory of planned behavior: a bibliometric analysis (1985–2024). Management Review Quarterly. https://doi.org/10.1007/s11301-025-00487-8

Neath, A. A., & Cavanaugh, J. E. (2012). The Bayesian information criterion: background, derivation, and applications. Wiley Interdisciplinary Reviews: Computational Statistics, 4(2), 199–203. https://doi.org/10.1002/WICS.199

Nelson, B. R. (2015). New Developments in Social Identity Research. Nova Science Publishers, Inc.

Neumayer, E. (2004). The Environment, Left-Wing Political Orientation and Ecological Economics. Ecological Economics, 51(3–4), 167–175.

Neuner, I., Arrubla, J., Werner, C. J., Hitz, K., Boers, F., Kawohl, W., & Shah, N. J. (2014). The default mode network and EEG regional spectral power: A simultaneous fMRI-EEG study. PLoS ONE, 9(2). https://doi.org/10.1371/JOURNAL.PONE.0088214

Nguyen, C., & Nguyen, N. (2024). Assessing the impacts of peer-to-peer recommender system on online shopping: PLS-SEM approach. Innovative Marketing, 20(4), 1–12. https://doi.org/10.21511/im.20(4).2024.01

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). The environmental price of fast fashion. Nature Reviews Earth & Environment, 1(4), 189–200. https://doi.org/10.1038/s43017-020-0039-9

Olson, I. R., & Berryhill, M. (2008). Some Surprising Findings on the Involvement of the Parietal Lobe in Human Memory. Neurobiology of Learning and Memory, 91(2), 155. https://doi.org/10.1016/J.NLM.2008.09.006

Olufemi, T. D. (2012). Theories of Attitudes. In Psychology of Attitudes (pp. 61–78). Nova Science Publishers, Inc.

Pascual-Marqui, R. D., Michel, C. M., & Lehmann, D. (1994). Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. International Journal of Psychophysiology, 18(1), 49–65. https://doi.org/10.1016/0167-8760(84)90014-X

Paul, J., Modi, A., & Patel, J. (2016). Predicting green product consumption using theory of planned behavior and reasoned action. Journal of Retailing and Consumer Services, 29, 123–134. https://doi.org/10.1016/j.jretconser.2015.11.006

Perry, L. R., Moorhouse, T. P., Jacobsen, K., Loveridge, A. J., & Macdonald, D. W. (2022). More than a Feeling: Cognitive Beliefs and Positive—but Not Negative—Affect Predict Overall Attitudes toward Predators. Conservation Science and Practice, 4(2). https://doi.org/10.1111/csp2.584

Phillips, D. M., & Englis, B. G. (2022). Green Consumption Is Both Feminine and Masculine—Just Ask the Androgynous Consumer. Journal of Consumer Behaviour, 21(5), 1028–1039. https://doi.org/10.1002/cb.2052

Pion-Tonachini, L., Kreutz-Delgado, K., & Makeig, S. (2019). ICLabel: An automated electroencephalographic independent component classifier, dataset, and website. NeuroImage, 198, 181. https://doi.org/10.1016/J.NEUROIMAGE.2019.05.026

Plassmann, H., O'Doherty, J. P., & Rangel, A. (2010). Appetitive and Aversive Goal Values Are Encoded in the Medial Orbitofrontal Cortex at the Time of Decision Making. The Journal of Neuroscience, 30(32), 10799–10808. https://doi.org/10.1523/JNEUROSCI.0788-10.2010

Plassmann, H., Venkatraman, V., Huettel, S., & Yoon, C. (2015). Consumer neuroscience: Applications, challenges, and possible solutions. Journal of Marketing Research, 52(4), 427–435. https://doi.org/10.1509/JMR.14.0048

Pozharliev, R., Rossi, D., & De Angelis, M. (2022). A picture says more than a thousand words: Using consumer neuroscience to study instagram users' responses to influencer advertising. Psychology & Marketing. https://doi.org/10.1002/mar.21659

Proshina, E., Mitiureva, D., & Sysoeva, O. (2024). Distinct brain systems are involved in subjective minute estimation with eyes open or closed: EEG source analysis study. Frontiers in Neuroscience, 18. https://doi.org/10.3389/FNINS.2024.1506987

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. Sustainability Science, 14(3), 681–695. https://doi.org/10.1007/S11625-018-0627-5

R Core Team. (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing.

R Core Team. (2024). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. https://www.R-project.org/

Radhakrishnan, S. (2020). Sustainable Consumption and Production Patterns in Fashion. In The UN Sustainable Development Goals for the Textile and Fashion Industry (Vol. 1, pp. 59–75). Springer Singapore. https://doi.org/10.1007/978-981-13-8787-6_4

Raimundo, A., & Mestres, L. (n.d.). Iberia: Spain and Portugal. In Europe's Brexit (pp. 173–192). Agenda Publishing.

Rajapaksa, D., Islam, M., & Managi, S. (2018). Pro-Environmental Behavior: The Role of Public Perception in Infrastructure and the Social Factors for Sustainable Development. Sustainability, 10(4), 937. https://doi.org/10.3390/su10040937

Ratten, V. (2022). World Heritage Sites in Portugal and Spain. In Contributions to Management Science (pp. 115–121). Springer. https://doi.org/10.1007/978-3-030-97699-6_7

Revelle, W. (2025). psych: Procedures for Psychological, Psychometric, and Personality Research. Northwestern University. https://CRAN.R-project.org/package=psych

Ribeiro, P. R., Batista, P., Mendes-Palma, F., Pintado, M., & Oliveira-Silva, P. (2023). Consumers' Engagement and Perspectives on Sustainable Textile Consumption. Sustainability, 15(22), 15812. https://doi.org/10.3390/su152215812

Rigdon, E. E., & Ferguson, C. E. (1991). The Performance of the Polychoric Correlation Coefficient and Selected Fitting Functions in Confirmatory Factor Analysis. Journal of Marketing Research, 28(4), 491–497. https://doi.org/10.1177/002224379102800412

Ripple, W. J., Wolf, C., Newsome, T. M., Galetti, M., Alamgir, M., Crist, E., Mahmoud, M. I., & Laurance, W. F. (2020). World scientists' warning to humanity: A second notice. BioScience, 67(12), 1026–1028. https://doi.org/10.1093/BIOSCI/BIX125

Rognli, E. W., Zahl-Olsen, R., Rekdal, S. S., Hoffart, A., & Bertelsen, T. B. (2023). Editorial Perspective: Bayesian Statistical Methods Are Useful for Researchers in Child and Adolescent Mental Health. Journal of Child Psychology and Psychiatry, 64(2), 339–342.

Royo, S., & Manuel, P. C. (2004). Spain and Portugal in the European Union: The First Fifteen Years. Routledge.

Saraiva, P. (2023). On Shannon entropy and its applications. Kuwait Journal of Science, 50(3), 194–199. https://doi.org/10.1016/J.KJS.2023.05.004

Scharnowski, F., Nicholson, A. A., Pichon, S., Rosa, M. J., Rey, G., Eickhoff, S. B., Van De Ville, D., Vuilleumier, P., & Koush, Y. (2020). The role of the subgenual anterior cingulate cortex in dorsomedial prefrontal–amygdala neural circuitry during positive-social emotion regulation. Human Brain Mapping, 41(11), 3100. https://doi.org/10.1002/HBM.25001

Schiaroli, V., Fraccascia, L., & Dangelico, R. M. (2024). How can consumers behave sustainably in the fashion industry? A systematic literature review of determinants, drivers, and barriers across the consumption phases. Journal of Cleaner Production, 483, 144232. https://doi.org/10.1016/J.JCLEPRO.2024.144232

Schrooten, M., Vandenberghe, R., Peeters, R., & Dupont, P. (2019). Quantitative analyses help in choosing between simultaneous vs. Separate EEG and FMRI. Frontiers in Neuroscience, 13(JAN), 426525. https://doi.org/10.3389/FNINS.2018.01009

Schultz, H., Sommer, T., & Peters, J. (2015). The Role of the Human Entorhinal Cortex in a Representational Account of Memory. Frontiers in Human Neuroscience, 9(NOVEMBER), 628. https://doi.org/10.3389/FNHUM.2015.00628

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The Constructive, Destructive, and Reconstructive Power of Social Norms. Psychological Science, 18(5), 429–434. https://doi.org/10.1111/j.1467-9280.2007.01917.x

Schultz, W. (1998). Predictive reward signal of dopamine neurons. Journal of Neurophysiology, 80(1), 1–27. https://doi.org/10.1152/JN.1998.80.1.1

Schultz, W. (2016). Dopamine reward prediction error coding. Dialogues in Clinical Neuroscience, 18(1), 23. https://doi.org/10.31887/DCNS.2016.18.1/WSCHULTZ

Seol, H. (2025). snowRMM. https://github.com/hyunsooseol/snowRMM

Severijns, R., Asanov, I., Streukens, S., Bruns, S. B., Moleman, P., Brouwer, J., van Griethuijsen, J., & Lizin, S. (2024). Involving Family and Friends Helps Sustainable Diets Last Longer. npj Climate Action, 3(1), 1–9. https://doi.org/10.1038/s44168-024-00192-4

Sheth, J. N., Newman, B. I., & Gross, B. L. (1991). Why we buy what we buy: A theory of consumption values. Journal of Business Research, 22(2), 159–170. https://doi.org/10.1016/0148-2963(91)90050-8

Shrivastava, P. (1995). The Role of Corporations in Achieving Ecological Sustainability. Academy of Management Review, 20(4), 936–960.

Silintowe, Y. B. R., & Sukresna, I. M. (2023). Understanding Green Self-identity: Does It Affect Green Buying Behavior? Scientific Papers of the University of Pardubice, 31(1). https://doi.org/10.46585/sp31011624

Silva, P. H. R., Spedo, C. T., Barreira, A. A., & Leoni, R. F. (2018). Symbol Digit Modalities Test adaptation for Magnetic Resonance Imaging environment: A systematic review and meta-analysis. Multiple Sclerosis and Related Disorders, 20, 136–143. https://doi.org/10.1016/J.MSARD.2018.01.014

Singh-Curry, V., & Husain, M. (2009). The functional role of the inferior parietal lobe in the dorsal and ventral stream dichotomy. Neuropsychologia, 47(6), 1434–1448. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2008.11.033

Smid, S. C., & Winter, S. D. (2020). Dangers of the Defaults: A Tutorial on the Impact of Default Priors When Using Bayesian SEM With Small Samples. Frontiers in Psychology, 11, 611963. https://doi.org/10.3389/fpsyg.2020.611963

Smidts, A., Hsu, M., Sanfey, A. G., Boksem, M. A. S., Ebstein, R. B., Huettel, S. A., Kable, J. W., Karmarkar, U. R., Kitayama, S., Knutson, B., Liberzon, I., Lohrenz, T., Stallen, M., Yoon, C., & Lett, M. (2014). Advancing consumer neuroscience. Marketing Letters, 25, 257–267. https://doi.org/10.1007/s11002-014-9306-1

Stanescu, M. D. (2021). State of the art of post-consumer textile waste upcycling to reach the zero waste milestone. Environmental Science and Pollution Research, 28(12), 14253–14270. https://doi.org/10.1007/s11356-021-12416-9

Stern, P. C., Dietz, T., Abel, T. D., Guagnano, G., & Kalof, L. (1999). A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism. Human Ecology Review, 6(2), 81.

Sun, F. T., Miller, L. M., & D'Esposito, M. (2004). Measuring interregional functional connectivity using coherence and partial coherence analyses of fMRI data. NeuroImage, 21(2), 647–658. https://doi.org/10.1016/J.NEUROIMAGE.2003.09.056

Sundby, K. K., Jana, S., & Aron, A. R. (2021). Double-blind disruption of right inferior frontal cortex with TMS reduces right frontal beta power for action stopping. Journal of Neurophysiology, 125(1), 140–153. https://doi.org/10.1152/JN.00459.2020

Tajfel, H. (1978). Social Categorization, Social Identity and Social Comparison. In Differentiation between Social Groups: Studies in the Social Psychology of Intergroup Relations (pp. 61–76).

Tanrikulu, C. (2021). Theory of consumption values in consumer behaviour research: A review and future research agenda. International Journal of Consumer Studies, 45(6), 1176–1197. https://doi.org/10.1111/IJCS.12687

Thaler, R. (1980). Toward a positive theory of consumer choice. Journal of Economic Behavior & Organization, 1(1), 39–60. https://doi.org/10.1016/0167-2681(80)90051-7

The MathWorks Inc. (2024). MATLAB version 24.2.0.2833386 (R2024b). The MathWorks Inc.

Tomkins, S., London, B., Isley, S., & Getoor, L. (2018). Sustainability at scale: Towards bridging the intention-behavior gap with sustainable recommendations. RecSys 2018 -

12th ACM Conference on Recommender Systems, 214–218. https://doi.org/10.1145/3240323.3240411

Toubes, D. R., del Junco, J. G., & Abe, M. (2019). Cross-Cultural Analysis of Japanese and Mediterranean Entrepreneurs During the Global Economic Crisis. Journal of International and Global Studies, 10(2).

Uddin, L. Q., Kelly, A. M. C., Biswal, B. B., Castellanos, F. X., & Milham, M. P. (2008). Functional connectivity of default mode network components: Correlation, anticorrelation, and causality. Human Brain Mapping, 30(2), 625. https://doi.org/10.1002/HBM.20531

UNDESA. (2015). THE 17 GOALS. United Nations.

UNDESA. (2024). The Sustainable Development Goals Report 2024. United Nations. https://unstats.un.org/SDgs/report/2024/

UNDP. (2023). THE SDGs IN ACTION. United Nations Development Programme.

Vecchiato, G., Astolfi, L., Fallani, F. D. V., Cincotti, F., Mattia, D., Salinari, S., Soranzo, R., & Babiloni, F. (2010). Changes in brain activity during the observation of TV commercials by using EEG, GSR and HR measurements. Brain Topography, 23(2), 165–179. https://doi.org/10.1007/S10548-009-0127-0

Venkatraman, V., Payne, J. W., Bettman, J. R., Luce, M. F., & Huettel, S. A. (2009). Separate Neural Mechanisms Underlie Choices and Strategic Preferences in Risky Decision Making. Neuron, 62(4), 593–602. https://doi.org/10.1016/j.neuron.2009.04.007

Vermeir, I., & Verbeke, W. (2008). Sustainable food consumption among young adults in Belgium: Theory of planned behaviour and the role of confidence and values. Ecological Economics, 64(3), 542–553. https://doi.org/10.1016/j.ecolecon.2007.03.007

Voola, R., Bandyopadhyay, C., Azmat, F., Ray, S., & Nayak, L. (2022). How are consumer behavior and marketing strategy researchers incorporating the UNDESA? A review and opportunities for future research. Australasian Marketing Journal, 30(2), 119–130. https://doi.org/10.1177/14413582221079431

Vysata, O., Kukal, J., Valis, M., Pazdera, L., Hort, J., & Prochazka, A. (2014). Lag synchronisation in the human brain: Evidence from 17,722 healthy subjects' EEG analyses. NeuroQuantology, 12(1), 40–45. https://doi.org/10.14704/NQ.2014.12.1.700

Walsh, C., Tait, L., Garrido, M. G., Brown, J. T., & Ridler, T. (2025). Transient cortical beta-frequency oscillations associated with contextual novelty in high density mouse EEG. Scientific Reports, 15(1). https://doi.org/10.1038/S41598-025-86008-9

Wang, Y., Hao, F., & Liu, Y. (2021). Pro-Environmental Behavior in an Aging World: Evidence from 31 Countries. International Journal of Environmental Research and Public Health, 18(4), 1748. https://doi.org/10.3390/IJERPH18041748

Wilkens, C. A., Cavallo, R., Niazadeh, R., Taggart, S., Technologies, T., & Research, Y. (2018). Mechanism Design for Value Maximizers.

World Health Organization. (2023). Climate Change and Health. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

World Medical Association. (2001). Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bulletin of the World Health Organization, 79(4), 373–374. https://doi.org/doi:10.1001/jama.2013.281053

Xia, W., & Li, L. M. W. (2023). Societal gender role beliefs moderate the pattern of gender differences in public- and private-sphere pro-environmental behaviors. Journal of Environmental Psychology, 92. https://doi.org/10.1016/j.jenvp.2023.102158

Yoon, C., Gonzalez, R., Bechara, A., Berns, G. S., Dagher, A. A., Dubé, L., Huettel, S. A., Kable, J. W., Liberzon, I., Plassmann, H., Smidts, A., & Spence, C. (2012). Decision neuroscience and consumer decision making. Marketing Letters, 23(2), 473–485. https://doi.org/10.1007/s11002-012-9188-z

Young, W., Hwang, K., McDonald, S., & Oates, C. J. (2010). Sustainable consumption: green consumer behaviour when purchasing products. Sustainable Development, 18(1), 20–31. https://doi.org/10.1002/SD.394

Yozukmaz, N., & Kiliç, B. (2022). Attitudes in Tourism. In Routledge Handbook of Social Psychology of Tourism (pp. 111–120). Taylor and Francis. https://doi.org/10.4324/9781003161868-11

Yu, J., Nickens, T., Liu, D., & Vincenzi, D. A. (2023). Decision-making under crisis conditions. In Human Factors in Simulation and Training (pp. 209–224). https://doi.org/10.1201/9781003401353-7

Zamani, J., & Boniadi Naieni, A. (2020). Best Feature Extraction and Classification Algorithms for EEG Signals in Neuromarketing. Frontiers in Biomedical Technologies. https://doi.org/10.18502/fbt.v7i3.4621

Zheng, J., Yang, M., Xu, M., Zhao, C., & Shao, C. (2019). An Empirical Study of the Impact of Social Interaction on Public Pro-Environmental Behavior. International Journal of Environmental Research and Public Health, 16(22), 4405. https://doi.org/10.3390/IJERPH16224405

Zilles, K. (2004). Architecture of the Human Cerebral Cortex. In The Human Nervous System: Second Edition (pp. 997–1055). https://doi.org/10.1016/B978-012547626-3/50028-4

Annex A: Researcher's Memoir: A Journey from Engineering to Applied Psychology

I came into this PhD with a level of uncertainty that I believe was justified by my background. Far too many conversations throughout this process have reached a point where I had to clarify that I am not a psychologist. In fact, I came into this program as an engineer. At first, this was a rather uncomfortable realization, I must admit I stood on uncertain theoretical ground, as my closest contact with psychology until then had been through User Experience design courses. For much of the first year of my PhD, I struggled to match up with my colleagues who came into this same process with a high level of certainty regarding what approach they would take, the questions they wanted answered, the practical outcome of their work. I entered the program driven by curiosity, focused on data analysis after being enrolled in projects at the Human Neurobehavioral Laboratory (HNL). My academic roots are in data analysis and neuroscience. Sustainability emerged later, almost unexpectedly, as an area where I felt my skills could make a meaningful contribution. I had learned of the importance of consumers and took notice of the unsustainable practices even I was party to, but I had little clue where I would fit in.

At the beginning of my education my focus had been on "making", on design, technology, and the tangible aspects of creation, and this was my first encounter with sustainable development, I started out on the side of industry with little understanding of consumer psychology. Yet I entered with a genuine desire to contribute. While others were thinking about their contributions to literature I was searching for where I could stand out. Over time, through my collaboration with psychologists, I discovered that my true strengths lay in method, data analysis and neuroscience, and that sustainability, though not my starting point, would later become a meaningful dimension of my work. I found I had a natural ease in learning and understanding method. Within a short time, I began contributing to the development of experimental paradigms, creating several computerized solutions for laboratory protocols, and progressively increasing the analytical complexity of my studies. I discovered that I genuinely enjoyed working with data, spending long afternoons designing the most revealing charts, refining models and finding new ways to explore my samples in depth. I realized this was where I could stand out. I felt free to propose bold and unconventional analyses, to simplify or complexify as needed. Before long, I understood that my place in applied psychology was within method itself.

I have considered many alternative paths I might have taken, yet none would have led me to the same realization. Working at the HNL, a laboratory that required me to communicate across disciplines with biologists, psychologists and neuroscientists, offered me the opportunity to engage in discussions about education, mental health, behavior and stress, and about countless topics I could never have imagined on my own. This experience shaped me into the researcher I am today: confident in my knowledge and secure in my ability to contribute to psychology, neuroscience and engineering alike.

Collaboration made this possible as well. I look back on my months in Barcelona working with my supervisor, Ignacio Cifre Leon, spending hours in his office examining charts and then returning to my workspace to create new ones. Ignacio taught me a great deal about data. Above all, he taught me how to be confident in my choices. He approached every method and every dataset with genuine curiosity, asking questions of the data and always uncovering valuable insights, even when the questions extended beyond the scope of our study. I soon realized that this curiosity was not optional but essential. Whereas as a Master's student I had viewed data analysis as a task to be completed as quickly as possible, as a PhD student working with Ignacio, I came to understand that analyzing data is a complex process of deduction, exploration, and explanation. A good analysis lies in our ability to explain results with the least speculation our data allows.

I was fortunate to attend a lecture by Niccolò Gaj from the Università Cattolica del Sacro Cuore in Milan, where I was introduced to the concept of methodolatry through an engaging exploration of Kurt Danziger's work. By that point, I had already understood that method was my intellectual home, yet in this discussion I discovered the very foundations upon which that home was built. Both Danziger and Niccolò view method as a tool chosen in reflection of the researcher's theoretical bias. When we fail to acknowledge this bias, we risk perpetuating the use of methods in contexts where they are inadequate. To avoid the continual subversion of method, we must therefore make our theoretical assumptions explicit and strive to understand the biases of the researchers who came before us.

I applied this knowledge most profoundly while working with my supervisor, Bahar Tunçgenç, both during her visit to Portugal and later when I joined her at Nottingham Trent University (UK). Bahar has a remarkable talent for grounding data in literature and theory. She taught me the importance of reading widely and of considering every possible explanation for our findings, especially when the data seemed to fall short. This collaboration was pivotal for me: it was through working with Bahar that I gained the confidence to step fully into the field of Applied Psychology. I came to understand where my strengths lay, but only through our first study together did I learn how to strengthen and clarify what I was contributing back to the literature.

I met Frederik "Ted" Scharf during my time as a PhD candidate. Ted, who, now retired and acting as a consultant for the Human Neurobehavioral Laboratory, used to be a researcher at NIOSH, and I got to see the way he thought about method. I learnt a lot from him working on my third study. Initially we were at odds, when within one of our first conversations he told me not to get hung up with the best statistical solution, but I now recognize this was perhaps one of the most important steps in me becoming the researcher I am today. Ted shared a passion for understanding how method works with me, but he learnt that sometimes the right methods point towards the wrong choice. For him the method of choice for pointing accurately at the wrong choice was Exploratory Factor Analysis – I am not yet certain which, if any, method will be my method of choice, I am, perhaps, far too excitable about trying new things to become a one method man. While looking at EFA with Ted I learned the value of looking at data through the lens of my own theoretical bias, and I relearned the value of exploring this bias in different ways. With him I looked for subjects who answered one of my questions how "they were supposed to", and in doing so shattered my misconceptions regarding my data. In this I realized I had held a misconception that bias is a bad thing, in this collaboration I learned that bias is a voice in our minds that we aim to prove wrong through our exploration of our study problem. With Nicolo I learned the importance of exposing my bias, with Ted I learned the importance of leveraging my bias to create science. Bias is simply a reflection of the knowledge that came before, and by arguing with it we create the knowledge that comes after.

Working with Professor Patrícia Oliveira-Silva I was able to step into various topics, things as varied as the effect of mobile video games on stress, and the analysis of text from websites of companies in the footwear industry to uncover how they discussed sustainability.

I estimate in my time working with her I may have been an active participant in over 10 different studies. Professor Patrícia runs an ambitious laboratory, and this demands a lot from everyone, but it also demands personal development and continuous improvement. At the beginning of this period, I was concerned with uncovering every parasitic variable that may affect our studies, testing everything, I would propose gigantic surveys, complex protocols. Quite early on I understood that no perfect paradigms exist. Not because of flawed research but because every problem in psychology and neuroscience, no matter how small it is, involves thousands of variables and considerations. This means not every single one of our variables will be tested every time. This is how I learned that a single study or a single Study cannot aim to solve every problem in a theme. I learned research is iterative, and no matter how creative a method, no matter how detailed the data, at the end every manuscript we write must consider limitations. While I believe every researcher reaches this conclusion I would have desired to reach it in no other environment. Working at HNL has been the most enriching experience I could have asked for as a young researcher, and as a young PhD candidate with much yet to learn.

I must admit, as well, how much I have learned from teaching as well as doing research, and how thankful I am to have had this opportunity. At the beginning, much like my journey in research, I was uncertain of what I had to offer. I was asked to teach what I know, so I taught about the equipment used in neuroscience, explained how they are used and why they are relevant, but what few links to psychology practice I could afford my students were based only on my experience at the HNL. And yet, over the years I began to feel more comfortable teaching, and in large part it is because I learned how to turn classes into a dialogue, how to build knowledge together, I learned how to allow my students to speculate and then fact-checked their ideas, explored them alongside the class. Teaching made my connection to psychology a lot stronger because I got to see how a professional in this area develops, I got to learn as they were learning, and all throughout I got to understand what contributions I could make in their training.

I truly do believe my journey through this PhD was not what it was because of classes or however much effort I have put in. It was about the people I have worked with, about the conversations I have had, every now and then, a thought about a book I have read. I am richer in knowledge for having come so far out of my comfort zone, but far richer as a person and the professional for the people I have met on this journey. And while I am yet to have many more awkward conversations about can only be described as an eclectic path in life, I remain in awe of these opportunities I have been afforded and thankful for having had the mind to hold them close. I have become a researcher who knows where he can contribute, who has the courage to speak up, the courage to experiment, I feel far more prepared for a career in academia, and I am uncertain no more.

Annex B: Beyond Research

Over the past three years, I have engaged in a range of academic, teaching, research and service activities that have complemented the core objectives of this PhD Projects and broadened its impact.

In terms of academic dissemination, I presented my work at three international conferences. I presented at the Affect, Personality and the Embodied Brain conference in December of 2022 with a work titled "EEG and ECG nonlinear and spectral multiband analysis to explore the effect of videogames against anxiety", where I presented the results of my Master's thesis, winning the best presentation award. I presented once more at this conference in a poster blitz, in December 2023, with a poster related to work being done on this PhD project titled "fNIRS As a Driving Motor For Consumer Neuroscience Research", where I discussed the growing potential for functional near-infrared spectroscopy as a neuroimaging method with growing applicability in consumer research, presenting the benefits it brings compared to other more established technologies.

I presented at the Education, Reflection and Development conference, held by the Babeş-Bolyai University, in Cluj-Napoca, Romania, which I attended and presented at on two occasions in May 2024 and May 2025. In May 2024 I presented a work titled "An application in the assessment processes of Cognitive and Affective Neuroscience students." where I discussed an innovative practice I developed for using generative Artificial Intelligence in the assessment process of the Cognitive and Affective Neuroscience module I was teaching at the time discussing the impact and feedback collected from the students- In May 2025, I presented a work titled "Learning from the Social Circle: A Cross-Cultural Study of Environmental Attitudes and the Role of Social Influence in Sustainability Education" which presented the results of study 1 of this thesis, and discussed what contributions these could provide in educating for sustainability in a Higher Education setting.

In October 2024, I presented at the InsureHub conference held at the Porto Regional Centre of Universidade Católica Portuguesa with a work titled "Understanding Social Environmental Attitudes: Gender and Politics in Focus" Here I discussed preliminary results from study 1 of this thesis, focusing on a discussion of the novel instrument developed, the

Social Environmental Attitudes Inventory and presenting as well the demographic and identitarian predictors found for Environmental Attitude.

In December 2024, I presented at two specialist research meetings at Nottingham Trent University. I presented a work titled “The Social Circle Effect: How social norms and identity contribute to environmental attitudes”, presenting the final results from study 1 of this thesis at the Social Interaction Bites research meeting, and a work titled “Source localized, Band-decomposed EEG functional connectivity for the prediction of purchase intention” discussing how the uncommon methods used in study 2 of this thesis were providing us with novel insights into consumer decision making.

Along these three years I served as lecturer and teaching assistant in the Cognitive and Affective Neurosciences module offered in the psychology course at the Faculty of Education and Psychology of the Universidade Católica Portuguesa. In this module I was responsible for teaching practical classes, with a focus on promoting the use of several neuroimaging and biosensor devices in neurosciences and psychology. Here I also developed a novel assessment methodology where students were asked to interview a generative artificial intelligence of their choice regarding a neuropsychology case study assigned randomly by group and fact check the AI, while critically thinking and using the results to suggest a solution to the specific case-study.

In the academic year of 2024-25 I also lectured for modules focused on biosignals analysis, and research paradigm creation within the post-graduate program in Neuropsychology at the Faculty of Education and Psychology of the Universidade Católica Portuguesa. Here I gave theoretical-practical classes where I gave students the opportunity to view the analysis of biosignals and interpret critical metrics associated with cognitive processes and demonstrated how tools like Psychopy can be used to run computerized laboratory protocols in neuroscience research.

With regards to other teaching activities I served as a lecturer in three editions of the Universidade Júnior program of the Medicine school of the Porto University in July 2023, 2024 and 2025, I lectured at the Blended Intensive program “Skill Enhancement through Music” in Prvik Luka, Croatia, in July 2024 and 2025 regarding the neuroscience of Music, and the Blended Intensive program “Evidence-Based Practices in Psychology” in Cluj-Napoca, Romania, in May 2025, with a practical session developing critical thinking skills in the creation and application of Psychology Service Learning programs.

In other research activities, I co-authored a Study regarding a Neuroeducation approach to sustainability training (Batista et al., 2024). I also participated in two, ultimately unsuccessful grant proposal, the project “VR-Resilience: Enhancing Stress Management in Emergency Personnel through Integrated Virtual Reality and Self-regulatory Neuromodulation Interventions VR4EP” for the 2024 ERC consolidator grant, and the proposal “Promoting Higher Education Student’s Mental Health: An adaptation of the RISE program with Biofeedback” for the FLAD grants in 2024. Additionally, I co-developed a social entrepreneurship proposal title “Semeando Sinapses” – translates to planting synapses – to the Porto City Hall’s Social Innovation Laboratory initiative, running a funding contest in a hackathon format, dealing with a neurofeedback psychoeducation approach for children and teenagers residing at foster-care institutions. This proposal reached the final stage, missing out on funding in seventh place.

I supported the supervision of eight master students during this PhD, with themes varied as neurofeedback for musicians with stage fright, and the study of the effect of coffee on attention and working memory. In this process I participated in discussions regarding the topic, helped design and build the research paradigms, participated in data analysis, and provided advice and writing and data interpretation.

I served on the organizing committee of three international weeks held at the Faculty of Education and Psychology of the Universidade Católica Portuguesa, participating in the organization of programs, providing guidance for visiting dignitaries and leading workshop and roundtable sessions.

In non-academic initiatives, I was elected and have served as the Treasurer and Communications Officer for the IEEE Portugal branches’ Young Professional affiliate group. Within this position I was responsible for developing a communication strategy, planning events and initiatives, and co-creating a series of webinars.

Together these activities have prepared me for a role in academia beyond a doctoral program. During my time as a PhD candidate I have undertaken leadership positions, participated in varied research projects and nearly every task required of a full researcher, aided in the writing of project grants, presented at a wide range of conferences on multiple topics, taught on more than one module, and aided in the supervision of graduate students.

Together, these activities have prepared me for a role in academia beyond the doctoral program. Over the course of this PhD, I have taken leadership positions, contributed to diverse research projects, assisted in grant writing, presented at international conferences, taught across multiple modules, and supported the supervision of graduate students — in short, I have carried out nearly every task required of a full researcher.