How personal relevance influences advertising effectiveness: a cognitive, affective, and neural perspective

Sofia Gumilevskaya

UCL

A thesis submitted for the degree of Doctor of Philosophy

Department of Experimental Psychology

University College London

2025

I, Sofia Gumilevskaya, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Publication Statement

The research forming Chapter 2 was first published in the following peer-reviewed article:

Gumilevskaya, S., Devlin, J., Richardson, D., Diab, H., Liu, Z., & Casey-Miller, P. (2023). Addressable TV Advertising Enhances Advertising Effectiveness. *Organizations and Markets in Emerging Economies*, *14*(2 (28)), 386-411.

Abstract

Personalised advertising is now a defining feature of the media landscape. Personalisation acknowledges the uniqueness of each consumer by tailoring content to their preferences, behaviours, or identity. In advertising, this strategy is often assumed to enhance effectiveness by increasing personal relevance. That is, making content feel more meaningful because it relates to the self. While this has clear commercial value, understanding how personalisation affects consumers on a cognitive and emotional level is equally important, as we are all recipients of these messages. This thesis investigates how personal relevance, along with contextual media factors, shapes advertising effectiveness by examining the mechanisms through which it influences information processing.

Chapter 1 outlines the rise of personalised media and reviews theoretical perspectives on self-relevance. Chapter 2 presents a study using self-report, behavioural, and physiological methods to examine how personal relevance and screen size affect audience engagement. Personally relevant ads were preferred and better remembered, while larger screens improved attention and memory recall compared to smaller devices. Chapter 3 used fMRI to investigate the neural mechanisms underlying this "addressability uplift." Contrary to predictions, there was no consistent evidence that personally relevant ads activated brain regions associated with attention, emotion, memory, or reward. However, ads embedded in viewer-chosen contexts elicited stronger responses in the nucleus accumbens and hippocampus. Chapter 4 offers a further behavioural exploration of how viewing context and age modulate engagement. As age increased, participants showed improved memory for relevant ads in self-selected TV contexts, while younger participants benefitted more in non-self-selected conditions.

Together, these studies provide new insight into the dynamic factors that shape the effectiveness of personalised advertising. While personal relevance enhances behavioural engagement, the underlying neural mechanisms remain complex. This thesis highlights the need for a more nuanced, evidence-based approach to personalisation.

Impact Statement

Personalisation in advertising is increasingly enabled by development in technologies like addressable television, which allows advertisers to show distinct advertisements to different households, or individuals, watching the same programme. This growing capability creates the opportunity to deliver more personally relevant and meaningful content to consumers, while offering advertisers greater efficiency by targeting audiences more precisely. As addressable TV continues to scale, particularly through streaming platforms, understanding its psychological effects has become both timely and essential.

This thesis contributes to that understanding by investigating how personal relevance in advertising, delivered through addressable formats, influences attention, memory, emotional engagement, and neural processing. While advertisers have long assumed that personalisation increases engagement and persuasion, the evidence remains mixed. This work helps clarify that debate by demonstrating that personally relevant advertising is reliably preferred and remembered yet does not consistently enhance attentional or neural responses in expected ways. These findings suggest that the positive effects of addressable advertising may operate through subtle mechanisms, such as alignment with self-schemas or reduced cognitive load, rather than overt emotional or attentional arousal.

By examining variables such as screen size, viewing context, and age, this research also reveals that personalisation is not a one-size-fits-all solution. Older viewers, for instance, showed better memory for relevant ads when watching content they had selected themselves, whereas younger viewers responded more strongly in non-self-selected conditions. These insights have implications for advertisers, media platforms, and regulators designing content strategies for diverse audiences.

Significantly, across multiple studies, participants consistently self-reported preferences for personally relevant messages over generic alternatives. This suggests that this TV-level personalisation, targeting basic demographics and broad interests, may represent a balanced approach where consumers perceive benefits from relevance without experiencing the negative attitudes or privacy concerns often associated with more granular targeting methods. Such findings offer valuable guidance for policymakers seeking to regulate digital advertising while balancing consumer protection with media advancements, particularly as they develop frameworks for emerging addressable technologies.

Beyond industry applications, this work contributes to academic debates by combining behavioural, physiological, and neuroimaging methods to explore the underlying mechanisms of personalised communication. It also offers insights to the broader ethical debate around targeting: while addressable advertising offers benefits, it also raises concerns around data use, intrusiveness, and consumer autonomy. By mapping both the potentials and limitations of addressability, this research supports a more balanced, evidence-based approach to personalised communication that can inform both industry practice and policymakers.

Acknowledgements

I would like to thank all the friends, family and colleagues, who helped me throughout my PhD journey. I am especially grateful to my supervisor, Joe, for his invaluable guidance, encouragement, and expertise. I would also like to thank my second supervisor, Daniel, for always being willing to help and his steady support along the way.

Table of Contents

Abstract 4
Impact Statement 5
Acknowledgements 7
1. Introduction 9
The Evolution of Advertising: From Mass Communication to Personalisation 10
Segmentation and Personalisation in Advertising 12
Distinguishing Personalisation from Relevance 13
Measuring Advertising Effectiveness 14
Defining Audience Engagement 16
Empirical Evidence of Relevance Effects 17
Privacy Concerns 20
Self-Schema and Cognitive Processing 24
Measuring Engagement through Neuroscience 29
Research Aims 31
2. How Addressable TV Advertising Influences Audience Cognitive and Emotional Engagement 34
2.1 Introduction 35
2.2. Methods 42
2.3 Results 49
2.4. Discussion 53
3. Investigating The Neural Basis of Addressability Effects 59
3.1. Introduction 60
3.2. Methods 72
3.3. Results 88
3.4. Discussion 107
4. Effects of Addressability and Content Choice on Emotional and Cognitive Engagement with TV Advertising 116
4.1. Introduction 117
4.2. Methods 123
4.3. Results 127
4.4. Discussion 134
6. General Discussion 139

1. Introduction

Every day, individuals face the challenge of processing vast amounts of new information from countless external sources while constrained by limited cognitive capacity. A critical aspect of effective information processing is the ability to pre-attentively assess incoming stimuli and determine which elements warrant further allocation of cognitive resources. Social psychologists have long emphasised that this selection process is not driven solely by the properties of the stimulus field itself but is heavily influenced by an individual's personal values, needs, and interests (Postman et al., 1948). Kelly (1955) proposed that individuals construct their understanding of reality by scanning their environment for personally meaningful elements.

More recently, psychology and neuroscience research have highlighted personal relevance, that is, how closely external stimuli relate to an individual, as a key determinant of attention, memory, emotion, and reward (Northoff, 2016). This thesis investigates the cognitive and neural mechanisms through which personal relevance influences information processing; with advertising and persuasive communications serving as the applied context for this fundamental psychological investigation. By using advertising as a real-world domain where personal relevance is systematically manipulated, this research aims to contribute to the broader understanding of how humans selectively process personally relevant information in complex environments.

Using a neurocognitive approach, I employ behavioural, physiological, and neuroimaging methods to examine the effects of personal relevance on cognitive and emotional engagement. More importantly, I seek to understand the cognitive mechanisms underlying these effects, providing insights into how and why personal relevance influences audience engagement.

The Evolution of Advertising: From Mass Communication to Personalisation

In its earliest form, advertising operated on a mass communication model, where marketers created generalised messages with the purpose to appeal to the widest possible audience. Traditional media, such as print, radio, and television, allowed little room for personalisation, relying primarily on demographic segmentation (e.g., age, gender, location). This method, rooted in the principles of widespread reach and repetition, prioritised volume over engagement quality (Chandra et al., 2022). While this approach was effective for building brand awareness, its capability to target potential customers was largely restricted and limited to broad demographic groups, which often led to wasted advertising spend (Danaher & Dagger, 2013).

The emergence of direct marketing techniques in the mid-to-late 20th century marked the first steps toward personalisation. Professionals in the field began leveraging consumer databases to tailor messaging based on purchase history, customer preferences, and geographic location. Loyalty programs and customer relationship management systems enabled brands to track customer interactions and refine targeting strategies, allowing businesses to move beyond simple demographic segmentation. Although these methods were still basic compared to current day advancements, they improved the ease of information access for consumers, accommodating group differences (Blom, 2000).

With the rise of digital advertising in the early 2000s, personalisation further benefited from rapid development. Communication with consumers was no longer made to be aimed at broad audiences. Instead, advertising practitioners began to benefit from readily available demographic data to reach individual target audiences. The internet enabled advertisers to track online behaviour, using cookies, browsing history, and search intent to serve more relevant digital ads. Thus, the introduction of programmatic advertising created an opportunity to instantly select which ads to show to specific users, ensuring people were seeing ads that matched their previous online activities and interests (Bleier & Eisenbeiss, 2015). Social media platforms like Facebook and Instagram further revolutionised targeting capabilities. Users' attitudes and preferences could be inferred from their engagement with content, including the pages they ‘liked’, posts they shared, and interactions with friends. Facebook, for example, was one of the first platforms that allowed advertisers to target audiences based on detailed demographic data, interests, and tracked behaviours, facilitating hyper-personalised advertising campaigns (Chan, 2012). This led to an advertising landscape where personalisation was no longer limited to demographic variables but was instead based on real-time behavioural data.

From a cognitive psychology perspective, this evolution raises important questions about how the human mind processes increasingly tailored information. Does personally relevant information engage different cognitive processes than generic ones in the mind of the recipient? And if so, what are the underlying mechanisms that explain these differences?

Segmentation and Personalisation in Advertising

The transition from basic demographic segmentation to behavioural targeting marked a significant shift in advertising effectiveness. Rather than assuming consumer preferences based on broad demographic categories, practitioners began analysing real-time interactions, such as web browsing activity, search engine queries, and social media engagement. The development of machine learning algorithms further enhanced personalisation by predicting user preferences and automating content recommendations. Platforms like Google, Facebook, and Amazon allowed advertisers to serve customised product suggestions based on individual browsing patterns and previous purchases. In fact, predictive analytics can now anticipate consumer needs before they are even explicitly expressed (GhorbanTanhaei et al., 2024). This shift towards more sophisticated personalisation that enables to create and deliver ads to match specific characteristics and preferences of their receivers (Pappas et al., 2017) led to apprehension about the benefits of traditional mass-targeted methods. With an unprecedented capacity to gather information about individual consumers and target them with personalised messaging, most producers, retailers, manufacturers, and third-sector organisations have leant into tracking individual-level data such as browsing history, demographic information, and interest preferences to create more personalised experiences (T. Kim et al., 2019; S. Matz, 2025; Schumann et al., 2014).

Such developments in communication aim to enhance consumer satisfaction by offering usefulness and informativeness (Ho & Tam, 2005). However, the idea that personalisation satisfies consumer needs and improves attitudes towards ads by helping filter out irrelevant information (Y. Kim et al., 2016) has been contradicted with evidence of avoidance of personalised ads due to a perceived invasion of privacy (Aguirre et al., 2015; Van Slyke et al., 2006). In order to better understand the range of responses to personalisation, which will be further addressed in this Chapter, it is important to note the various forms that audience segmentation and personalisation have taken in the digital landscape. These include cue-based approaches, such as adding an identifiable element like a person’s name in an email (Sahni et al., 2018) behavioural targeting, which shows people products based on their past purchases or browsing activity (Lambrecht & Tucker, 2013); and trait-based personalisation, where ads can be adapted to individuals' specific interests, characteristics, or psychographic profiles based on their online behaviour (Winter et al., 2021).

Importantly, personalisation it no longer exclusive to digital platforms and is now starting to shape how ads work in television too. Addressable TV is relatively new and quickly evolving targeted advertising strategy that enables different households, and sometimes individuals, to see different ads on TV based on factors such as household location, income and demographics, leveraging some advantages of trait-based personalisation (Malthouse et al., 2018). For example, a group of friends watching a live football match may see an ad for a popular fast-food chain, whereas a household with young children watching the same match, are more likely to be shown an ad for a local theme park. However, research on this form of targeting is sparce and deserves more academic attention (Taylor, 2019), given its potential impact on consumers, through the inclusion of relevance in the context of TV, and advertisers, who may experience some of the same benefits that data offers in the digital space.

This evolution in personalisation technology has significant implications for how consumers cognitively process incoming messages. As personalisation becomes more advanced, it may generate ads that better align with consumers' existing mental schemas and reflect their self-identity, leading to more favourable responses (Sirgy, 2018). However, this also raises questions about whether there are diminishing returns or even negative effects when personally relevant features or information becomes too precise or perceived as intrusive. Understanding these cognitive boundaries is essential for developing effective and ethical personalisation strategies that benefit the consumer.

Distinguishing Personalisation from Relevance

Before discussing the effectiveness of personally relevant advertising, it is important to clarify the distinction between personalisation and relevance. Personal relevance refers to the degree to which individuals perceive an advertising message as being related to them or instrumental in achieving their personal goals and values (Celsi & Olson, 1988). This differs from personalisation, which refers to the technical process of tailoring content based on user data (Chandra et al., 2022).

While personalisation aims to increase relevance, not all personalised content will necessarily be perceived as relevant by consumers, and relevance can sometimes be achieved without invasive personalisation techniques. For example, an advertisement for hay fever medicine may become highly relevant when a person is struggling with allergies, even without any personalisation technology. Conversely, a highly personalised advertisement that incorporates personal information may fail to achieve relevance if it does not align with the individual's current goals or interests.

This distinction is crucial for understanding the cognitive processes activated by relevance manipulations. From a psychological standpoint, it is the perception of relevance, and not the technical implementation of personalisation, that determines how information is processed. This thesis focuses primarily on personal relevance as the psychological construct of interest, with personalisation techniques serving as the methodological tools to manipulate the degree of relevance in experimental settings.

Throughout this thesis, I examine how increasing the personal relevance of incoming stimuli through personalisation, especially in addressable TV advertising, affects audience engagement and cognitive processing, and ultimately the effectiveness of the incoming message. By distinguishing between these concepts, I can better isolate the psychological mechanisms that underlie effective communication.

Measuring Advertising Effectiveness

To understand how personal relevance impacts advertising outcomes, it's crucial to define what constitutes "effective" advertising and how it is measured. According to general advertising models, the effectiveness of digital advertising can be assessed based on processing stage effects, communication effects, and behavioural outcomes (Rossiter & Bellman, 1999). From a cognitive perspective, effective advertising has been typically measured by how well consumers attend to, process, and remember ad content (MacInnis et al., 1991; Pieters & Wedel, 2004). Advertisers value metrics such as ad recall (whether consumers can remember seeing the ad), recognition (identifying the brand or message when prompted), attention duration (how long consumers engage with the ad), and comprehension (understanding the intended message; (Beerli & and Santana, 1999). These cognitive indicators are particularly valuable because they serve as precursors to behavioural outcomes like purchases (Krugman, 1965). A meta-analysis of academic research on advertising effectiveness measures has highlighted that the impact of advertising is most often evaluated through measures related to how people think about, remember, and respond to ads (Eisend & and Tarrahi, 2016). These include cognitive engagement, recall, decision-making, and stages of information processing. Given the centrality of these outcomes, some of them offer a useful foundation for examining how personal relevance might shape individuals' psychological and behavioural responses to advertising.

In practical research, advertising effectiveness is typically measured through multiple complementary approaches. Attentional measures assess whether and how long consumers engage with ad content. For instance, eye-tracking studies, such as that conducted by (Kaspar et al., 2019), track fixation patterns to determine which elements of an advertisement attract visual attention. These studies can reveal whether certain features of the content receive more visual attention than its alternatives. Memory-based measures include both recall and recognition, which are especially valuable given the typical delay between ad exposure and purchase decisions (Yoo, 2007). Affective measures evaluate emotional responses and attitudes toward advertisements (Otamendi & Sutil Martín, 2020). Self-reported liking, interest, and purchase intention are common metrics, although these may be influenced by social desirability bias, where participants respond in a manner they believe is more socially acceptable (Paulhus, 1984). Behavioural measures, such as click-through rates, conversion rates, and actual purchases, offer the most direct evidence of advertising effectiveness (Robinson et al., 2007), although these outcomes are often shaped by factors beyond content relevance. More recently, physiological and neurophysiological measures, including heart rate, skin conductance, and brain imaging, have been used to capture implicit emotional and cognitive responses that may not be consciously accessible through traditional self-report methods (Kawala-Sterniuk et al., 2021).

In terms of personalisation, some evidence suggests that personal relevance positively influences attention (Kaspar et al., 2019), memory (Köster et al., 2015), and attitudes toward the advertisement (Bang et al., 2019). However, the magnitude of these effects can vary significantly depending on how relevance is operationalised, the context in which the ad is encountered, and the measurement methods employed. As such, a deeper understanding of the cognitive and neural mechanisms underpinning these effects is essential for optimising personalisation strategies.

Defining Audience Engagement

As personalisation became more advanced, its effects on audience engagement became a focal point of research. Consumer engagement, also referred to as audience engagement, has generated a growing body of studies since its first conceptualisation in consumer psychology and neuroscience research (Brodie et al., 2011; Pansari & Kumar, 2017). The definition of engagement varies across literature. Some scientific literature defines engagement as an individual's exertion of cognitive effort, attention, or agency when performing a task (Beymer et al., 2018; Richardson et al., 2020), while in other contexts, it refers more generally to participation in tasks and activities (Finn & Zimmer, 2012; Fredricks et al., 2014). Consumer engagement, more specifically, is most commonly perceived as a multidimensional concept made up of cognitive, emotional, and behavioural components (e.g., Calder et al., 2009; Dessart et al., 2016). As cognitive and emotional engagement drive behavioural engagement, the operationalisation of engagement must incorporate multiple complementary approaches to capture both subjective experience and physiological responses.

Cognitive engagement involves the depth of information processing, attention allocation, and memory encoding (Rueda et al., 2004). It reflects an individual's mental effort and sustained focus, stimulating brand awareness and message recall rather than passive exposure. Emotional engagement refers to an individual's affective response, such as enjoyment or a sense of connection to an ad, revealing how emotional reactions influence content liking (Dessart et al., 2016; Heath, 2009). Behavioural engagement emerges as a consequence of cognitive and emotional engagement, representing observable actions such as interaction, recall, and purchase intent, indicating the extent to which individuals act on their thoughts and feelings toward the content (Malthouse & Calder, 2018).

Empirical Evidence of Relevance Effects

Existing findings linked to the outcomes of personalised advertising show conflicting evidence. Some scholars claim that consumers perceive targeted ads as more relevant, motivating, and appealing (Tucker, 2014). This view is empirically supported by empirical evidence showing positive attitudes towards personalised advertising (Maslowska et al., 2011)higher click-through rates online (Yan et al., 2009), increased perceived usefulness (Bleier & Eisenbeiss, 2015), and increased purchase decision-making (Goldfarb & Tucker, 2012). In other words, when advertisements match consumers' goals and interests, they can serve as useful information sources. However, another camp highlights potential drawbacks of personalisation, particularly if consumers perceive targeted ads as unnecessarily invasive. Research suggests that excessive personalisation can trigger psychological reactance, leading to negative attitudes towards brands and lower purchase intentions (Aguirre et al., 2015; Rosenthal et al., 2019). In other words, if consumers feel their privacy is being compromised, they may actively avoid personalised advertising or respond negatively to it (Baek & Morimoto, 2012). Given these conflicting perspectives, it is important to summarise the different ways in which personal relevance in advertising has been studied and explore the nuance of how it is perceived and received by its audience.

In advertising research, several behavioural studies have demonstrated that personalised content leads to higher consumer engagement levels compared to generic advertising. For example, Bleier and Eisenbeiss (2015) investigated the effectiveness of personalised retargeting banners, focusing on how the personalisation of an ad also interacts with its timing and placement. In their study, ad personalisation was operationalised through varying degrees of content personalisation, based on users' recent browsing behaviour. This ranged from generic product suggestions to banners featuring the exact product and brand previously viewed. The results showed that higher personalisation significantly increased click-through rates, particularly when consumers were still early in the purchase process and had recently visited the advertiser's site. However, this effect declined over time and was less effective in later stages of decision-making. The study also found that personalisation was more effective when ads appeared on websites that matched the user's browsing motivations, for example, shopping-related sites where users are already in a purchasing mindset. In addition, users were more responsive to personalised ads when they were casually browsing rather than when they were focused on a specific task and had a goal in mind. Overall, the study provides strong evidence that personalisation can have significantly positive effects on consumer engagement, but its success also depends on delivering the right content at the right time, in the right context, and to the right mindset.

This aligns with earlier findings by (Kalyanaraman & Sundar, 2006), who similarly explored the effects of personalised content, delivered through user-driven customisation, on attitudes and behavioural engagement. In their experimental study, participants were exposed to either low, medium, or high levels of content personalisation on an online portal, based on their pre-stated preferences across topics like weather, sports, entertainment, and news. The high personalisation condition matched 100% of the content to users' interests, while the low condition had no tailored elements. Results showed a linear relationship between personalisation and positive outcomes, which higher personalisation leading to significantly more positive attitudes toward the portal, greater perceived relevance, interactivity, involvement, and novelty, and increased behavioural engagement, such as more frequent returns to the homepage and reduced browsing of other sites. The study demonstrates that personalisation can enhance both attitudinal and behavioural engagement, particularly when users recognise content as aligned with their individual preferences. A message that is closely linked to an individual's self-concept may therefore exert persuasive effects, leading to a preference for the content.

Köster and colleagues (2015) conducted an experimental study to examine the effects of personalised banner ads on visual attention and recognition memory. Using eye-tracking and post-task recognition tests, they assessed how personalised versus non-personalised banners influenced participants' attention and memory while completing search tasks on simulated web pages. Personalisation was achieved through demographic targeting (e.g., age, gender, occupation), and banners were tailored accordingly. The study measured overt attention, that is, where users looked on the page, and found that while overall gaze time on banners was low, personalised banners attracted more focused visual attention, particularly to specific elements such as slogans and logos. More importantly, personalised banners significantly improved recognition performance, with participants recalling about 22% of the banner elements compared to lower rates for non-personalised versions. However, personalisation did not distract from task-relevant content, nor did it affect overall exploration of the web pages. This study suggests that even modest increases in overt attention, when directed toward self-relevant advertising content, can create improved memory, highlighting the cognitive value of personalisation in digital advertising.

Beyond theoretical and experimental evidence, real-world case studies have illustrated how personalisation strategies have evolved and so has their impact on consumer engagement. For instance, loyalty programmes have become increasingly popular as a form of behavioural personalisation, using purchase history to offer tailored promotions. This represents a more subtle yet sophisticated approach to personalisation. These programmes are often perceived as less intrusive because they involve voluntary participation, offer tangible benefits, and maintain transparency about data collection (Baik & Famularo, 2024) . However, they can also be more covert and “sneaky” in how they collect detailed consumer data, analyse behaviour, and subtly influence purchasing decisions, often without consumers fully realising the extent of the tracking involved. This is exemplified in a study by (Riefer et al., 2017) who analysed over 280,000 anonymised Tesco’s loyalty programme card datasets to explore how purchasing behaviour could be influenced through personalised targeting. They found that consumers tend to follow predictable patterns of repeated purchasing of the same brands or products but are more open to trying new products at specific points in their shopping cycles. By detecting moments when consumers were most open to change, Tesco was able to send targeted coupons that encouraged new product exploration. A follow-up field experiment with over 8,000 households confirmed that well-timed, personalised offers increased the likelihood of behavioural change. The study highlights how loyalty programmes not only enable sophisticated data collection but can also be used to personalise communication and offers and guide purchasing behaviour, often without consumers being fully aware of how their data is being leveraged.

While Riefer et al. (2017) focused on behavioural patterns via loyalty data, other work has demonstrated how deeper psychological profiling can also be used to influence consumer decisions. (S. C. Matz et al., 2017) demonstrated how personalisation based on psychological traits can significantly increase the effectiveness of digital advertising. In a series of large-scale field experiments involving over 3.5 million Facebook users, the researchers showed that tailoring ad messages to individuals’ Big Five personality traits, specifically extraversion and openness to experience, led to greater engagement. Users who saw ads that were phrased is a style that matched their personality were 1.54 times more likely to make a purchase (in

the extraversion-targeted campaign) and 1.38 times more likely to click (in the openness-targeted campaign) compared to those shown mismatched or generic ads.
Participants' personality traits were inferred using Facebook likes, allowing advertisers to reach psychologically defined audiences without collecting direct personal data.

This form of deep psychographic targeting allows advertisers to craft messages that resonate with consumers at a psychological level, moving beyond surface-level personalisation techniques. Evidently, when brands acknowledge individual differences, they can create more meaningful connections. These findings from industry applications provide valuable insight into how personalisation affects engagement in real-world settings. However, to fully understand the psychological mechanisms underlying these effects, I must examine the cognitive processes involved in processing personally relevant information.

However, not all personalisation strategies lead to positive results. Other studies have shown that highly personalised advertising can backfire when consumers feel their freedom of choice is being restricted (White et al., 2008) or when they perceive a violation of privacy (Rosenthal et al., 2019). These negative reactions can lead not only to reduced purchasing behaviour (Bambauer-Sachse & Heinzle, 2018) and greater ad avoidance (Baek & Morimoto, 2012), but also to more negative brand attitudes (Kaspar et al., 2019), which can have long lasting effects.

Privacy Concerns

Despite the documented benefits of personalisation, it can also trigger privacy concerns and feelings of discomfort among consumers. Multiple empirical studies have shown negative responses to personalised advertising, particularly when it reveals that sensitive personal data has been collected or when personalisation appears in contexts perceived as private (De Keyzer et al., 2022; Pfiffelmann et al., 2020).

(Meyers-Levy & Peracchio, 1996) found that while moderate self-referencing in advertising can enhance persuasion, excessive levels of self-reference may have the opposite effect. Their study showed that when ads strongly prompted individuals to relate the content to themselves, through second-person wording, it led to more critical scrutiny and, ultimately, less favourable evaluations. Second-person wording is often used to create a personal connection, increase self-referencing, and make the message feel directly relevant to the individual. The findings align with broader discoveries suggesting that when personalisation becomes too intense, especially by referencing personal data, it can trigger discomfort. Such "creepiness" typically arises when targeted messages exceed appropriate relevance thresholds, particularly in contexts that are perceived as private or overly intimate. These effects are often linked to the excessive of consumer data, which leads individuals to feel that their autonomy or privacy has been compromised.

For example, a study by White and colleagues (2008) found that increasing the level of personalisation in marketing emails can become counterproductive if the recipient is not given a clear explanation for why their personal information is being used. When a promotional offer closely matched the recipient's personal characteristics but lacked an explicit justification for how and why their personal information is being used, engagement with the message decreased - a phenomenon the authors termed "personalisation reactance." In other words, once personalisation crosses into the territory of perceived invasiveness, consumers are more likely to evaluate the communication as "creepy" and disengage from the message.

Tucker (2014) builds on this by demonstrating how perceived control can counteract such effects. In a large-scale field experiment involving over 1 million Facebook users, the study tested how perceptions of privacy control influence responses to personalised advertising. The experiment tested two types of ad content - personalised (mentioning specific user details like celebrity interests or university affiliation) and generic - both shown before and after Facebook introduced more user-friendly privacy settings. Although the underlying data use for ad targeting remained unchanged, the new interface gave users more perceived control over their personal information. The results showed that personalised ads were significantly more effective after the introduction of these enhanced privacy controls, nearly doubling click-through rates compared to their pre-policy performance. Interestingly, generic ads showed no change in effectiveness, indicating that it was the perceived control and not the content or targeting that made users more receptive to personalised messages. These findings highlight the psychological impact of privacy control. When users feel empowered, they respond more positively to tailored content.

Similarly, (Bright & Daugherty, 2012) found that individuals are more likely to engage with personalised content when they know their data has been collected, whereas when consumers believe that their personal information has been collected without their knowledge, they are less likely to engage with and click on ads. This reinforces the idea that transparency and perceived agency are key drivers of how personalisation is received.

This pattern can be understood through psychological reactance theory (Brehm, 1966), which suggests that individuals experience negative emotional responses when they perceive threats to their freedom or autonomy. When consumers believe their personal data has been collected without their knowledge or consent, they may respond with reactance, leading to avoidance behaviours, disengagement and negative brand associations. In these moments, the cognitive benefits of relevance are undermined, as consumers redirect their attention toward resisting or avoiding the message rather than meaningfully processing it.

Moreover, how consumers respond to personalisation also depends on what type of data is being used. Malheiros et al. (2012) found that while participants were generally comfortable with ads that used contextual data such as their holiday destination based on recent online searches, they reported significantly more discomfort with ads that included personally identifiable information, such as their name or photo. The study showed that ads using a participant's photo were rated as the most uncomfortable, with 80% of participants expressing discomfort. In contrast, 87% felt comfortable with ads using their holiday destination. Importantly, ads using personal photos attracted more attention (measured by fixation duration), but this increased visibility seemed to come at the expense of user comfort, suggesting a tension between capturing attention and respecting privacy boundaries to drive long-term effectiveness. Similarly, (van Doorn & Hoekstra, 2013) found that the use of highly personal details in targeted ads, especially when derived from transaction history, can increase perceptions of intrusiveness and even evoke feelings of vulnerability, reducing purchase intentions. Interestingly, even when an ad was highly relevant and fit the consumer’s needs, this positive effect was weakened if the ad was also perceived as intrusive. The authors concluded that personalisation can be a ‘double-edged sword’, enhancing both relevance and discomfort at the same time.

(Jung, 2017a) extended this line of research by examining how perceived ad relevance interacts with privacy concern in shaping social media advertising effectiveness. Using survey data, the study found that while relevance increased attention and reduced ad avoidance in participants, it also led to greater privacy concerns, which in turn led to avoidance behaviours, such as scrolling past or closing ads, despite participants still paying attention to the ads. These findings illustrate the key tension in personalised advertising, where the same factors that attract attention and enhance engagement can simultaneously trigger privacy-related disengagement. Similarly, (Kaspar et al., 2019) used eye-tracking methodology to show that while demographic targeting increased visual attention to personally relevant banner ads, this heightened attention did not necessarily lead to more positive brand evaluations. The authors argued that although attention to targeted content can be strong, it may not always lead to persuasion and favourable subjective responses towards the brand. Together, these findings challenge the assumption that personalisation-driven attention guarantees persuasive success, due to the privacy concerns that may arise during message processing.

(A. Lang, 2000) argues that when people perceive a threat, such as invasion of privacy by advertisers, they allocate greater cognitive resources to the threat in order to determine an appropriate response for managing it. As the level of perceived threat surpasses a certain threshold, individuals are inclined to pay heightened attention to it (Mogg & Bradley, 1998). Therefore, it is plausible that as concerns about privacy increase, consumers may become more attentive to advertisements, and not out of genuine interest, but in order to monitor the perceived risk. However, these findings also highlight that attention alone does not guarantee positive advertising outcomes.

Given that personal relevance is commonly assumed to increase effectiveness, it is important to recognise that it may also backfire under certain conditions. The mixed findings highlight the need to go beyond measuring advertising outcomes and investigate the psychological and neural mechanisms that shape how individuals process personal relevance. Understanding when and why personalisation enhances, or diminishes, advertising effectiveness requires a deeper examination of the cognitive processes involved in responding to personally relevant information.

Self-Schema and Cognitive Processing

From a cognitive neuroscience perspective, the effectiveness of personally relevant content can be explained by several core information processing mechanisms. When individuals encounter material that relates to the self, distinct cognitive systems are engaged compared to when they process generic or unrelated information. This section explores the key cognitive mechanisms that underlie the impact of self-relevant content, with particular attention to their implications in advertising contexts.

A self-schema is a cognitive structure that organises self-related knowledge, beliefs, and experiences, shaping how we perceive, interpret and respond to new information (Conway, 2005). These schemas develop over time through personal experiences and play a central role in how people categorise and retrieve information from memory. Research consistently shows that when new information aligns with an individual's existing self-schema, it is processed more deeply and remembered more accurately (Markus, 1977; Northoff, 2016).

The 'self' acts as a particularly powerful schema that enhances the processing, interpretation, and retention of incoming information. This is evident in the self-reference effect, which refers to the tendency for people to recall information more effectively when it is linked to their sense of identity (Rogers et al., 1977; Symons & Johnson, 1997). In a seminal study, Rogers and colleagues (1977) asked participants to evaluate adjectives using four different processing tasks: structural, phonemic, semantic, and self-referential. Words processed under the self-reference condition were recalled significantly better than those processed under the other conditions, demonstrating that self-related encoding is particularly effective for memory.

The self-reference effect primarily arises from the development of complex memory representations, in which new information is integrated with autobiographical knowledge and organised within the individual's self-concept (Klein & Kihlstrom, 1986; Symons & Johnson, 1997). This integration enhances recall by connecting incoming information to personal experiences. Self-referencing promotes deeper message elaboration and retrieval of personal experiences from memory, leading to greater cognitive engagement (Burnkrant & Unnava, 1995; Markus, 1977).

The effectiveness of personally relevant messages in advertising is often explained through the principle of self-congruity, in which content is tailored to match an individual's traits, goals, or preferences. A number of studies have shown that advertising messages aligned with a person's self-schema elicit stronger engagement and purchase intentions than messages that show no link to the consumer (Brock et al., 1990; Debevec & Iyer, 1988; Hong & Zinkhan, 1995). For example, Hong and Zinkhan (1995) found that participants responded more positively to ads that reflected their own personality traits: introverts preferred ads featuring introverted characters, while extraverts favoured ads with extraverted figures.

Beyond personality schemas, (Yu, 2022) demonstrated that individuals with a strong motivational self-schema in appearance, meaning those who place importance on and are driven by appearance-related goals, were more likely to engage with and express purchase intent for fashion ads featuring conventionally attractive models. While this effect was specific to appearance-related advertising, it highlights the broader principle that self-relevant content enhances attention and persuasion across diverse domains. For example, outside of advertising, studies in narrative psychology have shown that individuals are more immersed in and better recall stories more when they perceive personal relevance and identity-based connections within the narrative (Sikora et al., 2011).

The positive effects of self-congruent messages can be better understood by examining the cognitive and emotional processes they engage. Self-schemas guide attentional selection, making self-relevant information more likely to be noticed in complex environments (Moray, 1959). But attention itself is not a unitary function, and rather a multifaceted mechanism that governs both information selection and cognitive resource allocation (Chun et al., 2011). It is commonly conceptualised in two main ways. First, as a limited cognitive resource necessary for processing incoming stimuli (Wickens, 1991); and second, as a selection mechanism that prioritises particular stimuli for deeper processing based on relevance or salience (Desimone & Duncan, 1995).

Within this framework, personally relevant stimuli are effective because they engage both voluntary (top-down) and automatic (bottom-up) attentional processes. Automatic attention is largely driven by the salience of external stimuli, including their self-relevance (Alexopoulos et al., 2012; Sokolov & Cacioppo, 1997). The classic example is the "cocktail party effect" where hearing one's name in a crowded room triggers automatic attentional orientation

(Moray, 1959), suggesting that self-relevant stimuli receive processing priority even under high cognitive load conditions. In contrast, voluntary attention involves the conscious direction of focus based on personal goals or interests that align with one's self-schema (Sui & Rotshtein, 2019). People actively seek out and attend to information consistent with their self-concept, creating attentional biases that favour intrinsically meaningful information.

Eye-tracking studies provide empirical support for the role that personal relevance plays in directing top-down attention allocation. Kaspar and colleagues (2019) examined the impact of demographic targeting in online advertising on visual attention. Demographic targeting was operationalised as tailoring ad content to individual consumers based on characteristics such as gender, age, or academic interests, using modified slogans and images. For example, "The shampoo for women/men" or images of discipline-specific textbooks (e.g., psychology vs. geology). The researchers measured fixation duration and frequency and found that participants spent significantly more time viewing targeted ads compared to non-targeted ones. These findings highlight the psychological advantage of personal relevance in capturing attention in an advertising context.

Similarly, (Bang & Wojdynski, 2016) used eye-tracking to examine personalised banner ads that embedded participants' names, university affiliation, and local shop references. Their results showed that personalised ads received significantly longer fixations, particularly under high cognitive load conditions. Since cognitive resources are more limited under such conditions, this suggests that personalised content can automatically trigger bottom-up attentional capture, even when processing capacity is already strained.

These eye-tracking studies raise important questions about the underlying mechanisms of attention to personally relevant content. While Bang and Wojdynski (2016) demonstrated that personalised ads received greater attention under high cognitive load, it remains unclear whether this effect stems from genuine engagement with self-relevant content or merely the interruptive salience of self-relevant cues. Similarly, Kaspar et al. (2019) showed that demographic targeting increased fixation duration, but did not assess whether this increased visual attention led to deeper processing, memory encoding, or persuasive effects. As such, it is possible that personally relevant ads capture gaze but fail to elicit meaningful cognitive elaboration, limiting their long-term impact. Addressing these gaps requires further research into how personal relevance influences cognitive and emotional processing beyond attention.

In addition to direct attention allocation, personal relevance influences early-stage visual processing through perceptual prioritisation. (Sui et al., 2012) demonstrated this effect in a perceptual matching paradigm, in which participants were trained to associate simple geometric shapes with three identities: self, friend, and stranger. Participants were significantly faster and more accurate at identifying self-associated shapes, despite all stimuli being visually equivalent in complexity and familiarity. These results suggest that self-relevance biases perceptual decision-making at an early cognitive stage, leading to a processing advantage for self-related stimuli even before higher-order attentional mechanisms are engaged.

In addition to influencing attention, personal relevance enhances emotional engagement, which plays a critical role in cognitive processing and memory formation (Phelps, 2004). Research suggests that amygdala activation varies as a function of an individual's current needs, goals, and values, responding selectively to stimuli with motivational relevance (Mohanty et al., 2008). In their study, participants exhibited greater amygdala responses to food cues when hungry compared to when satiated, indicating that emotional salience is not fixed but dynamically shaped by current goals and needs. Notably, the amygdala's response was accompanied by increased activation in the posterior cingulate cortex and stronger functional coupling with attentional regions such as the intraparietal sulcus. These findings suggest that motivationally relevant stimuli engage both affective and attentional systems, enhancing the emotional significance of an incoming message and facilitating its prioritisation in attentional processing. Importantly, these early-stage processes are closely linked to memory formation, implying that personally relevant content is not only more likely to attract attention but also to be encoded more effectively.

Memory involves three key stages: encoding, retention, and retrieval (Keller, 1987). New information is encoded based on features such as imagery, context, and meaning, with deeper cognitive engagement enhancing long-term storage (Anderson, 1983). Retrieval depends on the presence of contextually relevant cues that reactivate stored representations. Importantly, information that is linked to the self is more likely to be remembered, a phenomenon known as the self-reference effect. This occurs because self-relevant content is processed more deeply and elaborately, resulting in more durable memory traces than generic or semantic information. Neuroimaging research supports this effect: self-referential processing engages the ventromedial prefrontal cortex (vmPFC), a region involved in integrating self-related thought with memory consolidation (Macrae et al., 2004; Northoff et al., 2006). For example, Macrae et al. (2004) found that words judged as self-relevant and later remembered elicited stronger vmPFC activation, suggesting that self-related encoding enhances subsequent memory performance.

The improved encoding efficiency of self-related information can be further explained by its intrinsic motivational value. Stimuli that are personally meaningful or related to the self are often perceived as more rewarding, which can influence how they are attended to, processed, and remembered (Sui & Humphreys, 2015; Yankouskaya et al., 2020). Beyond its role in emotional processing, personal relevance engages reward-related neural pathways. Neuroimaging research has shown that that self-referential and reward processing share overlapping neural circuits, particularly in the ventral striatum, ventral tegmental area (VTA), ventromedial prefrontal cortex, and pregenual anterior cingulate cortex (de Greck et al., 2008a; Enzi et al., 2009). This implies that encountering self-relevant stimuli may elicit a dopaminergic response, reinforcing attention, engagement, and memory formation. Supporting this, (Su et al., 2021) used functional magnetic resonance imaging (fMRI) to examine how personalised versus generalised content on TikTok activated the brain's reward system. They found that personalised videos elicited significantly stronger activation in the ventral tegmental area (VTA), a key dopaminergic region associated with reward sensitivity, motivation, and reinforcement learning. These findings suggest that self-relevant content not only enhances cognitive engagement, but also triggers reward-related responses, making it more likely to attract attention, be encoded into memory, and drive continued interaction through positive reinforcement mechanisms.

These findings help explain why personally relevant communication tends to be more engaging and persuasive. Personally relevant content is more likely to be perceived as self-related, capture attention, receive deeper cognitive processing, be retained in memory, and evoke more favourable evaluations. Together, these mechanisms highlight the powerful role of self-relevance in shaping how messages are perceived and remembered.

This can be further understood through one of the most widely recognised models of persuasion, the Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1984) which helps explain how individuals engage with persuasive messages based on their motivation and cognitive capacity. According to this model, people process information through one of two cognitive routes: the central route or the peripheral route.

Central route processing occurs when individuals perceive a message as highly relevant and engage in effortful evaluation, forming attitudes based on the quality of the arguments presented. This route tends to lead to stronger, more stable, and longer-lasting attitude change (R. E. Petty et al., 1983). On the other hand, when personal relevance is low, individuals are less motivated to process the message deeply and instead rely on peripheral cues, such as source credibility, emotional appeal, or aesthetic features, rather than the actual strength of the arguments. This peripheral route processing leads to more temporary, unstable attitudes, which are easily influenced by external factors. Empirical findings support the role of personal relevance in determining the route of persuasion. Petty, Cacioppo, and Schumann (1983) tested this model by showing participants an advertisement for a razor, manipulating both argument quality (strong vs. weak) and who was endorsing it (celebrity vs. non-celebrity endorser). When participants were told the product would soon be available in their area, thus increasing its relevance to the consumer, they engaged in central route processing and focused more on the strong arguments over weak ones. However, when the product was framed as low in relevance, participants relied more on peripheral cues (e.g., celebrity endorsements) regardless of argument strength.

In short, the ELM helps explain why messages that feel personally relevant are often more persuasive. By encouraging central route processing, personal relevance enhances attention, cognitive engagement, and memory, complementing the broader evidence on self-referential processing.

Measuring Engagement through Neuroscience

Much of the summarised research on personal relevance and advertising effectiveness has relied on self-report measures and eye-tracking techniques to assess attention and engagement (e.g., Bang & Wojdynski, 2016; Kaspar et al., 2019). While these methods provide valuable insights into visual attention and conscious preferences, they have limitations. Self-reports are prone to biases, inaccuracies in self-perception, and social desirability effects, while eye-tracking captures overt gaze patterns but does not necessarily reflect deeper cognitive or emotional engagement. To address these limitations, researchers have increasingly turned to neuroscientific methods, which offer complementary insights that are less susceptible to self-report biases and can reveal aspects of processing that may not be accessible through behavioural measures alone.

The application of neuroscientific methods to consumer research has grown substantially over the past few decades, influencing both academic research and commercial practice (Plassmann et al., 2012). Traditionally, advertising research, both in academia and practice, has relied on self-report techniques such as surveys, interviews, and focus groups to assess consumer attitudes and responses (Carrington et al., 2010; Plassmann et al., 2012). While these methods are cost-effective and widely used, they primarily capture conscious reflections and depend on participants' ability and willingness to self-evaluate their preferences, attitudes, and behavioural intentions. However, subconscious influences often shape consumer decisions in ways that self-reports fail to detect (Day, 1975; Griffin & Hauser, 1993; Kahneman, 2011). To overcome these limitations, researchers have adopted methods from psychology and neuroscience to explore the deeper cognitive and affective processes involved in advertising effectiveness.

Consumer neuroscience, which integrates neurophysiological and biological methods into consumer research, provides critical insights into how consumers engage with advertising beyond self-reported attitudes (Ariely & Berns, 2010). Neuroimaging can identify mechanisms influencing consumer decision-making without the biases associated with self-reports. These techniques offer moment-by-moment insights into how consumers engage with advertising content, capturing data on attention, emotional response, and memory formation that would otherwise remain potentially inaccessible to researchers.

An interesting study by (Berns & Moore, 2012) demonstrated the predictive abilities of neuroimaging compared to traditional self-report measures. Using fMRI, the group measured brain responses in adolescents listening to relatively unknown music. When tracking the commercial success of these songs over the next three years, they found that neural activity in the ventral striatum significantly predicted future sales, whereas self-reported likability ratings did not. This highlights that brain responses can reveal implicit preferences that individuals may be unable, or unwilling, to articulate explicitly. Yet these responses are highly predictive of real-world market outcomes.

By employing techniques such as fMRI, electroencephalography (EEG), and biometric measurements, academic researchers and marketers can now assess how various aspects of communication affect engagement at multiple levels. Furthermore, neurophysiological methods enable the moment-by-moment collection of data, allowing to capture the dynamic nature of advertising interactions (Venkatraman et al., 2012), which is valuable in studying how personally relevant content affects ad processing.

These approaches complement traditional behavioural metrics by offering insight into the underlying cognitive mechanisms through which personalisation influences consumer responses. While click-through rates and purchase behaviours reveal what consumers do, psychological and neuroscientific methods help explain why, by directly measuring cognitive and neural activity in response to personalised versus generic content. This deeper understanding not only enables researchers and marketers to design more effective advertising strategies, but also helps understand the broader implications of personalisation on consumer experience and decision-making.

Research Aims

Personal relevance is a powerful driver of information processing, shaping attention, memory, and attitudes. While prior research suggests that under certain circumstances relevance enhances engagement, the cognitive and neural mechanisms underlying these effects remain insufficiently understood. This thesis addresses this gap by integrating behavioural, physiological, and neuroimaging methods to investigate how relevance influences cognitive engagement in the context of addressable TV advertising. Unlike much of the existing literature, which predominantly solely relies on self-report measures, click though rates, and eye-tracking, this research additionally employs objective markers such as heart rate (HR) and functional magnetic resonance imaging (fMRI) to examine the ways in which addressable content affects information processing.

Furthermore, this thesis extends beyond addressability processing to explore how contextual factors, such as screen size and choice of media environment, modulate the effectiveness of such content, providing a more ecologically valid perspective on personal relevance-driven engagement.

This thesis is structured to systematically address these questions through a series of empirical studies, each building on the findings of the previous chapter to develop a more comprehensive understanding of the cognitive and neural underpinnings of relevance effects. Chapter 2 presents an experimental study that examines how personalisation, in the form of addressable advertising, affects audience engagement. This study uses a combination of self-report, memory tests, and heart physiology monitoring to assess whether relevant advertisements lead to greater sustained attention, memory, and attitudes. Given prior evidence that personalisation enhances visual attention in advertising, as shown through increased fixations in eye-tracking studies, heart rate was included in Chapter 2 as a physiological index of attentional engagement. Given the dynamic, audiovisual nature of TV ads, heart rate offers a useful advantage as it doesn't rely on gaze location. Unlike eye tracking, it captures sustained cognitive focus even as viewers naturally shift their gaze. The study also investigates whether screen size influences these effects, addressing the question of whether viewing context modulates engagement with personalised content. This is interesting to consider because addressable TV allows to take ad personalisation from small devices to the big screen.

Chapter 3 builds on these findings by investigating the neural mechanisms underlying the "addressability uplift" in advertising effectiveness. Using fMRI, this study identifies the brain regions activated during the processing of personally relevant versus non-relevant advertisements, focusing on areas associated with attention, memory, emotional processing and reward. By linking neural activation patterns with behavioural outcomes, this chapter seeks to uncover the mechanisms through which relevance enhances cognitive processing. Furthermore, the role of self-selected (choice) versus externally assigned (random) context conditions is examined. The effectiveness of addressable TV ads is explored within these two viewing contexts in attempt to better reflect real-world TV consumption environments. The findings contribute to our understanding of how relevance-driven processing occurs at the neural level.

Chapter 4 investigates how contextual factors shape the effectiveness of addressable advertising, using a large-scale online behavioural experiment that overcomes the small sample-size limitation of the fMRI study in Chapter 3. It examines the impact of self-selected (choice) versus externally assigned (random) TV contexts, alongside participant age, as moderators of addressability effects on ad recall and attitudes. By exploring the relationship between personal relevance, context, and age, this chapter offers deeper insight into how addressable advertising can be optimised across diverse viewing conditions to enhance audience engagement.

Finally, Chapter 5 summarises the findings across studies, highlighting the key contributions of this thesis to research on personal relevance and its effects on cognitive and emotional engagement in the context of addressable advertising. This chapter also discusses the theoretical implications of the results, particularly for understanding how relevance interacts with contextual and demographic factors to shape attention, memory, emotional engagement, and reward processing in response to personalised advertising. Chapter 5 also discusses the limitations of this research and future directions.

2. How Addressable TV Advertising Influences Audience Cognitive and Emotional Engagement

2.1 Introduction

This chapter addresses a key question arising from the literature reviewed in Chapter 1: does personal relevance enhance the effectiveness of advertising, and can this be captured using quantitative measures beyond self-report? While previous research suggests that personalised content may improve ad outcomes, the evidence remains mixed, and much of it relies on subjective ratings rather than objective behavioural or physiological indicators. The aim of this chapter is to assess whether addressable TV advertising, which is a real-world example of ad personalisation, produces a measurable uplift in audience engagement when assessed using both behavioural and physiological methods. Here, I operationally define engagement as the level of sustained attention, memory recall and liking towards an advertisement and assess it using both explicit and implicit, physiological measurements.

In addition to testing the effects of personal relevance, this study also explores the role of screen size. As TV content and advertising are increasingly viewed across a wide range of devices, from large television screens to tablets and smartphones, screen size has become a potentially meaningful contextual factor in shaping audiences' cognitive processing. Previous research has shown that screen size can impact immersion and emotional intensity, which may play a role in how ads are perceived and remembered. The inclusion of screen size allows to explore whether its effects are independent of ad relevance, or whether these two factors interact. For example, does personal relevance become more or less important on smaller screens? Therefore, this study helps place screen size within broader questions about the contextual influences on advertising effectiveness.

Television has long been the most prominent medium for advertising, due to its massive reach and ability to deliver a message to a captive audience. In recent years, traditional, or linear, television has suffered from a drop in advertising revenue due to its shrinking number of viewers and the growing availability of more audience-specific streaming platforms (Statista, 2021). Consumers are increasingly choosing video-on-demand services such as Netflix and Amazon Prime Video to stream video content when and where they desire, across multiple devices - from the small screens of their phones to the larger screens of their televisions (Ofcom, 2021). With the emergence of such time-shifted and fragmented audiences in the media landscape and an increasing demand for online video viewing, there has been a demand from brands for more effective methods to reach and engage audiences. The new, emerging platform, *addressable TV*, allows industry professionals to explore the power of data, using it to align with the needs of specific consumer segments in the same way as digital advertisers have been doing for years. However, in contrast to the digital space, the addressable approach offers the delivery of personally relevant messages by using readily available data including consumers' screening device, household demographics, and location, without intruding too much on their privacy. Although academic literature on the subject of addressable TV advertising is still very limited, the technology behind the concept is growing and so it is important to test whether it is in fact a valuable targeting method. Therefore, this investigation is necessary to understand both the conscious and subconscious consumer responses to addressable advertising.

Advertising effectiveness has often been understood through a combination of several core psychological constructs, including attention, affect, and memory. All of which contribute to how an ad is processed and remembered (Haley & Baldinger, 2000; Walker & Dubitsky, 1994). These variables can be grouped into three main types of advertising effects: perceptual (e.g., exposure and attention), emotional (e.g., liking), and cognitive (e.g., memory and recall; Pozharliev et al., 2017). Each plays a role in shaping overall advertising success and understanding them in combination can provide a more complete view of audience engagement.

For example, attention is considered to be a very important metric because it is closely linked to subsequent memory for ad content and product information (Donthu et al., 1993; Pieters et al., 2002; Wilson et al., 2015). However, affective responses, such as ad likeability, have more recently been also associated with key outcomes such as recall, sharing intentions, and even sales performance (Rossiter & Eagleson, 1994; Shehu et al., 2016; Tomkovick et al., 2001). For example, Shehu et al. (2016) determined that the likeability in online videos ads was directly linked with people's desire to share them with others, highlighting the positive influence that affective responses can have of ad effectiveness.

Despite the importance of these constructs, a lot of the research examining them has relied heavily on self-report methods such as surveys. These tools are practical, easy to implement and provide insight into conscious consumer responses, but they are weakened by inevitable participant biases (Kahneman & Riis, 2005; Micu & Plummer, 2010). As a result, more recent research has turned toward psychophysiological measures, such as heart rate, skin conductance, and facial expression analysis, to capture aspects of engagement that occur outside of conscious awareness (Bartholow & Bolls, 2013; Hamelin et al., 2017). Biometric methods, which measure the physiological responses to an incoming stimulus, have been particularly popular because they provide immediate feedback on how participants react to advertising stimuli in real time, offering a complementary insight on underlying attention and emotion processes (Guixeres et al., 2017).

Importantly, attention itself is not a singular construct but rather a multifaceted process involving both automatic and controlled mechanisms (Ramsøy, 2019). While some measures, such as eye tracking, primarily capture overt visual attention, they fail to account for internal attentional processes that contribute to deeper cognitive engagement. Heart rate, in contrast, reflects both conscious and unconscious attention, providing a more comprehensive indicator of ad engagement. A decrease in heart rate is associated with enhanced external focus and deeper memory encoding (De Pascalis et al., 1995; Jennings, 1992), making it a valuable indicator of enhanced sustained attention and can serve as an indirect measure of cognitive and emotional engagement (Jola et al., 2011).

Recently research demonstrated that heart rate is a highly reliable and scalable physiological measure of attention, capable of distinguishing between high and low engagement conditions in video advertising (Hartnett et al., 2025). Unlike eye tracking, which is limited to measuring visual engagement, heart rate captures deeper cognitive processing and reflects both auditory and visual engagement, making it a more holistic metric. Furthermore, this study compared multiple attention measures and found that heart rate strongly correlated with EEG alpha suppression, a widely accepted neural marker of cognitive engagement. This relationship suggests that heart rate deceleration serves as a powerful implicit indicator of attentional resource allocation, similar to EEG, providing a robust physiological marker of engagement.

Nonetheless, physiological data can be difficult to interpret in isolation, and there is a risk of attributing too much meaning to noise or ambiguous responses (Vecchiato et al., 2014). For this reason, the current study combines physiological and behavioural data with self-report, using heart rate to index attention, memory tasks to assess recall, and self-reported liking ratings to capture affective responses. While self-report may be limited, it remains a valuable measure, particularly for capturing subjective impressions that are known to influence advertising success. Guixeres et al. (2017) conducted a study that combined neuroscience-based physiological measures (such as EEG, heart rate, and electrodermal activity) with self-reported evaluations to assess advertising effectiveness, demonstrating the benefits of including these measures in experimental design. Participants were shown various video ads, and both real-time biometric responses and post-experiment survey data were collected. They found that neurophysiological metrics strongly correlated with traditional self-report measures like explicit liking. In addition, the physiological signals also correlated with objective indicators of ad success, such as the number of views or shares an ad received on YouTube. Therefore, combining multiple research methods my study, allows me to build a well-rounded understanding of audience engagement with addressable advertising.

Moreover, while many advertising effectiveness studies, such as Baack et al. (2008), have effectively used self-reported recall and recognition to assess ad memory, these measures only capture the outcome of memory retrieval, not the process. By incorporating reaction time and mouse-tracking data in my current design, I aim to gain a more nuanced view of participants' memory certainty and cognitive engagement, revealing not just whether they remembered an ad, but how confidently that information was accessed and retrieved from memory.

To help explain why addressable TV advertising is expected to enhance audience engagement, I draw on two well-established models of message processing: the elaboration likelihood model (ELM; Petty & Cacioppo, 1986) and the limited capacity model of motivated mediated message processing (LC4MP; Lang, 2000, 2006, 2017). Both models emphasise that an individual's motivation and ability to process information play a key role in determining the depth of cognitive engagement. According to ELM, personally relevant information is more likely to be processed via the central route. This results in deeper cognitive elaboration, stronger memory, and more favourable attitudes. The LC4MP suggests that humans are cognitively limited information processors and only have a fixed pool of mental resources to spend at any given time (Fiske & Taylor, 1984). If cognitive processing during task performance demands more mental resources than are available, the quality of information processing suffers and the cognitive overload impairs message encoding (Srivastava, 2013). However, if a message is relevant to the individual, it is more likely to trigger motivational activation - the internal drive to attend to relevant stimuli - increasing the allocation of cognitive resources, which in turn enhances attention, encoding, and persuasion (Kranzler et al., 2019).

In other words, these theoretical accounts converge to suggest that increasing personal relevance in TV advertising enhances message salience, stimulates motivation to attend, and leads to deeper cognitive engagement and more effective persuasion.

In this study, addressable TV ads represent a form of personalisation designed to match household-level characteristics rather than individual browsing histories. As such, this technique may offer relevance rather than feelings of intrusiveness. That is, be specific enough to be perceived as personally meaningful, but general enough to avoid the sense of hyper-targeting that can lead to discomfort or reactance. Based on the discussed frameworks, I predict that:

H1: addressable ads will elicit greater attentional engagement (as indexed by decreased heart rate), improved memory, and higher self-reported liking compared to non-addressable ads.

As an advertising medium, not only can modern television reach a wide variety of audiences, but it can also do so across a range of devices. Consumers are no longer limited to watching television on the large screens in their living rooms but can choose to stream the exact same content on a smartphone screen of only a few inches. In general, larger screens are known to create a more emotional and intense experience (Kim, 1997). Reeves et al. (1999) assessed participants' attention and arousal with screen sizes of 56, 13 and 2 inches. Physiological measures of electrodermal activity and heart rate demonstrated that there were significant differences in emotional responses to the displayed videos. The largest screen produced greater heart rate deceleration, suggesting that people pay more attention to audiovisual stimuli presented on large screens. Furthermore, in a study by Lombard and colleagues (1997) larger screens produced greater memory recall, greater physiological response and subjects self-reported greater excitement to images on the screen. Larger screens have been shown to facilitate better learning too (Maniar et al., 2008). The authors used three mobile phones with different screen sizes and found that the smallest screen impaired students' ability to learn an origami technique, and reduced feelings of immersion. A recent online learning study has also shown a positive effect related to larger screen sizes on students' ability to recall learning material immediately after a pre-recorded lecture (Park et al., 2018). The evidence from these studies indicates that larger screens facilitate information processing whilst smaller screens may limit cognitive access to content.

In terms of advertisement effectiveness, Weibel et al. (2019)found that ads viewed on a larger screen (TV) captured significantly more visual attention, evoked more positive emotions, and triggered stronger physiological responses linked to implicit memory than those viewed on a smaller smartphone screen (YouTube), even when the ad content was identical. This supports the idea that screen size is a meaningful contextual factor in advertising effectiveness. A possible explanation for these effects is that the neural mechanisms for emotion and memory consolidation are closely interconnected in the medial temporal lobe (LaBar & Phelps, 1998). Larger screens create a more emotionally arousing experience and thus aid encoding and storage of the displayed information. Another possible explanation for the advantage of larger screens is that they provide a bigger, richer source of information by producing larger retinal images. In an experimental study by Troscianko et al. (2012), the researchers showed a film to participants and positioned the small and large screens so that they took up equal amounts of their visual field. They found that physically larger screens created a greater sense of presence and immersion, measured both by self-report and pupil dilation. These results suggest that object size is an important visual measure, and larger displays are generally perceived as more impressive and engaging. Evidence from fMRI supports this claim by showing that the spread of activation across the primary visual field increases with an increase in perceived size, even when the retinal size is constant (Murray et al., 2006). Therefore, the features of handheld devices that make them desirable and easy to use may also act as barriers to effective cognitive processing. Smaller screens have been shown to constrain cognitive access to presented material, whereas large screens facilitate a more rich and immersing experience (Dunaway & Soroka, 2021). For all these reasons, I hypothesise that audience engagement will be greater with TV advertisements shown on larger screens vs. smaller screens. More formally:

H2: Larger screens will lead to greater audience engagement with TV advertisements compared to smaller screens, as measured by explicit liking ratings, improved memory recall, and greater external focus.

If addressability and screen size are effective manipulations, they can encourage the audience to evaluate the viewed content more actively and effortfully allocate resources towards the message, as evidenced by decreased heart rates. This would promote deeper memory encoding and improve retrieval of the advertisements from memory (Geiger & Reeves, 1993). The question I asked in this study is whether the addressability of a TV ad and screen size would influence both behavioural and physiological measures of engagement with the message on screen.

In addition to predicting a main effect of screen size, it is also possible that screen size may interact with ad relevance to influence audience engagement. While both factors may independently enhance engagement, smaller screens may place additional cognitive demands on viewers due to their limited visual and immersive capacity. As a result, the relevance of the ad content may become especially important on smaller screens, where cognitive processing is more constrained. That is, personally relevant ads may be more likely to capture and sustain attention in low-immersion settings than less relevant content. Conversely, on larger screens, where engagement is generally higher, relevance may have a smaller or more additive effect. Therefore, this study also explores whether screen size and ad relevance influence engagement together, or whether their effects are independent. More formally:

H3: The effect of ad relevance (addressability) on audience engagement will interact with screen size, such that the positive effects of relevance will be amplified on smaller screens, where cognitive processing is more limited.

Using both behavioural and physiological measures, this chapter aims to clarify how addressability and screen size shape attention and memory in media processing. The data reported in this chapter were originally collected as part of an MSc project prior to the start of my PhD. I contributed to the subsequent data analysis and write-up. To test the effects of ad relevance and screen size, participants were invited to watch television content embedded with advertisements. Each advertisement was categorised into one of four broad addressability groups: gender, family, cars, and mobiles. These product categories were chosen because the products or services that fall into them are commonly featured in TV advertising and have widespread appeal. The first two categories reflected demographic characteristics (identifying as female; having at least one child under 13 in the home), while the latter two captured consumer intent (interest in cars; planning to purchase a new phone or mobile contract within the next year). Prior to the experiment, participants completed a pre-screening survey, which allowed me to identify two categories they were personally interested in and two they were not. This enabled a within-subjects manipulation of ad relevance, where each participant viewed both relevant (addressable) and non-relevant (non-addressable) ads throughout a TV show. Screen size was manipulated between participants, with individuals randomly assigned to either a large-screen or small-screen viewing condition.

2.2. Methods

Participants

A total of 78 people (39 F, 39 M, aged 18-65) volunteered for this experiment. Participants were selected through a targeted pre-screening process conducted by the market research company DRG (Newcastle, UK). This process ensured that each individual fit exactly two of the four predefined addressability categories (gender, family, cars, mobiles). This design was chosen to allow systematic comparisons between addressable and non-addressable advertisements within each participant's viewing. Identifying individuals who fit exactly two of the categories ensured that half of the ads in the experiment would be relevant to each participant. A total of six groups (A-F) of participants were formed with *N*=13 in each group. Due to a hardware failure, data were lost for one participant in group E (see Table 2.1). In addition, participants were chosen who: i) had not taken part in a neuroscience or brain imaging study in the past twelve months, ii) did not work in market research, marketing, or advertising, and iii) had at least one TV in their household. Verifying that the participants have at least one TV in their household allowed to be more confident that they watch TV and TV advertisements on at least one device. DRG compensated the participants for their time. All participants provided written informed consent before the experiment began. This research was approved by the university's Research Ethics Committee (EP/2019/003).

Table 2.1. Participant group based on their addressability categories. There were 6 groups with 13 participants in each, except for Group E where data were lost for one participant due to a hardware problem. The table shows that the two addressability categories that were relevant to each group (Female/Yes) and the two that were not (Male/No).

Group	Gender	Family	Car	Mobile
A	Female	Yes	No	No
B	Female	No	Yes	No
C	Female	No	No	Yes
D	Male	Yes	Yes	No
E	Male	Yes	No	Yes
F	Male	No	Yes	Yes

Stimuli and Materials

The experiment was implemented on the Gorilla (www.gorilla.sc) platform (Anwyl-Irvine et al., 2018). A total of sixteen 30-second TV advertisements were used in this experiment, four in each of the addressability categories. The ads targeted at women (gender category) included make-up and fashion products. The ads targeted at parents (family category) included family holidays and products for children. Car ads were targeted at people interested in cars (car category) while the ads in the mobile category were either new mobile phones or a new network supplier. Each advertisement was chosen because it was addressable to a specific demographic group. All of the advertisements had been previously shown on TV in the UK, although none had been broadcast on standard British TV for at least 6 months prior to the experiment to avoid recency effects. It is important to note that it is the nature of addressability that people were different systematically (e.g., some people are interested in cars, and they are in many ways different to people who are not). Whether those differences relate to physiological and behavioural differences is one of the key questions.

The ads were embedded in a TV program chosen by each participant from a set of three Sky TV programmes: *Modern Family, Manifest* and *Riviera.* Shortened versions of the two longer shows (*Manifest* and *Riviera)* were used so that all programs fit into a typical 30-minute time slot, including the 16 advertisements. Allowing participants to select their TV show mimics a video-on-demand viewing context and increases the ecological validity of the task. The shows had pre-existing ad breaks that allowed to embed the chosen advertisements in a naturalistic manner at the beginning, middle and end of the 30 minutes. The order in which the ads were shown was randomised across participants to remove potential order effects on attention and memory (Zhao, 1997). Each participant watched the same set of ads throughout in the show, which ensured that the stimuli in the addressable and non-addressable conditions were identical across participants.

Procedure

After reading information about the experiment, participants provided their consent to take part. They were fitted with an Empatica E4 wrist-worn device to record biometric signals including heart rate (HR) and electrodermal activity (EDA). The experiment began with participants watching a 4 minute, 14 second David Attenborough video about Emperor Penguins on a laptop computer. This allowed the physiological measurements to reach an initial steady-state before the main experiment began. Participants were then randomly allocated to either a large (n=36) or small screen (n=41) for viewing the content in the main experiment. The large screen was a traditional laptop monitor (22-inch) and the small screen was an Acer tablet (8-inch). Next, they read a brief description of the three TV shows and then made a choice of what to watch (*Modern Family*, n=49, *Manifest*, n=18 or *Riviera*, n=10). The advertisements were embedded in video in a naturalistic manner. Half of the advertisements were addressable to the participant and half of the advertisements were non-addressable. Finally, participants completed a short behavioural questionnaire that tested their memory for the ads they saw, their interest in each of the ads, and a simple manipulation check to test whether "addressability" successfully manipulated the relevance of the ads.

All participants completed the memory test and the self-report questionnaires after the main task on laptops – in other words, post-hoc behavioural testing was done on one size screen. In the memory test, each trial began with a screen reading "Please click to indicate whether you saw the following image in the advertising breaks." Participants had to press a "ready" button in the middle of the screen to begin the trial, forcing their mouse to always start from the same location. The subsequent screen showed a still image in the middle of the screen as well as two response buttons in the bottom corners of the screen. The image came from one of four conditions: i) an image from an ad seen previously, ii) the brand image from an ad seen previously, iii) an image from a similar, but unseen, ad (i.e., a foil), and iv) the brand image from a similar, but unseen, ad (i.e., a foil). The participant clicked on the appropriate response button to indicate whether they had seen the image previously (“yes”) or not (“no”). Images appeared one at a time, in a random order. In addition to recording accuracy and reaction times, this experiment used mouse tracking (Maldonado et al., 2019) to record the trajectory of the response from the initial “ready” button to the final response button (see Figure 2.1).

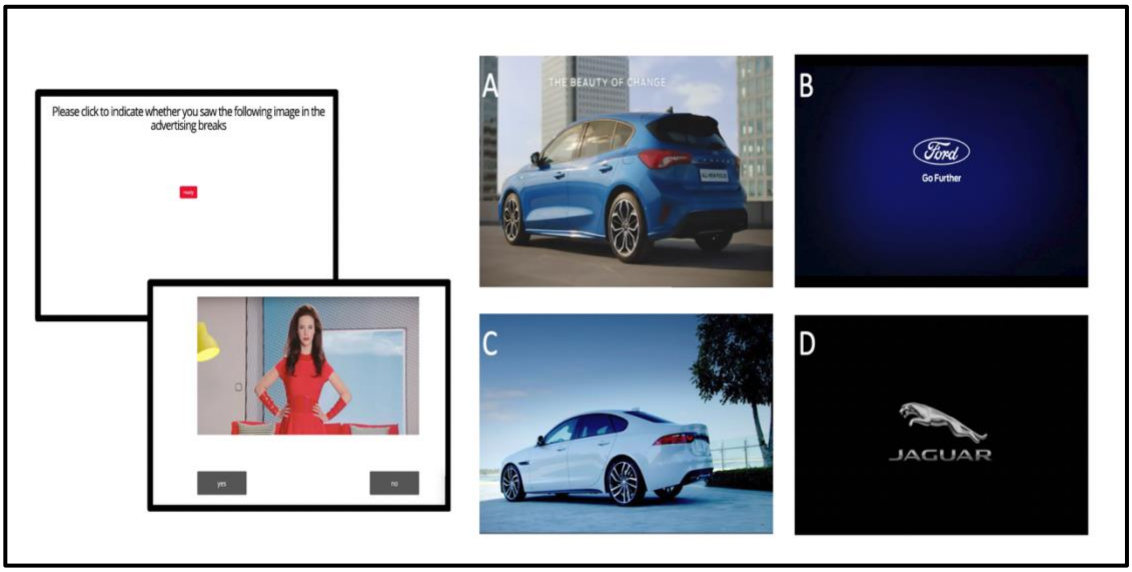

Figure 2.1. The format of the memory test is shown on the left and still images from the four different trial types are shown on the right: A) an image from an ad seen earlier, B) a logo seen earlier, C) a foil image from an ad that was not seen earlier, and D) a foil brand logo not seen earlier.

A second part of the experiment assessed participants’ liking for the ads they saw. Still images from each of ads seen during the TV program were rated on the extent to which the ads changed the participant’s interest level in the products. They responded by moving a 20-point slider-bar that ranged from “less” (-10) to “more” (+10) with zero indicating no change. One image was shown from each of the 16 ads.

Finally, participants saw still images from all four advertisements within an addressability category (e.g., images from all four car ads) and were asked to indicate their level of interest in “these types of products” using a slider-bar ranging from “very interested” (100) to “not interested at all" (0). There were only four trials, each one corresponding to one of the addressability categories. These data were used as a manipulation check to check whether the recruitment paradigm successfully identified the categories of advertisements relevant to each participant. On completion of the behavioural tasks, the participant was fully debriefed about the aims of the experiment and thanked for their participation.

Analysis

I used the Bayesian mixed model approach to directly quantify the effects of addressability and screen size on behavioural and physiological measures, as well as the strength of evidence in support of any differences, overcoming some of the issues associated with null hypothesis testing (Kruschke, 2010; Wagenmakers et al., 2011). I used R (version 3.4.3) the *rstanarm* package (Stan Development Team, 2016) for Bayesian analysis of the data, and the *psycho* package to interpret the models and express the results as probabilities of main effects being present (Makowski, 2018).

From 4000 samples, estimates of posterior distributions of the model parameter coefficients were generated, which quantified the strength of evidence that each experimental condition influenced behaviour in a consistent way. Below I report the estimates of differences between addressable and non-addressable ads, and large and small screen sizes. To quantify the strength of evidence in support of these differences I use the Maximum Probability of Effect (MPE). The MPE quantifies the likelihood that a given experimental condition produced a real effect, rather than being due to chance. Further, the MPE value is the probability that the effect is positive or negative (depending on the median's direction). The MPE values were derived by fitting, for each dependant variable, a Markov Chain Monte Carlo model. Weakly informative priors from the Gaussian family were used that were scaled by the *rstanarm* package. I used random effects for participant, the advertisement and the show watched, and fixed effects for the addressability, screen size and advertisement category, specified as:

Dependent variable ~ addressability + screen size + advertisement category + (1 | participant) + (1 | advertisement) + (1 | show watched)

The Bayesian approach encourages quantifying the strength of evidence in this manner, rather than simply reporting whether or not an (arbitrary) threshold of significance has been passed. That being said, researchers generally suggest that an MPE of above 90% can be considered as 'strong evidence', an MPE between 70-89% as weak evidence and an MPE below 70% as no meaningful evidence (Makowski, 2018).

Before proceeding to the main analysis, it was necessary to preprocess the physiological data to account for baseline differences across participants. The sensors used for collecting physiology data sometimes failed to record complete data, due to technical issues with the sensor, incorrect placement, the participant moving the wristband, and so on. After spotting and cleaning problematic recordings, the data were left with 69 participants with complete heart rate data, but only 45 with complete electrodermal activity data, as it is much more sensitive to movement artifacts and sensor failure. This is not enough electrodermal activity data to draw any meaningful conclusions from, therefore the measure was excluded from all analyses. Heart rate data were aligned to stimulus and condition information and trimmed to trial durations using the Universal Time Coordinates that were recorded by the Empatica sensors and the Gorilla system. Prior to watching the shows with the embedded ads, each participant watched a 4-minute documentary extract that provided a measure of their baseline heart rate. In order to remove inter-subject differences in baseline physiology throughout the experiment, participants' heart rates during ads were mean-centred based on the baseline readings. That is, once a mean heart rate value was computed for a participant over an ad, I subtracted their mean baseline heart rate (from the documentary) to obtain the participant's average change in heart rate for that particular ad. This removed baseline differences between participants (e.g., their resting heart rates) and allowed to focus on differences between addressability and screen-size conditions within each participants' data (Potter & Bolls, 2012).

For the analysis of mouse-tracking data, I used the *mousetrack* package (Coco & Duran, 2015) in R (version 3.4.3). The primary focus was on area under the curve (AUC), a widely used index that quantifies the geometric deviation of the mouse trajectory from a direct path. Smaller AUC values indicate more efficient and direct movements, whereas larger AUC values reflect greater deviation and uncertainty (see Figure 2.2). For each trial, reaction time (RT) - measured from cursor movement initiation to "yes/no" button press - and AUC were recorded as key dependent variables.

Response times were used to indicate memory efficiency for correct responses. Reaction time data were screened for outliers using a 3 standard deviations (SD) criterion applied within each participant's responses. Outliers were defined as trials where RTs deviated by more than 3 SDs from the participant's mean (Ratcliff, 1993). Trials exceeding this threshold were excluded from analysis to minimise the influence of extreme values.

Memory accuracy was quantified using d-prime (d'), a sensitivity measure from Signal Detection Theory that accounts for both correct identifications (hits) and incorrect identifications (false alarms). D-prime (d′) was calculated as a measure of memory sensitivity, using the formula:

$$d' = Z(\text{ hits } / [\text{hits} + \text{misses}]) - Z(\text{false alarms } / [\text{false alarms} + \text{correct rejections}])$$

Higher d′ values indicate greater sensitivity in distinguishing previously seen (critical) advertisements from new (foil) advertisements, with 0 representing chance-level performance. Unlike raw accuracy, d' corrects for response biases by measuring the participant's ability to distinguish previously seen advertisements from unseen distractors.

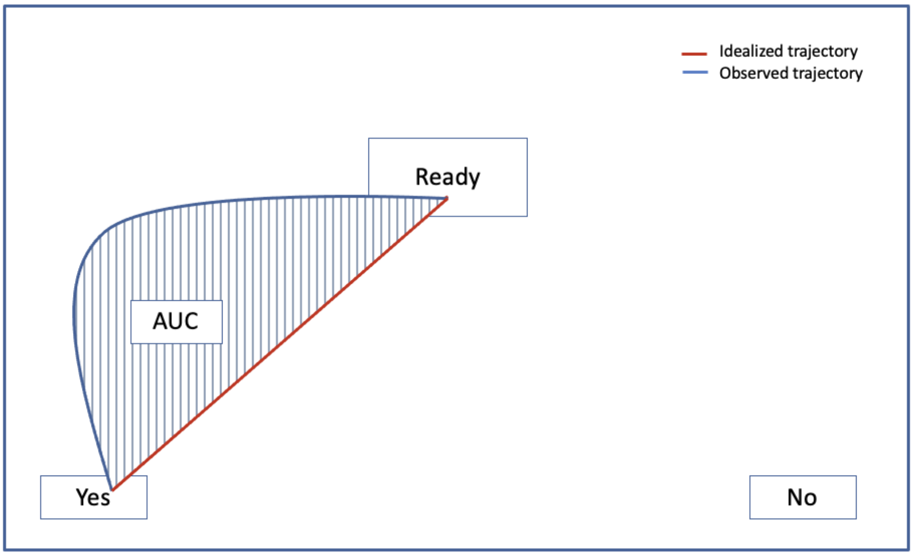

Figure 2.2 An example of mouse-tracking in the memory task. After seeing an image on the screen and clicking the "Ready" box, participants saw the proposed response boxes. The area under the curve (AUC), shown as the hatched area and exaggerated in this diagram, is the area between the observed trajectory of the mouse cursor (blue curve) moving from the starting point to their response and the idealized trajectory, which is a straight line from the starting point to the response (red line).

2.3 Results

As a manipulation check, participants rated their interest in the previously viewed advertisements on a scale ranging from 0-100. There was strong evidence that participants rated their interest level higher for addressable ads rather than non-addressable ads (MPE=99.99%). Participants' interest in addressable ads (*M*=65.6, *SD*=19.3) was greater than participants' interest in non-addressable ads (*M*=50.5, *SD*=20.3). In other words, the addressability variable in the design was successfully operationalised; addressable ads were indeed more relevant to the participants than non-addressable ads. Figure 2.3 presents the means and distributions for participants' self-report interest level contrasting the two addressability conditions. The thick horizontal bar in each violin plot represents the mean and the darker shaded area around it is the interquartile rage of the population. The dotted line represents the rest of the distribution, except for data points that are determined to be outliers. On each side of the dotted, vertical line is a kernel density estimation to show the distribution shape of the data. Wider parts of the violin plot represent a higher probability that individuals from the population will take on the given value, whereas the slimmer parts represent a lower probability.

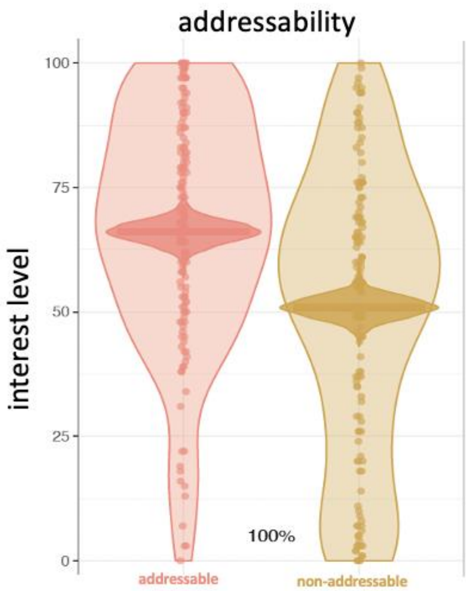

Figure 2.3. Participants' self-rated interest level in addressable and non-addressable advertisements. If the addressability manipulation worked, then there should be a clear difference between the ratings for addressable and non-addressable ads. Indeed, there is strong evidence that participants were more interested in ads that were assigned to them as being relevant (shown in red on the left) and expressed lower interest in ads that were treated as irrelevant to them (shown in yellow on the right).

Participants reported liking ads that were relevant to them more than those that were not (MPE=100%). On average, participants reported becoming approximately three times more interested in the addressable relative to the non-addressable ads (2.1 vs. 0.6 on a scale ranging from -10 [less] to +10 [more], see Figure 3). In contrast, there was no meaningful difference in how much they liked the ads when viewed on a large or small screen (MPE=59.3%). Furthermore, there was little to no evidence for an interaction between addressability and screen size (MPE=72%). Across all reported analyses, there was no meaningful evidence for an interaction between addressability and screen size. As a result, I focus on the main effects, where stronger differences were observed. Figure 2.4 presents the means and distributions for participants' self-report liking contrasting addressability conditions and screen size conditions.

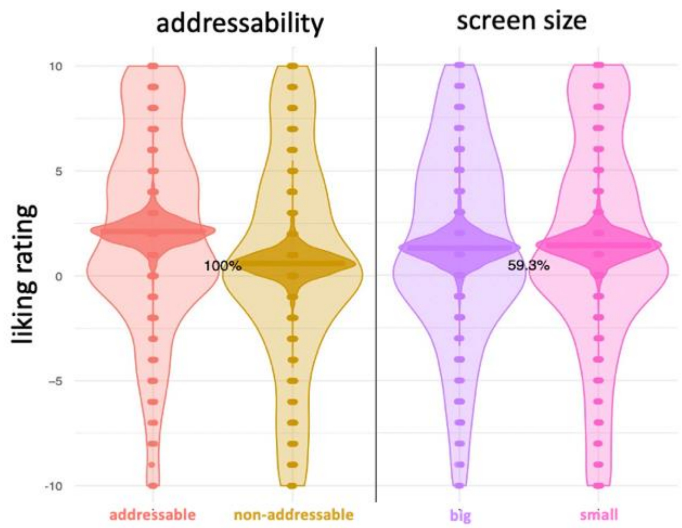

Figure 2.4. Participant self-reported how the advertisement changed their level of interest in the product or service from -10 (less) to +10 (more). The results are split between addressability conditions (shown in red and yellow on the left) and screen size conditions (shown in purple and pink on the right). The shape of the distribution (skinny on each end and wide in the middle) indicates the liking ratings are highly concentrated around the mean.

To assess conscious recall of advertisements seen during the show, I analysed participants' accuracy in identifying previously viewed images. Results showed strong evidence that memory accuracy was higher for addressable ads (73.1% accurate) than the non-addressable ads (69.2% accurate, MPE=96.9%, Figure 2.5a). In other words, participants showed better recollection for ads that were more relevant to them. There was also weak evidence for greater response accuracy for advertisements presented on a large screen (73.1% accurate), as opposed to a handheld device (69.5% accurate, MPE=84.2%, Figure 2.5a).

While accuracy indexes explicit recall for the ads, reaction times serve as an implicit measure of recollection, with faster responses on correctly identified items indicating better recall. Prior to analysis, RTs were screened for outliers using a 3 SD criterion, resulting in the exclusion of 57 trials (1.22% of total trials) to minimise the influence of extreme values. There was strong evidence that participants' reaction times were shorter for ads that were relevant to them (2086 ms vs. 2116 ms, MPE = 93.7%, Figure 2.5b), meaning that participants were significantly faster to recognise addressable ads than non-addressable ads. Similarly, response time evidence demonstrated strong evidence for lower reaction times for ads viewed on a larger screen (2008 ms vs. 2182 ms, MPE = 94.70%).

Faster responses on memory tests are commonly associated with more errors (i.e., a speed-accuracy trade-off); however, in this task, participants responded with higher accuracy and greater speed, indicating better memory for relevant ads and ads viewed on a larger screen.

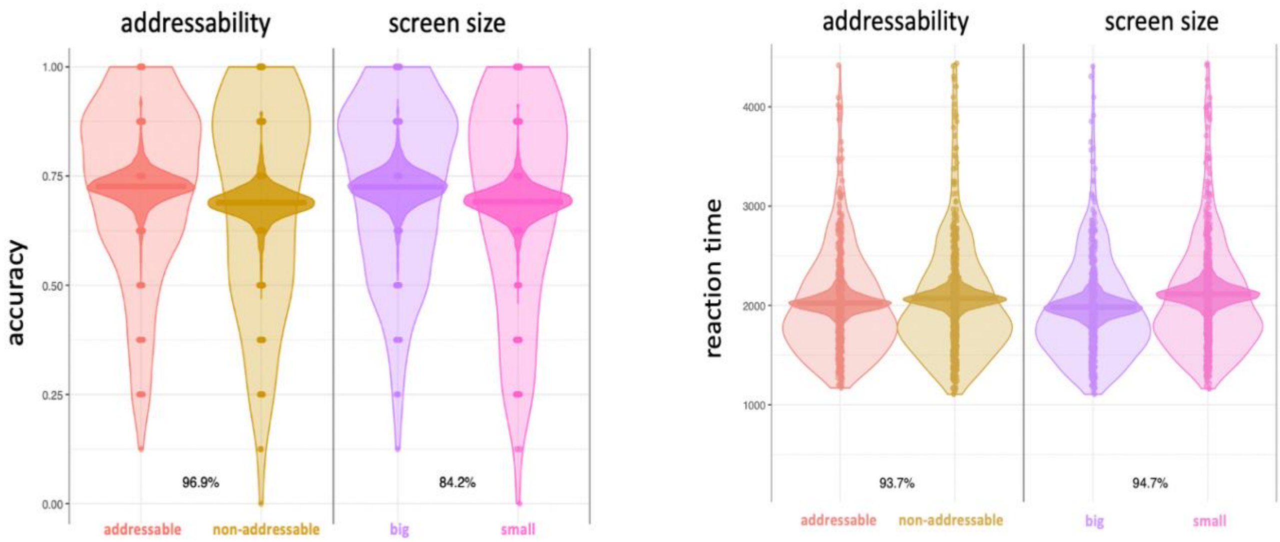

Figure 2.5. a) Participant accuracy score on the post-experiment memory test, split between addressability conditions and screen size conditions. Participant accuracy scores were obtained by calculating the proportion of correct responses to seeing an advertisement image/brand image that did in fact appear in the experiment. **b)** Participant reaction time score during the post-experiment memory test shown in milliseconds, split between addressability conditions and screen size conditions. This was the time taken for the mouse-cursor to move from the starting point to response.

Mouse tracking was included as a complementary measure to reaction time, aiming to provide additional implicit measure of memory performance (Maldonado et al., 2019). The trajectories of participants' mouse movements during the memory test were analysed. The deviation from a straight-line response path was used as an index of uncertainty, with more complex trajectories indicating greater hesitation or cognitive conflict. There was strong evidence that addressable ads produced more direct mouse trajectories (MPE = 93.2%), suggesting greater confidence and fluency in recognising these ads. However, there was no meaningful effect of screen size on mouse trajectories (MPE = 59.3%, Figure 2.6). While reaction time data provided strong evidence for effects of both screen size and addressability, mouse-tracking did not yield similarly strong evidence. However, the lack of strong evidence in mouse-tracking for screen size does not necessarily contradict the reaction time findings but rather suggests that the effects may not have been as pronounced in movement-based response patterns. Overall, memory for addressable ads was superior across both explicit and implicit measures, with higher recall accuracy, faster reaction times, and more direct mouse movements.

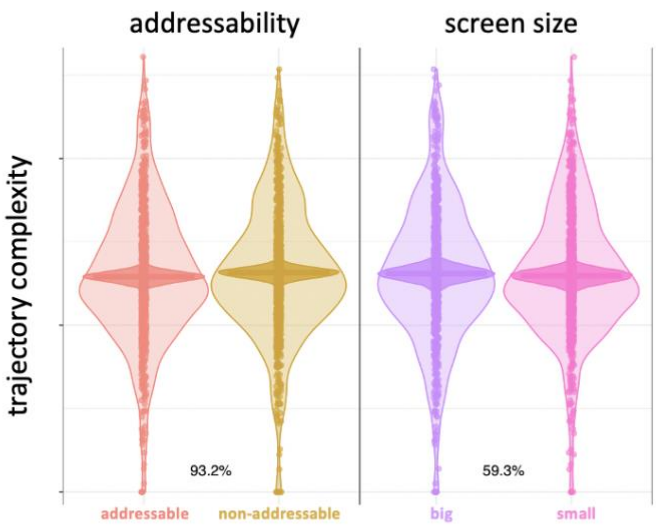

Figure 2.6. Participant mouse tracking results taken during the post-experiment memory test, split between addressability conditions and screen size conditions. Trajectory complexity is equivalent to the calculated AUC, with more uncertainty in a participant's response resulting in greater AUC and greater trajectory complexity.

Finally, I examined heart rate (HR) as an implicit physiological measure of engagement with the advertisements. There was weak evidence that heart rates differed between addressable and non-addressable ads (MPE = 75.3%, Figure 2.7). Specifically, mean-centred HRs were lower by 0.2 beats per minute (bpm) when participants viewed ads relevant to them, compared to less relevant ads, though this effect was small. However, there was strong evidence that screen size influenced heart rate (MPE = 96.2%). Heart rates were lower by 2.7 bpm when participants watched ads on a large screen compared to a handheld device, suggesting that a larger screen promoted greater external focus and reduced physiological arousal (Lacey & Lacey, 1980). This aligns with prior research showing that screen size can modulate attentional engagement and cognitive processing.

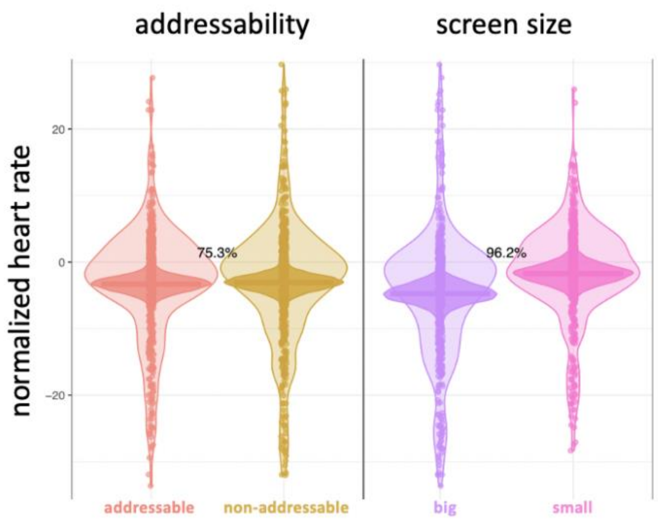

Figure 2.7. Participants' mean-centred heart rate recorded as they viewed the advertisements, split between addressability conditions and screen size conditions.

2.4. Discussion

In this chapter I investigated the effects of addressability and screen size of television ads on audience engagement, an important measure of advertising effectiveness. I operationally defined engagement as the level of sustained attention, memory recall and liking towards an advertisement and assessed it using both explicit and implicit measures, including physiology. This study revealed that addressable TV advertisements elicited greater ad recall, and more ad liking compared to traditional, non-addressable, advertisements. There was also some support for addressable advertisements eliciting more sustained attention, however, the evidence was weak. Furthermore, TV advertisements viewed on a larger screen elicited greater attention and ad recall, however, viewing advertisements on a larger screen did not affect ad liking. I did not find any significant interactions between addressability and screen size, and therefore decided to focus on the two manipulations separately. These findings contribute to broader psychological theories of attention, memory, and media processing, while also offering insights into how evolving media consumption habits influence engagement with audiovisual content. I discuss the contributions that this study makes to the literature and marketing practitioners.

First, the findings indicate that people both prefer and remember TV advertisements that are tailored to their interests and demographics more than those that are not relevant to them. Participants showed greater accuracy, shorter reaction times and more direct mouse trajectories for addressable stimuli in the memory test. These findings agree with previous evidence that shows that message tailoring significantly increases people's learning and memory (Hartmann-Boyce et al., 2014; Noar et al., 2008). Furthermore, in line with previous online-advertising studies (Grigorios et al., 2022; Maslowska et al., 2016), the current findings suggest that relevant TV advertisements based on lifestyle and demographic data evoke more favourable self-report responses than non-relevant advertisements. This data helps contribute to the debate whether targeted content creates a positive attitude towards advertising (Maslowska et al., 2011) or a negative one (Aguirre et al., 2015; Rosenthal et al., 2019). My interpretation is that greater personal value delivered to the audience by addressable TV ads leads to positive attitudes towards the ad and stronger motivation to process and encode the content.

While the findings from this study suggest that addressable advertisements enhance engagement and memory by increasing personal relevance, not all research supports the universal benefits of personalisation. De Keyzer et al. (2022) pointed out that while personalisation improves relevance and engagement, it can also elicit feelings of intrusiveness, leading to simultaneous ad engagement and avoidance. Feelings of consumer autonomy being threatened, such as when an ad appears to "know too much", can lead to reactance and negative attitudes. However, there is evidence showing that consumers feel more comfortable with ads personalised using broad interest-based data (e.g., travel preferences, general demographics) than with ads that incorporate highly personal details like names, photos, or transaction history (Malheiros et al., 2012). These insights are particularly relevant when comparing TV addressability to online personalisation. While digital platforms, such as social media, employ real-time browsing behaviour, TV ads remain less invasive, targeting at a household or demographic level rather than an individual, hyper-personalised level. As a result, the privacy concerns and personalisation reactance commonly observed in digital advertising may be less pronounced in TV advertising, where the inclusion of personal relevance is less granular, and data usage feels less intrusive. This suggests that addressable TV may successfully enhance engagement without provoking the same level of resistance seen in hyper-personalised digital ads, as evidenced by the positive self-reported ad ratings in this study.

I also proposed that greater message addressability in TV advertisements would lead to greater externally focused attention in viewers. However, heart rate findings did not fully support this hypothesis: addressability only resulted in a marginal increase in sustained attention, suggesting that physiological engagement alone does not fully account for the observed improvements in memory. Typically, a reduction in heart rate is an indicator of increased allocation of cognitive resources to a message, whereas an increase in heart rate reflects resource allocation away from the message (Park & Bailey, 2018). While previous research has linked heart rate deceleration to increased attention and deeper encoding (Abercrombie et al., 2008), the lack of a strong physiological response in my results suggests that memory enhancement for addressable ads may arise through alternative mechanisms rather than sustained autonomic engagement alone.

Although sustained attention is often associated with deeper cognitive processing, it is possible that even brief or low-attention exposure can be sufficient to positively influence recognition or attitudes, particularly when the viewer has some familiarity with the product category (Alba & Hutchinson, 1987; Santoso et al., 2021; Zajonc, 1968). Dual-process theories of persuasion suggest that under low-involvement conditions, advertising can still be effective through more automatic, heuristic processing routes (Chaiken, 1980). From this perspective, even low-level attention may be enough to enhance memory when the message is personally relevant, and such low-effort processing may actually reduce critical evaluation of the ad (Heath, 2009). This could explain why addressable ads in the current study improved memory performance despite limited physiological evidence for increased sustained attention.

Another possibility is that addressable ads benefited from predictive processing and schema congruency, which promote efficient encoding without necessarily requiring high levels of sustained attention. According to Predictive Coding Theory (Friston, 2010), the brain constantly generates expectations about incoming stimuli and processes information more easily when it aligns with these expectations. Addressable ads, by aligning with participants' personal interests, may have supported schema-congruent encoding, which is a process where familiar content is more fluently integrated into memory (van Kesteren et al., 2012). This kind of efficient, low-effort encoding could enhance recall without needing a strong physiological attentional response.

From these perspectives, my findings suggest that the small effect of addressability on conscious attention does not necessarily contradict its substantial effect on memory performance and ad liking. Instead, memory enhancement may be driven by reduced processing costs, leading to deeper encoding without requiring greater external focus. Further research should investigate whether other processes mediate the effect of addressability on ad memory and attitude.

My results further show that providing viewers with TV advertisements on a larger screen makes the ads more motivationally relevant, easier to process and more memorable. The LC4MP claims that the greater sensory richness and realism brought on by large screen size may lead to split attention and cognitive overload (Lang, 2000), however, my findings suggest that large screens do not compete with the ad's content for limited cognitive resources and are able to aid optimal information processing by increasing attentiveness and encoding of the message displayed. The result also supports previous research on larger screens attracting greater levels of attention and external focus (Lombard & Ditton, 1997; Reeves et al., 1999), enabling easier cognitive access (Dunaway & Soroka, 2021), and facilitating learning and better recall (Park et al., 2018) A separate study has also shown that when watching a film on a mobile phone, people are more prone to distraction (Szita & Rooney, 2021). Self-report, eye tracking and physiological measures showed that people feel more engaged with stationary large screens. Therefore, in a real-world setting, I would expect to find similar patterns to the current findings. On a hand-held device, a user may be more likely to feel less immersed in the video content and choose to multitask and engage with notifications or switch between windows, which would degrade performance (Tombu & Jolicœur, 2004) and hinder cognitive processing (Rogers & Monsell, 1995) with the advertisements. I found no difference in how much participants reported liking the ads when viewed on a large screen or a small screen. One of the few studies that examined the effect of screen size on enjoyment manipulated screen size, resolution, and viewing distance (Neuman, 1990). Their results showed differences in enjoyment favouring larger displays, but only for high resolution images, which signals that the difference may only become significant in the presence of increased image quality.

The findings from this chapter demonstrate that addressable TV advertising enhances cognitive and emotional engagement, which may have implications for consumer decision-making and brand recall. While TV advertising is perceived as costly, addressability allows for more precise audience targeting, potentially improving cost-efficiency without sacrificing engagement. Additionally, my results confirm that screen size influences ad processing, reinforcing the importance of large-screen formats despite the growing dominance of mobile advertising. However, no interaction was found between screen size and ad relevance, suggesting that the effects of personalisation were consistent across device types. These insights contribute to a better understanding of how different media formats shape viewer engagement, which may inform advertising strategies.

While this study demonstrates clear effects of addressability and screen size on engagement, several limitations must be considered. First, addressability was tested using only four broad categories, and not all categories were equally effective. For instance, the car and gender-based categories were more homogenous, while the family and mobile phone categories contained greater variability in consumer preferences. Future research should explore more refined operationalisations of addressability by incorporating additional demographic and psychographic factors, allowing for greater generalisability of results.

Second, although heart rate was used as a physiological measure of externally focused attention, the effects were weak, suggesting that other cognitive or neural processes may drive the memory benefits observed. Future research should incorporate neuroimaging techniques to examine the neural mechanisms underlying addressability effects.

The next chapter of this thesis builds on these findings by using fMRI to investigate the neural basis of addressability-driven engagement. Specifically, I examine activation in brain regions associated with visual attention, memory encoding, reward, and emotion to determine how personal relevance in advertising influences cognitive and affective processing. This study also expands on my current design by introducing a new set of ad groups and advertisements, allowing for further generalisation of the addressability effect.

3. Investigating The Neural Basis of Addressability Effects

3.1. Introduction

While Chapter 2 demonstrated robust behavioural evidence for enhanced engagement with addressable TV advertisements, the neural mechanisms underlying this 'addressability uplift' remain unexplored. This chapter employs functional magnetic resonance imaging (fMRI) to investigate how personal relevance in advertising influences four key cognitive systems: reward, emotion, memory, and attention. Traditional measures of advertising effectiveness, while valuable, cannot fully capture the unconscious and automatic processes that drive viewer engagement (Davidson, 2004; Johansson et al., 2006). By utilising fMRI, I can examine both the conscious and unconscious neural responses that underlie the behavioural effects documented in my previous study.

As established in previous chapters, engagement is widely recognised as highly important for driving positive advertising outcomes, yet its precise definition varies across disciplines. In marketing literature, engagement is generally understood as the process of capturing a consumer's interest in a brand idea, with its impact being shaped by the surrounding situational context (Wang, 2006), while neuroscience defines it through patterns of brain activation associated with motivation, attention, and affect (Elliot, 2013; Watson et al., 1999). This study integrates these perspectives, operationalising engagement as a multidimensional construct encompassing both behavioural responses and neural mechanisms. Specifically, addressable advertisements, which are tailored to individual viewer characteristics, are hypothesised to enhance engagement by amplifying reward processing, emotional arousal, memory encoding, and attentional capture.

Understanding these neural mechanisms is essential for advancing both theory and practice in both (neuro)psychology and advertising. According to the hierarchy-of-effects model, consumer decision-making progresses sequentially from cognition to affect, and finally to behaviour (Wijaya, 2012). Neural evidence suggests that personal relevance likely modulates multiple cognitive pathways that contribute to enhanced viewer response. Attention is thought to be strengthened through increased activation of frontoparietal attention networks (Corbetta & Shulman, 2002), while emotional responses may be intensified through engagement of the amygdala and insula (Sabatinelli et al., 2005). Memory encoding is expected to be enhanced via increased activity in the hippocampus and medial temporal lobe (MTL; (Rugg & Vilberg, 2013), and reward-related processing may be heightened in the nucleus accumbens (NAc) and orbitofrontal cortex (OFC; Bartra et al., 2013). Together, these mechanisms provide a basis for the exploration of the neurobiological foundation for the addressability uplift, demonstrating how personal relevance enhances cognitive and affective processing of advertisements.

Although the primary focus of this chapter is on the neural mechanisms underlying addressability, viewing context (i.e., whether participants have a choice in the content in which ads appear) is included as a secondary factor. Prior research suggests that having choice in media consumption may enhance engagement by increasing perceived autonomy and intrinsic motivation, while a lack of choice may diminish involvement or alter attentional allocation (Moorman et al., 2012). However, direct neural evidence for the effects of choice in advertising remains limited. From a neurocognitive perspective, choice may influence engagement through the reward system. Self-determination theory (Ryan & Deci, 2000) suggests that autonomy enhances intrinsic motivation, a this has been in part supported by fMRI studies showing increased activation in the ventral striatum and vmPFC when individuals engage in self-directed decision-making (Murayama et al., 2015). If choice enhances engagement, I may observe amplified activation in reward-related regions when participants view addressable ads in self-selected content. Conversely, if a lack of choice is perceived as controlling or limiting, it may reduce engagement through increased activation of the anterior insula, a region linked to negative affect and cognitive effort (Ullsperger et al., 2010). These exploratory analyses will provide insight into how viewing context interacts with addressability at the neural level, though a more detailed discussion of context effects will be deferred to the following chapter.

Taken together, this study seeks to bridge gaps in the literature by investigating the interplay between personal relevance and contextual factors in advertising. The neural basis of advertising engagement involves multiple interacting cognitive systems, each contributing distinct but complementary processes to viewer response. Exploring these systems together creates the rich psychological understanding of engagement with personally relevant content. The following sections examine each system's role in processing personal relevance, building toward an integrated model of how it enhances advertising effectiveness at the neural level. This offers insights with theoretical and practical implications for advertising, neuroscience, and consumer psychology.

To fully understand how addressability enhances advertising effectiveness, I first examine how personal relevance influences key neural systems. Research in consumer neuroscience has identified distinct but interconnected networks that process advertising content, particularly highlighting the role of brain regions like the prefrontal cortex, hippocampus, and amygdala (Cook et al., 2011; Klucharev et al., 2008; Reimann et al., 2011; Venkatraman et al., 2015). This investigation focuses on four fundamental cognitive systems that prior research suggests are crucial for advertising effectiveness: reward, emotion, memory and attention.

Attention: The Gateway to Engagement

Attention serves as the foundational cognitive mechanism for advertising effectiveness, acting as a gateway through which all subsequent processing must pass. Recent neuroimaging research has revealed two distinct but interacting attention networks: the dorsal attention network, which supports voluntary, top-down attention allocation, and the ventral attention network, which enables bottom-up capture by salient stimuli (Corbetta & Shulman, 2002). This dual-network framework helps explain how personally relevant advertisements might enhance attention through multiple pathways, either by deliberate focus or automatic attentional capture.

The dorsal attention network, of which the Frontal Eye Fields (FEF) and Intraparietal Sulcus (IPS) are integral regions, plays a crucial role in guiding voluntary visual attention, particularly when individuals selectively focus on task-relevant stimuli (Kastner & Ungerleider, 2000). Prior eye-tracking research supports this, showing that personally relevant stimuli elicit longer fixation durations and more sustained visual attention than irrelevant stimuli (Bang & Wojdynski, 2016; Jung, 2017b), a pattern that aligns with increased FEF-IPS activation. In advertising contexts, it has been suggested that viewers are more likely to engage with ads that match their personal interests, identities, or needs, suggesting that personal relevance may modulate neural activity in attention-related regions (Harris et al., 2018).

While behavioural studies have provided valuable insights into visual attention, neuroscientific methods offer additional evidence on how personally relevant stimuli engage attentional networks. For instance, (Bayer et al., 2017) used EEG to demonstrate that emotional words embedded in personally relevant sentence contexts, such as references to a participant's significant other, elicited increased activity in the visual cortex within 100 milliseconds. This was reflected in enhanced amplitudes of the P1 component, a neural marker of early visual processing. The study also found that personal relevance was associated with heightened pupillary responses and elevated arousal ratings, suggesting increased attentional allocation and emotional engagement. These findings imply that personally relevant information not only captures attention rapidly and automatically but also facilitates deeper visual and emotional processing; mechanisms that may extend to how consumers process personalised advertising. These findings support the notion that personally relevant information not only captures attention early but also enhances subsequent visual processing, which may extend to advertising contexts.

Further supporting this, (Hartnett et al., 2025) examined neural attention to video advertising using EEG, demonstrating that reductions in alpha power, which a common marker of attentional engagement, could differentiate high- and low-engagement ads. This suggests that beyond behavioural measures such as eye-tracking, neuroimaging techniques can reveal more nuanced attentional mechanisms that may not be observable through overt responses alone.

Despite these advances, fMRI research on attention to advertising remains limited, particularly in understanding how personal relevance modulates dorsal attention network activity. While prior research has linked self-relevant processing to ventral midline structures such as the ventromedial prefrontal cortex (vmPFC) and posterior cingulate cortex (PCC) (Schmitz & Johnson, 2007), less is known about how personal relevance engages top-down visual attention mechanisms in dorsal attention regions of the parietal and frontal cortex. Given that eye-tracking and EEG measures provide evidence for enhanced visual engagement for personally relevant stimuli, an important question remains: does personal relevance enhance neural mechanisms of visual attention, engaging key dorsal attention regions such as the IPS and FEF?

Emotion: Enhancing Engagement and Memory

While attentional engagement provides the foundation for advertising effectiveness, the emotional response to it plays a crucial role in determining how that attention translates into

meaningful engagement. The interaction between the attention and emotion systems creates a powerful mechanism for enhanced processing of personally relevant advertisements.
The impact of emotional processing on advertising effectiveness has been well-documented through behavioural studies. Emotionally arousing advertisements consistently demonstrate superior memorability and influence on brand attitudes, with emotional intensity shaping how viewers engage with and recall marketing messages (Aaker et al., 1986; Bolls et al., 2001). A particularly compelling demonstration comes from (Ambler & Burne, 1999) neurobiological study, which investigated the role of emotional arousal in advertising recall using β-blockers - medications that reduce physiological arousal by blocking noradrenaline receptors. Participants who received a β-blocker, exhibited significantly weaker recall of advertisements compared to those given a placebo. This suggests that emotional arousal plays a critical role in encoding and consolidating advertising content into memory. Notably, this study examined responses to real-world, emotionally engaging advertisements rather than highly distressing stimuli, reinforcing the idea that moderate, everyday emotional arousal enhances memory for marketing messages.

Beyond these findings, physiological measures provide key insights into how emotional arousal is modulated by personal relevance. Electrodermal activity (EDA), a well-established marker of autonomic arousal, has been shown to increase significantly in response to personally relevant stimuli compared to standardised emotional images (D. Fernández et al., 2020). In a study examining the impact of personal relevance on emotional engagement, participants who viewed autobiographical images exhibited greater EDA responses and heart rate variability than those viewing standardised images, suggesting stronger emotional and physiological engagement. Since EDA is closely linked to amygdala activation, with studies demonstrating that amygdala responses to emotionally salient stimuli correlate with heightened electrodermal responses (Bonnet et al., 2015; Critchley, 2002), these findings align with broader evidence that the amygdala modulates autonomic arousal in response to personally meaningful stimuli (N'Diaye et al., 2009).

Further supporting this, recent EEG and fMRI research has revealed shown emotionally engaging stimuli evoke increased amplitudes of the late positive potential (LPP), a well-established neural marker of sustained attention to affective content (P. J. Lang & Bradley, 2010). These LPP enhancements are typically observed for both pleasant and unpleasant stimuli and correlate closely with self-reported emotional arousal. Additionally, emotionally salient cues drive increased activation in the amygdala and orbitofrontal cortex, reflecting deeper affective evaluation and emotional significance. Since LPP amplitude has also been linked to enhanced memory encoding (Hajcak & Olvet, 2008), these findings reinforce the idea that emotionally arousing advertisements may not only increase sustained attention but also facilitate long-term retention through deeper engagement with motivationally relevant content.

This has direct implications for advertising, where emotionally arousing content that feels personally relevant may engage the amygdala to a greater extent, leading to heightened engagement and memory consolidation. However, while EDA and EEG studies have demonstrated the physiological impact of personally relevant stimuli, fMRI research on emotional arousal and advertising remains limited. While prior research has shown evidence of amygdala activation in response to emotionally relevant stimuli, less is known about how emotionally engaging advertisements recruit these networks to modulate attention, memory, and the overall consumer response. Overall, behavioural and physiological studies suggest that personal relevance may enhance emotional arousal, however the amygdala's role in detecting self-relevant stimuli and modulating memory formation in personalised advertising remains unexplored.

Memory: The Role of Affective Processing in Recall

The formation of lasting memories is crucial for advertising effectiveness, as the delay between ad exposure and purchasing behaviour requires long-term retention of product or brand information (Moorman et al., 2002).(Moorman et al., 2012) While traditional advertising models have emphasised explicit memory recall as a predictor of success, growing evidence suggests that emotional arousal plays a key role in modulating memory encoding and consolidation. Studies measuring both recall and recognition have demonstrated that highly arousing images - regardless of valence - are often remembered more effectively than neutral content (Bradley et al., 1992). However, it is important to note that, the relationship between arousal and memory is not entirely linear; while moderate emotional arousal enhances memory consolidation, high-intensity emotions, particularly stress or fear, can impair encoding or retrieval due to excessive amygdala and cortisol activation (Cahill & McGaugh, 1998).

Beyond its role in explicit memory, emotional arousal has also been shown to enhance implicit learning and association-based memory. Repetition priming studies suggest that high-arousal words lead to stronger memory traces and faster recognition compared to neutral or low-arousal stimuli (Thomas & LaBar, 2005). Importantly, recent findings indicate that arousal can enhance memories specifically relevant to self-schemas. (Rameson & and Lieberman, 2007) observed that self-relevant information evokes an emotional response, leading to improved memory encoding and retrieval. These findings suggest that if personally relevant stimuli evoke a stronger emotional response, they may not only benefit from stronger explicit memory formation but also from enhanced associative learning processes.

A recent neuroimaging study has further supported the idea that personally significant content enhances memory encoding. Gómez-Carmona et al. (2022) found that individuals with high personal concern for an issue (e.g., environmental sustainability) exhibited greater recall for advertisements related to that issue, with increased activation in the amygdala and ventromedial prefrontal cortex (vmPFC). The amygdala's involvement suggests that emotional salience enhances encoding, while vmPFC activation aligns with its role in self-referential processing and value integration. These findings reinforce the assumption that when advertisements are personally meaningful, they engage deeper cognitive and emotional processing, leading to improved long-term memory.

A key mechanism underlying this memory advantage is the interaction between the vmPFC and the hippocampus, which facilitates the integration of personally relevant content into existing knowledge networks. The vmPFC has been implicated in self-referential processing, supporting memory encoding when information aligns with an individual's personal experiences (Gilboa & Marlatte, 2017). This aligns with schema theory, which suggests that memory is enhanced when new information connects with existing knowledge structures. Recent developments in memory research further show that the hippocampus does more than just encode new events, but it actively integrates them with prior knowledge to create more durable and retrievable memory traces (Schacter et al., 2012). This process may explain why previous behavioural studies (e.g., Kaspar et al., 2019) have shown that personally relevant advertisements are more effectively remembered over time, as they are embedded within a richer associative network that later facilitates retrieval.

Behavioural evidence further supports the role of personal relevance in memory encoding. (Rathbone & Moulin, 2024) found that autobiographical memories cluster around self-defining events, suggesting that self-relevant experiences are prioritised during memory retrieval. Supporting this, Viskontas et al. (2009) found that hippocampal neurons were more likely to respond selectively to personally relevant images, such as photographs of patients' family members or experimenters, than to famous or unfamiliar faces. These findings provide direct neural evidence that personal relevance enhances hippocampal engagement, likely through the retrieval of autobiographical associations, reinforcing the encoding of these stimuli into long-term memory.

While there is growing evidence that personal relevance enhances memory encoding, and behavioural advertising studies have shown that personalised ads lead to better recall, there remains a lack of direct fMRI evidence demonstrating how personal relevance in advertising influences hippocampal activity and memory encoding mechanisms. Although previous research suggests that personally relevant information engages the hippocampus to facilitate integration into existing knowledge networks, it remains unclear whether this process extends to targeted advertising. Understanding whether personalised ads enhance hippocampal engagement and improve encoding at the neural level is crucial for bridging the gap between behavioural findings and underlying memory mechanisms.

Reward Processing: Reinforcing Positive Engagement

Beyond attention and memory, reward processing plays a critical role in sustaining engagement with advertising content. The brain's reward system, particularly the nucleus accumbens (NAc), is closely associated with motivation, preference formation, and purchase decision-making (Haber & Knutson, 2010; Knutson & Cooper, 2005). Because personally relevant advertisements are expected to be more rewarding, they may engage the NAc to a greater extent, reflecting heightened subjective value and positive reinforcement.

Neuroscientific findings suggests that NAc activation during ad exposure can predict purchasing behaviour, often more accurately than traditional self-reported measures (Knutson & Genevsky, 2018). The NAc encodes the perceived reward value of an advertisement, while the vmPFC integrates these reward signals with self-relevant information to guide decision-making. Venkatraman et al. (2015) used a comprehensive neuromeric approach combining fMRI, EEG, eye-tracking, and biometrics to assess consumer responses to TV advertisements Their findings revealed that ventral striatum activation during ad exposure significantly predicted advertising effectiveness and subsequent purchase intent. As part of the brain's mesolimbic dopamine system (Daniel & Pollmann, 2014), greater activation in this region may reflect enhanced perceived value of personally relevant content, potentially explaining why targeted ads often result in greater engagement and brand affinity. When incoming stimuli match viewer interests, they engage reward circuits more effectively, potentially creating a positive feedback loop that reinforces attention and memory processes while promoting positive brand associations. Still, neuroimaging research on how personal relevance modulates neural reward pathways remains limited. This raises an important question: how does personal relevance in advertising influence reward system activation?

Research Questions and Hypotheses

Building on these theoretical foundations, this study addresses two primary research questions within an fMRI framework: what are the neural correlates underlying the previously observed behavioural uplift in engagement with addressable TV ads? And how does viewing context (choice vs. no-choice) moderate these neural responses to addressable content? These questions guide the experimental design, ensuring that each cognitive system - reward, emotion, memory, and attention - is examined in relation to the key hypotheses about addressability and potential contextual influences.

Alongside fMRI, implicit and explicit behavioural measures assessed the extent to which neural activity aligns with engagement at a behavioural level. This study employed a 2x2 factorial design. The factors were:

1. Addressability examined how engagement differs between addressable vs. non-addressable ads, operationalised via neural activation in reward-related, emotional arousal, memory, and attention-related regions, localised using functional localiser tasks.
2. Viewing context examined whether the choice (or not) of a show influences the engagement uplift observed for addressable ads.

Given the literature reviewed above, I propose a series of hypotheses about how addressability will influence neural activation across key cognitive systems:

Main Effects of Addressability:

- H1 (Reward): Addressable ads will elicit higher activation in the nucleus accumbens (NAc), reflecting increased reward-related processing associated with personal relevance and engagement. This hypothesis is supported by evidence linking personalised stimuli to motivational salience and striatal activation (Knutson & Cooper, 2005).

- H2 (Emotion): Addressable ads will elicit greater activation in the amygdala, suggesting increased emotional arousal due to personal relevance. This builds on research linking motivationally relevant stimuli to enhanced amygdala-mediated affective processing (Cunningham & Brosch, 2012).

- H3 (Memory): Addressable ads will result in greater activation in the hippocampus, reflecting enhanced memory encoding and consolidation compared to non-addressable ads. This prediction aligns with research on the role of the hippocampus in encoding personally relevant information (McGaugh, 2004; Viskontas et al., 2009).

- H4 (Attention): Addressable ads will engage the frontoparietal attention network, with increased activation in the frontal eye fields (FEF) and intraparietal sulcus (IPS), reflecting enhanced attentional allocation and sustained visual processing. This hypothesis builds on prior findings that personalised advertising modulates top-down attentional control (Bang & Wojdynski, 2016; Jung, 2017).

Contextual Moderation:

- H5 (Interaction Effect): Viewing context (choice vs. no-choice) will moderate the neural effects of addressability, with potentially stronger responses in reward-related (NAc) and emotional (amygdala) networks when participants have actively chosen the viewing content. However, given mixed findings in the literature regarding autonomy and engagement, this interaction remains exploratory and non-directional.

To ensure precise neural engagement measurement across multiple cognitive systems, functional localiser tasks were conducted to independently define regions of interest (ROIs). This approach enhances precision in identifying the exact regions engaged by each of the four cognitive processes in the current set of participants. By defining ROIs with independent data, this design mitigates circular analysis and reduce false positives (Kriegeskorte et al., 2009). The localisers targeted key cognitive processes relevant to advertising engagement, enabling functionally specific tests of addressability and context effects.

Functional Localiser Tasks and Theoretical Rationale

To precisely measure the hypothesised neural effects of addressable advertising, I ran four independent functional localiser tasks before the main experiment to independently define ROIs, targeting the four cognitive systems mentioned above. Functional localisers provide a robust method for identifying individual differences in neural activity, reducing inter-subject variability, and enhancing statistical power in subsequent analyses (Devlin & Poldrack, 2007; Saxe et al., 2006). Below, I outline the rationale for each localiser and its relevance to my research objectives.

The adapted Monetary Incentive Delay (MID) task (Knutson et al., 2000, 2001a) serves as a primary tool for identifying reward-processing regions. This paradigm reliably engages the fronto-striatal-limbic network. I focused primarily on the NAc as a region of interest, given its well-established role in reward anticipation and valuation (Knutson & Genevsky, 2018). According to the Affect Integration Motivation framework, the NAc is particularly sensitive to anticipatory affective responses, making it a key predictor of audience engagement and decision-making. Since addressable advertising is theorised to enhance reward value through increased relevance, examining NAc activation allowed me to assess the extent to which addressable ads elicited stronger reward-based neural responses. Also, the MID task demonstrates high test-retest reliability (Plichta et al., 2012), ensuring robust identification of reward-related regions at the individual and group level. Meta-analyses confirm its efficacy in detecting reward-related activity across various experimental conditions, reinforcing its suitability for this study (Bartra et al., 2013; Liu et al., 2010).

The emotion localiser employed standardised images from the International Affective Picture System (IAPS; L Lang, 1995) to examine neural responses to high-arousal versus low-arousal stimuli. This task robustly activates the amygdala and related emotional processing networks, which are involved in emotional reactivity (Hamann et al., 2002; Sabatinelli et al., 2005). While test-retest reliability of amygdala activation in single-subject analyses has been debated (Plichta et al., 2012), group-level analyses consistently show robust engagement of the emotional processing network (Varkevisser et al., 2023). Moreover, studies in consumer neuroscience suggest that emotional arousal enhances advertising memory and brand recall (Riemer & and Noel, 2021), further justifying the use of this task in this study.

To assess memory encoding processes, I employed a post-hoc analysis of the IAPS task based on subsequent memory effects. By comparing neural activity during the initial viewing of later-remembered versus later-forgotten images, I could identify regions involved in successful memory encoding, including the hippocampus and the MTL (Rugg & Vilberg, 2013). This approach allowed me to efficiently localise memory-related regions within the hippocampus without requiring additional data collection, leveraging naturally occurring variability in memory performance (Wagner et al., 1998). While an explicit encoding paradigm may have provided stronger causal evidence, this method maintained ecological validity by measuring incidental encoding processes, which more closely resemble real-world advertising exposure.

To map attention networks, I employed a variation of the Pop-Out Task (Treisman, 1980), which has been widely used to examine visual search efficiency and the role of feature-based attention. This paradigm reliably activates the IPS and FEF, regions involved in attentional control, particularly in guiding eye movements and spatial attention (Corbetta & Shulman, 2002; Kastner & Ungerleider, 2000). Attention plays a fundamental role in advertising effectiveness, as consumer engagement is reliant on the ability of an ad to capture and sustain attention (Pieters & Wedel, 2004). Precise localisation of these regions was essential for testing my attention-related hypotheses about addressability effects.

A full description of each task design, stimulus presentation, and analysis procedures is provided in the Methods section.

Overall, this chapter provides a neural account of the addressability uplift, investigating how personal relevance in advertising enhanced engagement through reward, emotion, memory and attention systems. By employing functional localisers, this study ensured precise group-level ROI definition, improving the validity of neural engagement measures. While the primary focus was on addressability, viewing context (choice vs. no-choice) was included as a secondary factor to explore potential moderating effects, with further discussion deferred to the next chapter.

3.2. Methods

Participants

Because the experiment used four categories of advertisements (cars, cruises, dogs, and video games), I needed participants with an interest in exactly two of the categories to maintain a balanced, within-subject design. There are exactly six combinations that fit that requirement (Table 3.1). As a result, I recruited 24 volunteers, four from each group (A-F).

Table 3.1. Participant groups based on their addressability categories

Group	Cars	Cruises	Dogs	Gaming
A	Yes	Yes	No	No
B	Yes	No	Yes	No
C	Yes	No	No	Yes
D	No	Yes	Yes	No
E	No	Yes	No	Yes
F	No	No	Yes	Yes

To do this, I first ran a pre-screening experiment to identify individuals interested in exactly two of these four categories. 304 UK-based people completed an on-line survey through Prolific (https://www.prolific.com) where they were asked about their leisure time activities. Topics included the four activities of interest (driving/cars, dog walking/owning, taking cruises and video gaming) interspersed with others (going to the theatre, camping, watching television, foreign travel, BBQing, going to the gym, etc) to mask my interest in the first four topics. This was designed to identify individuals who fit exactly two of the four addressability categories. Order of the items was randomised. For each opinion item participants moved a slider to indicate the degree to which (a) they had a positive or negative view of the item, and (b) they intended to use or purchase the item in the near future. These two opinion measures were averaged to give a single rating for each item. To account for individual differences in response tendencies, each participant's ratings were standardised (z-scored) relative to their own average response. This transformation ensures that responses reflect how much each rating deviates from a participant's personal mean rather than absolute values, reducing response biases such as consistently high or low ratings. Additionally, some ad categories were generally more appealing than others (e.g., dog-related ads may be more popular than cruise ads). To control for this, responses were also z-scored within each ad category across participants. To determine which ads were personally relevant to each participant, I classified an ad category as 'addressable' if the participant rated it more positively than the average person. This on-line experiment was approved by the UCL Research Ethics Committee (EP/2019/003).

Of the 304 participants, 102 fell into one of the six groups (A-F) above. The other 202 participants liked either zero, one, three of four of the categories and therefore were unsuitable for the fMRI experiment. Ultimately, 42 were invited to participate and 27 were tested. Three were excluded for excessive head movement during scanning, leaving me with a total of 24 participants (11 M, 13 F). Eight volunteers were between the ages of 18-34; thirteen were between the ages of 35-54; and three were between the ages of 55-65. The mean age of the participants was 38.6 years old (σ=11.0). There were exactly four volunteers in each of the six groups ensuring that each addressability category was fully counter-balanced across participants.

Participants were informed that the aim of the study was to investigate how the brain processes stories presented in video form. They were told that they would be asked to watch a 30-minute television episode presented as it would appear on commercial TV, including advertisements, while their brain activity was recorded. The explanation emphasised that visual and auditory brain regions would naturally be engaged by the images and sounds, but that the study was primarily interested in how higher-order brain regions respond to narrative content. This description ensured that participants understood the overall design of the study without drawing attention to the experimental manipulation of advertisement categories. The fMRI study was approved by the UCL Research Ethics Committee (fMRI/2019/002).

Functional Localisation

In order to quantify neural activity associated with reward, emotion, memory, and attention I chose to functionally localise key components of each of the anatomic systems directly within this group of participants to maximise sensitivity (Kanwisher et al., 1997). Three short functional localiser experiments were run to collect independent data for identifying these systems (Saxe et al., 2006).

Reward

To identify reward-related patterns of activity I employed the Monetary Incentive Delay (MID) task (Knuston et al., 2000; 2005) which has been previously shown to robustly identify nucleus accumbens contributions to reward processing (Dillon et al., 2008; Knutson et al., 2001b). This was a purely event-related design. Each trial began with a fixation cross for 500 msecs. Then a cue and a random amount of money were displayed on the screen for 500 msec. When the cue symbol was a circle, this denoted the amount of money that could be won (i.e. a reward trial) whereas a square cue indicated the amount of money at risk of being lost (i.e. a loss trial). A third condition was included where participants could neither win nor lose money (i.e. a control trial). Reward trials were the most frequent (60% of the time) and the amount of money that could be won was selected from a uniform random distribution between £1 to £3. Control trials were next most common (25% of the time) and the amount of money for these was always £0. Finally, loss trials were the least common (15% of the time) and the amount of money at risk was selected from a uniform random distribution between £3 to £5. In other words, reward trials were more common but less valuable than loss trials.

The cue then disappeared, and a blank screen was present for 500 msec before a green triangle appeared. This was the target that participants were looking for. Upon seeing the target, their task was to press a response button as quickly as possible. If they responded within 350msec, then they either won the money on a reward trial or avoided losing the money on a loss trial. If they responded too slowly, then they failed to win the money on a reward trial or they lost the money in a loss trial. The target remained on the screen for 2 seconds. Afterwards, it was replaced by feedback on the trial. This read “Nice one! You gained £1.53” for a successful reward trial or “Too late. You GAINED nothing on this trial” for an unsuccessful reward trial. For a successful loss trial, the feedback read “Nice one! You lost no money on this trial” or “Too late! You LOST £4.44 on this trial” for an unsuccessful loss trial. The bottom of the screen displayed their total winnings/losings. This feedback was present for 2 seconds. This was followed by a blank screen for a random duration of time between 1 to 3 seconds to induce temporal jitter between trials and provide an implicit “rest” baseline. The process then repeated for the next trial (Figure 3.1). In this fashion, the experiment implemented an event-related design, with each trial lasting 5.5 seconds with an addition 1-3 second inter-trial interval (ITI) used to optimise sensitivity (Josephs & Henson, 1999). There were 48 trials in a run and participants each completed two runs, lasting approximately 12 minutes.

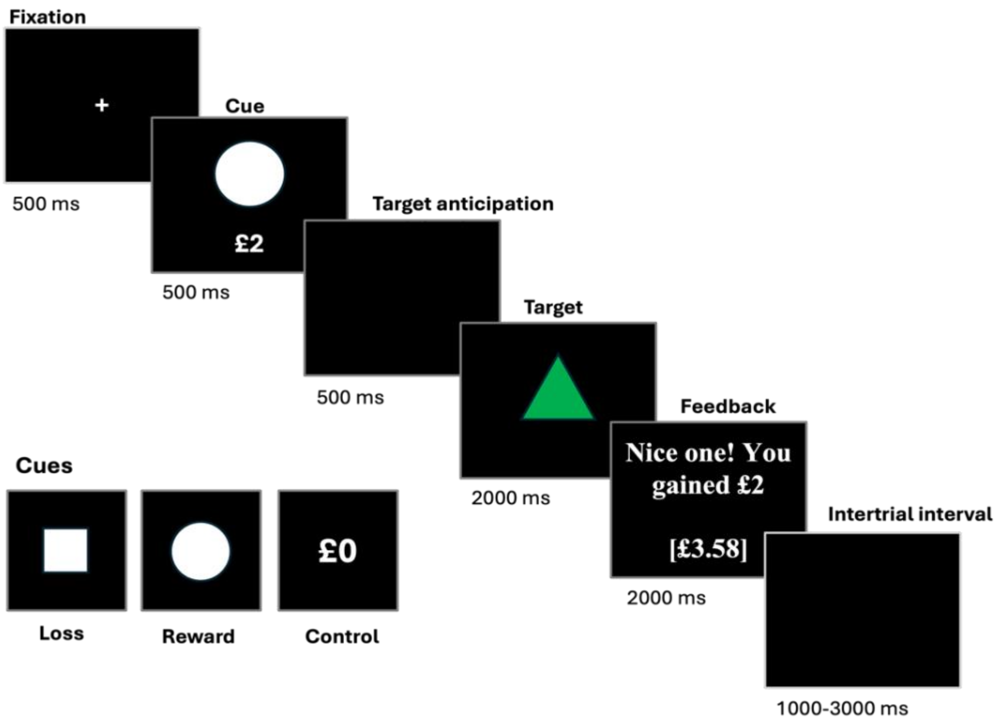

Figure 3.1: The reward task. Each trial began with a fixation cross presented for 500msecs. Then a cue with a random amount of money was presented for 500msecs, followed by a blank screen present for 500msecs. A triangle target appeared on the screen for 2000msec, followed by feedback on participant’s performance for a further 2000msecs. A jittered intertrial interval (1000-3000msecs) acted as a rest period.

The first 8 volumes of each run were deleted to settled into T1 equilibrium before the task began. The time series were then realigned, normalised to the MNI-152 template using an affine transformation (Jenkinson et al., 2002), and smoothed with a 6mm FWHM Gaussian kernel. A total of two runs had estimated head motion exceeding the minimal voxel dimension (2mm) and as a result, these two runs were excluded from further analyses. Otherwise, the maximum movement estimates did not exceed 2mm of displacement.

The first level statistical analysis included three conditions (reward trials, control trials, and loss trials), each modelled as events starting with the cue and including the rest of the trial (a duration of 5.5 seconds). These were convolved with a canonical haemodynamic response function (HRF; (Glover, 1999) to create regressors. Temporal derivatives were included as covariates-of-no interest to remove time-to-peak HRF timing differences. Each condition was contrasted with the implicit baseline (fixation) and entered into a second-level fixed-effects model to generate an estimate of each individual participant's performance on the task across their two runs. Two participants only had a single first-level run because one was removed due to excessive head motion.

Finally, a third level random-effects analysis was conducted for the whole group (n=24) to identify brain regions showing reward-related activity by focusing on the contrast [reward trial > fixation]. The significance threshold was set at $p < 0.05$ after family-wise error correction for multiple comparisons across the whole brain.

To examine the role of the NAc in the MID task, I used a specific *a priori* anatomical mask to constrain the analysis, and a small volume correction (SVC) was applied to restrict the analysis to the NAc. This approach enabled me to focus on activations within this region-of-interest.

The NAc was anatomically defined by creating two 6-mm radius spheres centred on the MNI coordinates [±12, 10, -8] following a previously established procedure (Welborn et al., 2020). The spheres were created using the MarsBar region-of-interest toolbox for SPM (https://marsbar-toolbox.github.io/) and combined to form a single bilateral NAc ROI. This method ensured that the analysis focused on portions of the NAc that are reliably engaged during reward trials in the MID task, consistent with prior studies (Abe & Greene, 2014;

Arrondo et al., 2015; Buckholtz et al., 2010; Cao et al., 2018, 2021; Hariri et al., 2006). The identified region was subsequently used as the "reward" mask in the analysis of the main experiment.

Emotion

I used the International Affective Picture System (IAPS; Lang et al., 2005) to identify brain regions where emotional arousal evoked activity. A total of 60 photographs were selected from the IAPS database of 1185 images. Based on the arousal and valence ratings provided, 30 were chosen to be highly emotionally arousing and 30 were low arousal images (Table 3.2). An equal number of positive and negative valanced images were selected. The chosen images did not contain nudity, sexual scenes, or graphic violence. Sample images are shown in Figure 2 but note, that these are not the actual images used in the experiment. In order to use the IAPS images, the owners stipulate that they may not be shared, even in publications. As a result, similar images are shown Figure 3.2. A 2×2 ANOVA with Arousal (high, low) and Valence (positive, negative) was used to verify the manipulation. There was a significant main effect of Arousal ($F(1,56)=720.2$, $p<0.001$) with high arousal photos rated as more arousing than low arousal photos (6.60 vs. 3.26). There was no significant effect of Valence on Arousal ratings ($F(1,56)=0.16$) and no interaction ($F(1,56)=0.38$).

Table 3.2. Arousal ratings for the IAPS images. These were used in the functional localiser for emotion. The figures are based on the mean (±σ) of the 15 images in each cell.

	Positive valence	**Negative valence**
High arousal	6.66 (±0.4)	6.53 (±0.3)
Low arousal	3.24 (±0.6)	3.27 (±0.6)

Figure 3.2. Sample images similar to those used in the experiment. Note that these are not actual photographs from the IAPS database for copyright reasons.

The experiment involved showing one image at a time and asking the participant to think about how it made them feel. Trials began with a fixation cross at the centre of the screen for 500 msec. It was then replaced by an image displayed for 1000 msec and then a blank screen (ITI) for a random duration between 500 and 3500 msec before the next trial began. Images were presented in a pseudorandom order in blocks of 10 trials followed by a 15 second rest block. There were 6 sets of trial and rest blocks. As a result, it used a mixed block, event-related design where images in individual trials came from either the high or low arousal conditions. Each participant performed a single run of this task that lasted approximately 5 minutes. A software problem prevented collecting these data in one participant.
The first 8 volumes of each functional run were discarded to allow for the stabilisation of T1 signal equilibration. The time series were then realigned, normalised to the MNI-152 template using an affine transformation (Jenkinson et al., 2002; Devlin & Poldrack, 2007), and smoothed with a 6mm FWHM Gaussian kernel. The maximum movement estimates did not exceed 2mm of displacement.

The first level statistical analysis included two conditions (high arousal images and low arousal images), each modelled as 1 second events starting with onset of the image presentation. These were convolved with a canonical haemodynamic response function (Glover, 1999) to create regressors. Temporal derivatives and estimated head motion parameters were included as covariates-of-no-interest to remove structured sources of noise due to slice timing and head movement. Each condition was contrasted with the implicit baseline (rest) and entered into a second-level random-effects model over the group (n=23).

To identify brain regions associated with emotional arousal-related activity, I focused on the contrast [task > rest], as even the low-arousal images contained emotional imagery. A voxel-wise statistical threshold of $Z > 4.5$ ($p < 0.05$, FWE-corrected) was initially applied. Given the importance of the amygdala in processing emotional arousal, I selected an anatomical mask of the amygdala bilaterally from the Harvard-Oxford subcortical structural probabilistic atlas in FSL (Rushmore et al., 2022). To ensure anatomical specificity, I applied a 50% probability threshold, including only voxels with at least a 50% likelihood of being part of the amygdala. An SVC was used to identify active voxels within this ROI. This analysis was expected to reveal bilateral amygdala activation, consistent with the region's well-documented role in responding to emotional arousal (Adolphs et al., 1999; Bonnet et al., 2015; Costa et al., 2010; Garavan et al., 2001; Sabatinelli et al., 2005).

Memory Encoding & Retrieval

To identify brain regions activated by memory encoding, the data from the emotion localiser task were re-analysed based on a surprise memory test for the images after scanning was complete. Outside of the scanner, participants completed a post-hoc, computer-based memory test where they were shown 60 photographs from the IAPS set. Approximately 40 minutes after they first saw the emotional (i.e. IAPS) images in the scanner, each participant completed a short experiment where they saw one image on a screen at a time and were asked to indicate whether they saw that image previously by pressing either the “yes” or “no” button (see Figure 3.3). There were 60 trials. 30 were images used to functionally localise emotion-related activity and 30 were matched images from the IAPS database not used previously. The stimuli were matched so that for each image from the emotion localiser task there was a corresponding image. These were matched as closely as possible on the basis of content and valence and arousal ratings.

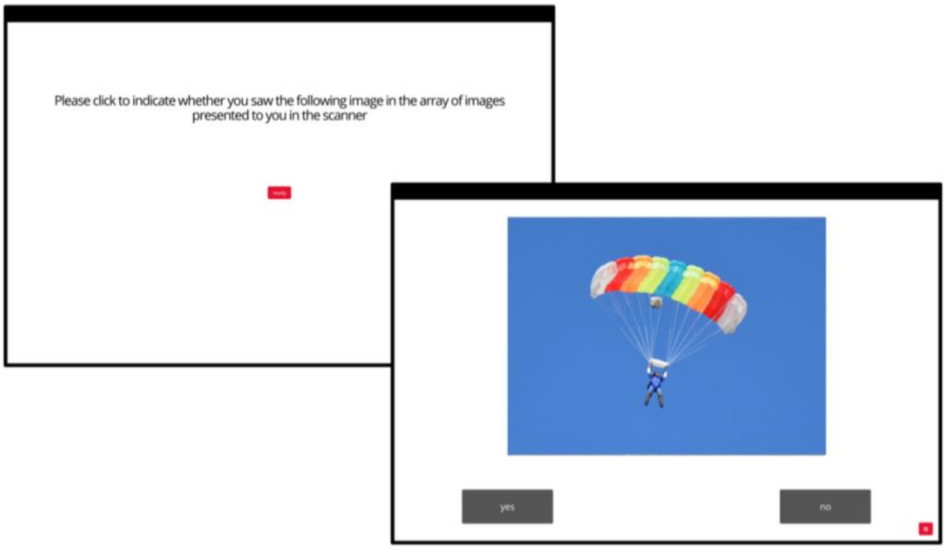

Figure 3.3. A sample trial from the post-hoc memory test. Note that due to copyright of the IAPS images, the actual image shown here is not part of the IAPS database.

I was specifically interested in which items they remembered of the images they saw in the scanner because that demonstrates that these items were successfully encoded into memory at the time. Using these data, I then re-analysed each participant's fMRI data from the emotion functional localiser. Trials were classified into three conditions. A "hit" was a remembered item; a "miss" was a forgotten item; and "untested" referred to the 50% of the items that were not tested in the post-hoc memory experiment. In other words, the participant's behavioural data allowed me to *post-hoc* classify individual trials in order to re-analyse their EPI data. Pre-processed fMRI data from each participant underwent a first-level statistical analysis using a GLM. Prior to model estimation, a high-pass filter with a cut-off frequency of 1/128 Hz was applied to remove low-frequency noise and signal drift. Each condition (hit, zero and miss) was modelled separately, with the onsets of stimuli convolved with a canonical hemodynamic response function (Glover, 1999) to generate regressors of interest. Temporal derivatives and estimated motion parameters were included as covariates of no-interest to enhance statistical sensitivity. The contrast [hits > rest] was computed at the group level (n=23) to identify brain regions activated by successful memory encoding.

I expected this would reveal specific portions of the hippocampus based on previous studies (Brewer et al., 1998; Dolan & Fletcher, 1997; G. Fernández et al., 1998; Grady et al., 1995;

Kircher et al., 2008; Stern et al., 1996; Trivedi et al., 2008). Given the importance of the hippocampus in memory encoding and retrieval, I analysed BOLD response within left and right hippocampal ROI defined *a priori.* A bilateral hippocampus anatomical mask was defined using the Harvard-Oxford subcortical structural probabilistic atlas in FSL (Rushmore et al., 2022). Similar to the amygdala, I applied a 50% probability threshold, including only voxels with at least a 50% likelihood of being part of the hippocampus. An SVC was applied to limit the analysis to the hippocampus. This approach allowed me to focus on activations within this region and extract significant activations for further analysis.

Visual Attention

To localise brain regions associated with sustained visual attention a classic visual search paradigm was employed, where participants were asked to find a red circle either in a field of green circles or in a field with circles of multiple colours (Treisman, 1980). In the former, the target "pops out" and is easily identified, independent of the number of distractors. When the distractors are of multiple colours, however, the task becomes more difficult, requiring a serial search through the visual field. By contrasting these two conditions, I aimed to functionally identify the Frontal Eye Fields (FEF) and the Intraparietal Sulcus (IPS), two regions commonly associated with sustained visual attention (Bedini & Baldauf, 2021; Donner et al., 2002; Esterman et al., 2015; Kincade et al., 2005; Leonards et al., 2000; Muggleton et al., 2003). The FEF is involved in voluntary eye movement and attentional control (Bressler et al., 2008; Corbetta & Shulman, 2002; Kelley et al., 2008; Muggleton et al., 2003; Schall, 2004; Thompson et al., 1997), while the IPS is associated with the deployment of spatial attention and eye movements (Culham & Kanwisher, 2001; Hopfinger et al., 2000; Lauritzen et al., 2009).

A trial began with a fixation cross for 500 msecs. It was then replaced with a display of 80 coloured circles, randomly placed on the screen. In the easy condition, the distractors were uniformly green and the red target "popped out". In the difficult condition, the colour of each distractor was randomly chosen from orange, green, magenta, purple, and blue, making the task more difficult and requiring sustained visual attention (see Figure 3.4). 10% of the trials were catch trials where no red circle appeared, in order to keep participants doing the task honestly. These were equally distributed between the easy and difficult conditions. Participants responded by pressing a button when they saw the red circle. Accuracy and reaction times were recorded. After 1500 msec, a blank screen replaced the array of circles for a variable interval of time ranging between 500 and 4500 msec before the next trial began. After 10 trials, an 8 second rest block occurred. There were 7 sets of trials and rest blocks, making a run last approximately six minutes.

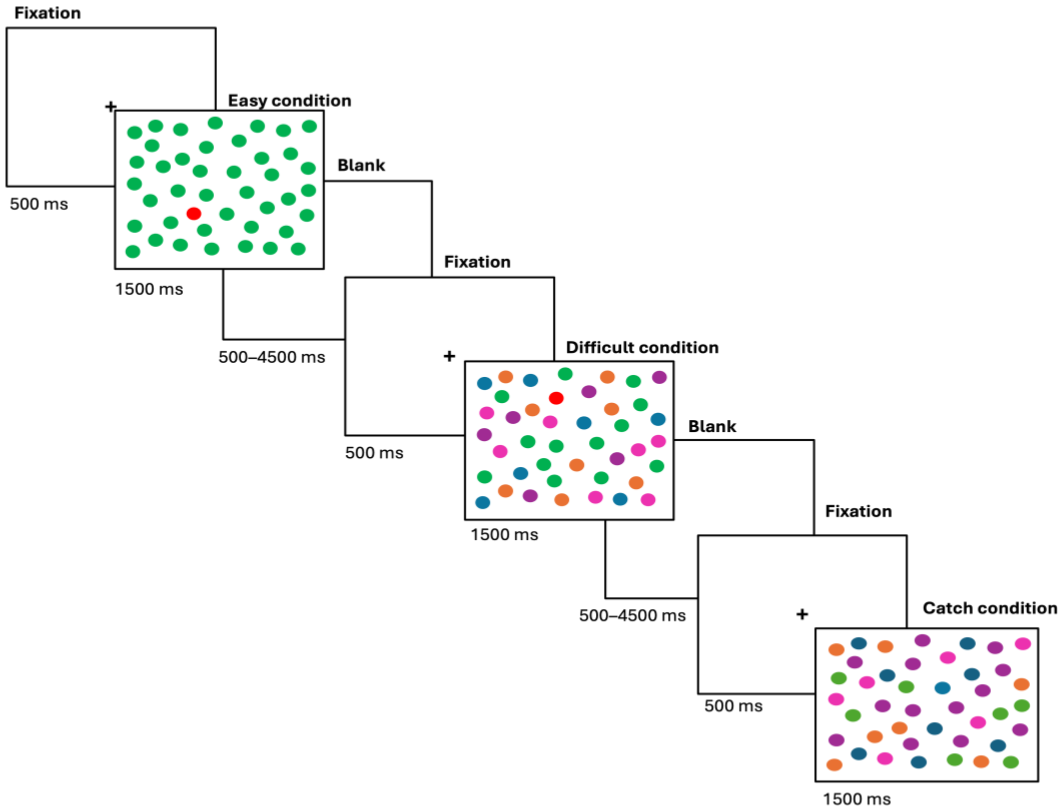

Figure 3.4: The visual attention task. Each trial began with a fixation cross presented for 500msecs. It was then replaced with a display of 80 coloured circles, randomly placed on the screen for 1500msec. A blank screen was presented after each trial, implementing the temporal jitter (500–4500 ms) before the next trial began with a fixation cross.

The first 8 volumes of each run were deleted to allow for T1 equilibrium before the task began. The time series were then realigned, normalised to the MNI-152 template using an affine transformation (Jenkinson et al., 2002; Devlin & Poldrack, 2007), and smoothed with a 6mm FWHM Gaussian kernel. One participant's head motion exceeded the minimal voxel dimension (2mm) and as a result, that run was excluded from further analyses. Otherwise, the maximum movement estimates did not exceed 2mm of displacement.

The first level statistical analysis included two conditions (easy and difficult), each modelled as a 1 second event starting with onset of the circle array. These were convolved with a canonical haemodynamic response function (Glover, 1999) to create regressors. Temporal derivatives and estimated head motion parameters were included as covariates-of-no-interest to remove structured sources of noise due to slice timing and head movement. Each condition was contrasted with the implicit baseline (rest) and entered into a second-level random-effects model over the group (n=23). To identify brain regions showing activity related to visual attention, I contrasted [difficult > easy] trials, inclusively masked this with the [difficult > rest] contrast and used a voxel-wise statistical threshold of $Z>4.6$ ($p<0.05$, after correcting for family-wise error). I expected this contrast to reveal bilateral FEF and IPS activity, consistent with previous studies (Donner et al., 2002; Kelley et al., 2008; Kincade et al., 2005; Leonards et al., 2000; Muggleton et al., 2011). These clusters were then selected as a binary mask of these two regions bilaterally.

Main Task

Experimental Design

Each participant attended two 1-hour sessions a minimum of one day apart (mean days apart = 7.7). Each session consisted of: (i) two ~7-minute functional localiser tasks in the scanner, (ii) the main 30-minute task, where participants watched a TV show episode in the scanner; and (iii) a brief behavioural experiment outside of the scanner. The visual attention and the emotion functional localiser tasks occurred in the same scanning session, although the order was counterbalanced across participants. Furthermore, the data from the emotion functional localiser task were re-analysed to functionally localise regions involved in encoding memories based on a post-hoc memory test for the IAPS images outside of the scanner. The second scanning session involved the reward functional localiser task, which occurred as two 7-minute runs. Half of the participants did the reward task in their first visit while the other half performed the emotion and attention tasks in their first visit. The functional localiser tasks were followed by the main experiment in the scanner, which involved watching a 30-minute TV show episode with naturalistically embedded advertisements. In one scanning session, participants chose the show they wanted to watch, whilst in the other scanning session, the TV show was chosen for them at random by the computer. Half of the participants chose their TV show in their first scanning session while the other half of participants had it chosen for them. This was reversed in the second scanning session.

After each scanning session, participants completed a short behavioural experiment outside of the scanner on a laptop, which was implemented on the Gorilla (www.gorilla.sc) platform (Anwyl-Irvine et al., 2019). The experiment tested their memory for the ads they saw, their liking for each of the ads, and a simple manipulation check to test whether the pre-screen had successfully identified participants who were interested, or not, in each category.

Task and Stimuli

A total of sixteen TV advertisements were used in this experiment and ranged from 20 to 30 seconds in length, four in each of the addressability categories. The ads targeted at dog owners (dog category) included dog food and dog insurance products. Video-gaming ads were targeted at people interested in videogames (gaming category). The ads in the cruise category were targeted at people who were interested in, or intended to go on, a cruise whilst ads in the car category were targeted at people interested in cars. Each advertisement was chosen because it was addressable to a specific demographic group.

The advertisements were embedded in a TV program that was either chosen by each participant or randomly allocated to them by the computer from a set of five options: *The Bold and the Beautiful, Carp Wars, Dog the Bounty Hunter, Married with Children*, and *Modern Family*. A brief description of each TV show was provided to participants prior to the experiment. Half of the participants chose their show in their first scanning session while the other half had it chosen for them. This was reversed in the second scanning session. All programmes fit into a typical 30-minute TV time slot, including the 16 advertisements. These shows had pre-existing ad breaks that allowed us to embed our chosen advertisements in a naturalistic manner at the beginning, middle and end of the 30 minutes. The order in which the ads were shown was randomised across participants to remove potential order effects on attention and memory (Zhao, 1997).

The main experiment adopted a block design. Within every TV programme, four advertisements from each of the four categories (16 total) were shown; one block before the show began and three other blocks were at planned advertising breaks during the episode.

Half of the ads were relevant to each participant and half were not. Ads were pseudo-randomly ordered such that they alternated between addressable and non-addressable ads and were tailored to the participant's specific interests. This ensured optimal sensitivity to experimentally induced brain activity from the advertisements while minimising physiological noise (Worsley & Friston, 1995). All video stimuli were projected onto a screen and viewed using a mirror attached to the head coil and the audio was played through headphones. Finally, at the end of the second scanning session, each participant received a five-minute structural scan to identify their underlying neural anatomy.

After scanning, participants performed a brief memory experiment outside of the scanner where they were tested on their recollection of the IAPS images they saw during the emotion localiser task. Based on their responses, I was able to compare items that were subsequently remembered (and therefore successfully encoded into memory) to those that were later forgotten (and thus, unsuccessfully encoded). This difference was used to functionally localise brain activity associated with memory encoding.

Finally, participants completed a short behavioural experiment relating to the advertising stimuli seen during the fMRI task. In the memory test, each trial began with a screen reading "Please click to indicate whether you saw the following image in the advertising breaks." Participants had to press a "ready" button in the middle of the screen to begin the trial. The subsequent screen showed a still image in the middle of the screen as well as two response buttons in the bottom corners of the screen. The image came from one of four conditions: i) a screen-grab image from an advert seen previously, ii) the brand image from an advert seen previously, iii) an image from a similar, but unseen, advert (i.e., a foil), and iv) a brand image from a similar, but unseen, advert (i.e., a foil). The participant clicked on the appropriate response button to indicate whether they had seen the image previously ("yes") or not ("no"). Images appeared one at a time, in a random order. We recorded participants' accuracy and reaction times.

A second part of the short behavioural task assessed participants' interest in the ads they saw. Still images from each of ads seen during the TV program were rated on the extent to which the ads changed the participant's interest level in the products. They responded by moving a 20-point slider-bar that ranged from "less" (-10) to "more" (+10) with zero indicating no change. One image was shown from each of the 16 ads.

Lastly, participants saw still images from all four advertisements within an addressability category (e.g., images from all four car ads) and were asked to indicate their level of interest in "these types of products" using a slider-bar ranging from "very interested" (100) to "not interested at all" (0). There were only four trials, each one corresponding to one of the addressability categories. These data were used as a manipulation check to check whether the recruitment paradigm successfully identified the categories of advertisements relevant to each participant. On completion of the behavioural tasks, the participant was fully debriefed about the aims of the experiment and thanked for their participation.

MRI Acquisition

Whole-brain imaging was acquired using a 3T Siemens Prisma MRI scanner with a 32-channel head coil, at the Birkbeck-UCL Centre for Neuroimaging (BUCNI). Functional data were collected using a multiband echo-planar imaging (EPI) sequence, allowing simultaneous acquisition of 4 slices per TR (Multiband Acceleration Factor = 4), improving temporal resolution. The acquisition parameters were: Repetition Time (TR) = 1300 ms, Echo Time (TE) = 35.2 ms, flip angle = 60°, FOV = 212 × 212 mm, and matrix size = 106 × 106, giving a resolution of 2 × 2 × 2 mm. Structural T1-weighted images were collected using an MPRAGE sequence (TR = 2300 ms, TE = 2.98 ms) with an isotropic 1 mm^3 voxel size.

Pre-processing

Image processing and statistical analysis were performed using SPM12 software (https://www.fil.ion.ucl.ac.uk/spm/software/spm12) in MATLAB. The first eight volumes of each run were discarded to account for T1 equilibrium effects. Head motion parameters were estimated during volume-to-volume realignment using SPM's rigid body transformations, with initial screening thresholds set at 2 mm of translation or 2 degrees of rotation in any direction. Given the 30-minute duration of each run, head motion was observed in multiple participants. Of the 48 runs, 23 runs contained at least one volume exceeding this 2mm/2° motion threshold. However, removing all high-motion runs would have resulted in excessive data loss, especially as motion was found primarily during the 22-minute television show portion (baseline) rather than during the advertisement segments that were the primary focus.

To mitigate motion-related artifacts, I employed a two-stage motion correction approach based on the severity of movement. Rapid motion changes affecting isolated volumes were addressed via linear interpolation, replacing the affected volumes with interpolated values from temporally adjacent “clean” volumes. This method was applied to 14 runs, and only a total of 10 volumes that underwent interpolation occurred during advertisements. For more severe or sustained motion, Independent Component Analysis (ICA) was performed. In other words, if more than 5 consecutive volumes in a run were affected, ICA-based denoising was applied, as interpolation over extended periods can introduce artificial temporal correlations (Power et al., 2014).

Of the 23 runs that exceeded the motion thresholds, 9 runs exhibited substantial motion artifacts that required additional cleaning through ICA. For these runs, pre-processed fMRI data were analysed using the SPM Group ICA of fMRI Toolbox (GIFT) software (Calhoun et al., 2001); http://mialab.mrn.org/software/gift/index.html). The Infomax algorithm estimated independent components for each participant, and components were visually inspected and manually classified as either signal or noise, following criteria adapted from (Griffanti et al., 2017) and (R. E. Kelly et al., 2010). Components were identified as noise if they exhibited one or more of the following characteristics: (1) spatial localisation outside grey matter, particularly in white matter, ventricles, or large blood vessels; (2) spatial patterns showing ring-like artifacts around the brain edges or isolated clusters inconsistent with anatomical structures; (3) temporal characteristics such as sudden spikes or discontinuities in the time course; (4) strong temporal correlation with head motion parameters; or (5) vascular and physiological artifacts, such as components centred around major blood vessels.

Only clearly identifiable noise components were removed. If there was any uncertainty regarding classification, the component was retained to minimise the risk of removing genuine neural signal. The remaining components were back-reconstructed for each subject to create individual pre-processed data with the problematic “noise” components filtered out.

This multi-step motion correction strategy ensured the retention of as much usable data as possible while minimising motion-related confounds in subsequent analyses.
All runs were then normalised to the MNI-152 template, maintaining the original 2x2x2mm resolution. Finally, images were smoothed using an isotropic 6mm full-width half-maximum (FWHM) Gaussian kernel, to increase signal-to-noise ratio. The T1-weighted

structural images were also normalised to the MNI-152 template, and a mean structural image was computed from the individual normalised structural scans.

3.3. Results

The analysis of the fMRI data proceeded in three stages. First, I identified regions of interest using functional localisers, targeting activity associated with reward, emotion, memory, and visual attention. Next, I analysed the main experimental task data, examining neural responses during addressable advertisements in different contexts. Finally, I conducted behavioural analyses of the post-scan task. Below, I present the results from each stage of analysis in turn.

Functional Localisation

Reward

To identify reward-related patterns of activity, I compared activation for the reward trials relative to rest during the MID task. Imaging results revealed that reward trials led to widespread cortical and subcortical activity, as shown in Figure 3.5 and Table 3.3. The small volume correction revealed significant activation in the right NAc (10, 14, -4; Z=4.41) and the left NAc (-10, 14, -4; Z=4.02), supporting the region's involvement in reward anticipation during the MID task (e.g., Hariri et al., 2006; Figure 3.5). I observed robust bilateral activation in the caudate nucleus, with distinct clusters in the head, body, and tail portions, aligning with the caudate's central role in reward-related learning and motivation (Delgado et al., 2005; Kawagoe et al., 1998; Knutson et al., 2001a). The activation also revealed significant frontal lobe involvement, with bilateral activation in the inferior frontal gyrus and right middle frontal gyrus - regions commonly associated with reward evaluation and decision-making (Liu et al., 2010; Rushworth et al., 2011). In the orbital region, a significant cluster was found in the right medial orbital gyrus, an area linked to encoding and representing the subjective value of rewards, integrating information about reward magnitude, probability, and delay (Padoa-Schioppa, 2007; Peters & Büchel, 2010). The activation extended into temporal regions, with bilateral activation in the middle temporal gyrus and a notable cluster in the left hippocampus and right hippocampus tail. Strong activations were also observed in the right supramarginal gyrus. In the occipital lobe, significant activations were found in the left middle occipital gyrus and left fusiform gyrus.

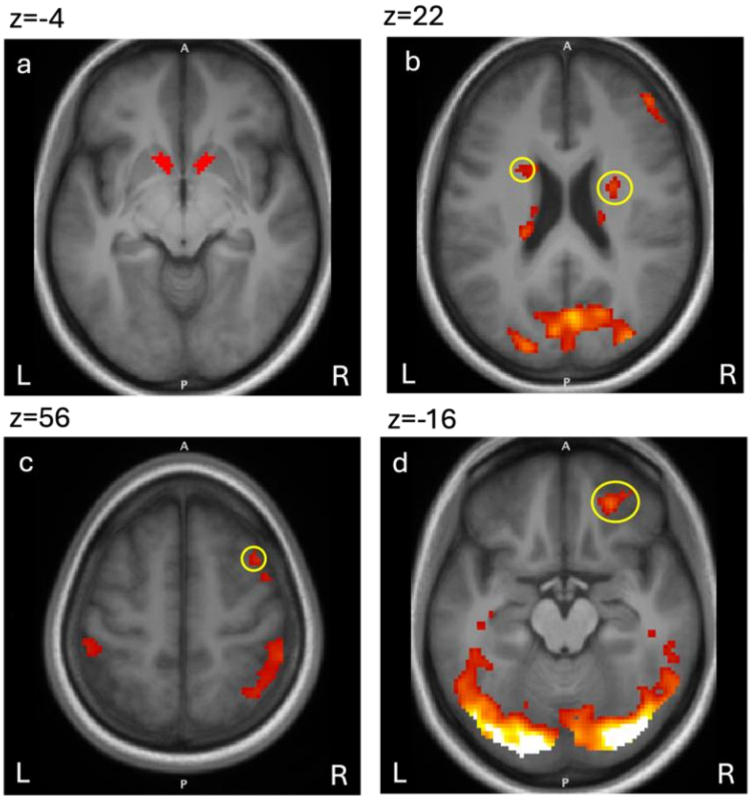

Figure 3.5. Activations for reward trials relative to rest. a) Significant activation within the NAc bilaterally. b) bilateral caudate nucleus c) right middle frontal gyrus d) right medial orbital gyrus.

Table 3.3. Activation for reward trials relative to rest.

Region	X	Y	Z	Z-score	*k*
Frontal lobe					
L. inferior frontal gyrus	-46	44	6	5.37	34
R. inferior frontal sulcus	44	42	24	5.74	260
R. middle frontal gyrus	40	12	56	5.63	27
R. middle frontal gyrus	44	22	38	5.01	72
L. postcentral gyrus	-44	-38	60	5.53	72
R. inferior frontal gyrus	52	18	38	5.46	36
R. superior precentral sulcus	42	2	58	5.33	21
R. medial orbital gyrus	24	42	-16	6.03	87
Occipital lobe					
L. middle occipital gyrus	-20	-94	-4	Inf	13045
L. fusiform gyrus	-40	-12	-20	5.39	19
Parietal lobe					
R. supramarginal gyrus	52	-38	54	6.23	1032
Temporal lobe					
L. middle temporal gyrus	-54	-38	0	5.61	183
R. middle temporal gyrus	56	-36	-2	5.27	96
Subcortical					
R. nucleus accumbens	10	14	-4	4.41	25
L. nucleus accumbens	-10	14	-4	4.02	18
R. caudate nucleus	24	-2	22	5.51	46
L. caudate nucleus	-26	6	20	5.12	63
L. tail of caudate nucleus	-16	-14	20	4.91	12
R. tail of caudate nucleus	16	26	2	5.01	28
L. hippocampus	-22	-28	20	6.58	64
R. tail of hippocampus	24	-30	-4	5.90	108

This analysis looked at the effects of reward>rest, to establish common areas involved in reward processing (family-wise error (FWE)correction, threshold p=0.05). This analysis used an extent threshold of 10 voxels.

Emotion

To identify brain regions associated with emotional arousal-related activity, I compared activation for the IAPS images relative to rest. The results demonstrate widespread cortical activity shown in Figure 3.6 and Table 3.4. The SVC revealed significant activation in the amygdala bilaterally. The analysis revealed that the right amygdala exhibited a strong activation peak (18, -8, -22; Z=5.49), accompanied by a notable cluster in the left amygdala (-18, -10, -20; Z=4.36). These findings align with the amygdala's well-established role in processing emotional salience, particularly for arousing stimuli (Janak & Tye, 2015; LeDoux, 2003; Phelps & LeDoux, 2005). There was extensive activity in the occipital lobes spreading from the calcarine sulcus both ventrally towards the left middle occipital gyrus and dorsally towards the posterior end of the right intra-parietal sulcus. These regions are associated with early sensory processing, visual attention, and higher-order visual analysis (Corbetta & Shulman, 2002; P. J. Lang et al., 1998; Vuilleumier, 2005). Activation was also seen in the left frontal eye fields (FEF), consistent with increased sustained visual attention evoked by emotionally arousing pictures (Sabatinelli et al., 2014). This indicates that the amygdala not only helps in the initial identification of emotional stimuli but also primes the visual cortex for enhanced processing of these stimuli.

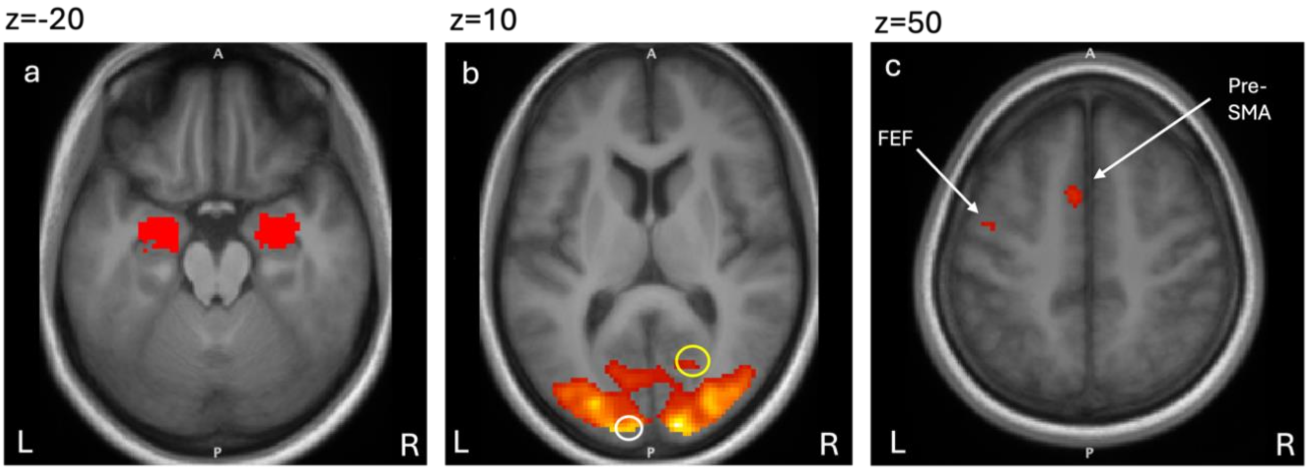

Figure 3.6. Activations for trials showing emotional images relative to rest. a) overlap of the anatomical mask of the amygdala with the functional localiser's activation ($p<0.001$). b) right and left calcarine fissure c) left FEF and left pre-SMA ($p<0.05$ FWE).

Table 3.4. Activation for emotional images relative to rest.

Region	X	Y	Z	Z-score	*k*
Occipital lobe					
R. calcarine fissure	18	-66	10	5.30	22
L. calcarine fissure	-8	-96	2	Inf	14193
R. posterior IPS	24	-56	54	4.90	2
Frontal lobes					
L. pre-SMA	-6	8	50	5.51	64
R. precentral gyrus	46	8	30	4.93	24
L. FEF	-42	-6	46	5.58	34
Temporal lobes					
R. amygdala	18	-8	-22	5.49	75
L. amygdala	-18	-10	-20	4.36	28

This analysis looked at the effects of task>rest, to establish common areas involved in the processing of emotional arousal ($p<0.05$, after correcting for FWE).
Abbreviations: SMA=supplementary motor area; IPS=intraparietal sulcus.

Memory Encoding & Retrieval

I was specifically interested in which items they remembered of the images they saw in the scanner because that demonstrates that these items were successfully encoded into memory at the time. The behavioural data demonstrated that participant accuracy ranged from 37 to 58 correct (out of 60) or 61.7% to 96.7%. I used signal detection theory to analyse the memory data to avoid response bias. I calculated the d' score as a measure of sensitivity:

d' = Z(hits / [hits + misses]) – Z(false alarms / [false alarms + correct rejections])

In some trials the sum of hits and false alarms was 0 so therefore the Snodgrass and Corwin (1988) correction was applied, that is, hit rate = (*n* hits + 0.5)/(*n* old + 1); false alarm rate = (*n* FAs + 0.5)/(*n* new + 1). The final sensitivity (d') scores ranged from 0.795 to 3.542. A high *d′* indicates that an individual accurately distinguished between critical and foil items, reflecting better memory. Therefore, both in terms of overall accuracy and in terms of sensitivity, participants performed well on the memory test.

Correctly recalled trials resulted in widespread cortical and subcortical activity that included key regions of the memory network (Figure 3.7 and Table 3.5). The SVC identified significant activations in the left hippocampus, with distinct peaks in both the anterior head (-36, -8, -32; Z=6.07) and posterior regions (-22, -32, -6; Z=5.30), and the right hippocampus (24, -30, -8, Z=4.33), consistent with its role in encoding and retrieving new information (Eichenbaum et al., 2007b; Spaniol et al., 2009). In addition, there was activation in the left parahippocampal gyrus, a region associated with successful memory formation (Eichenbaum et al., 2007a; Shrager & Squire, 2009; Stern et al., 1996; Wais et al., 2010). In the prefrontal cortex, strong activation was shown in bilateral precental gyri, left inferior frontal gyrus, and the pre-supplementary motor are (pre-SMA). These activations (FWE-corrected, p=0.05) represent a network of regions that predicted subsequent memory for the presented stimuli.

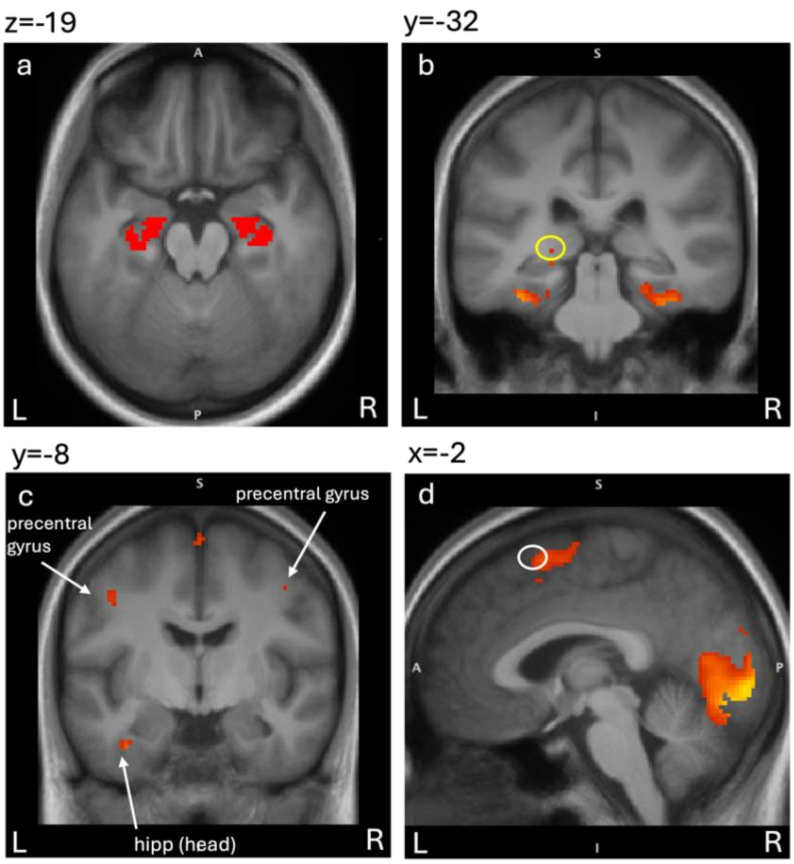

Figure 3.7. Activations for trials with successfully encoded stimuli relative to rest. a) overlap of the anatomical mask of the hippocampus with the functional localiser's activation ($p<0.001$). b) left parahippocampal gyrus c) left and right precentral gyrus; left head of hippocampus d) pre-SMA ($p<0.05$ FWE).

Table 3.5. Activation for successfully encoded trials relative to rest.

Region	**X**	**Y**	**Z**	**Z-score**	***k***
Frontal lobe					
R. precentral gyrus	44	-4	46	5.91	33
L. precentral gyrus	-44	-4	40	5.95	85
L. pre-SMA	-2	10	60	5.89	250
L. inferior frontal gyrus	-54	28	16	5.82	
Temporal lobe					
L. head of hippocampus	-36	-8	-32	6.07	10
L. hippocampus	-22	-32	-6	5.30	32
R. hippocampus	24	-30	-8	4.33	12
L. parahipocampal gyrus	-22	-32	0	4.99	4
Occipital lobe					
R. fusiform gyrus	22	-78	-12	inf	14853
L. cuneus	-2	-88	26	4.93	3
Orbital lobe					
L. posterior orbital gyrus	-40	26	-16	5.17	9
Cerebellum					
R. Vermis V	8	-68	-24	5.20	3
L. Vermis V	-8	-68	-24	4.92	5

This analysis looked at the effects of hits>rest, to establish common areas involved in memory encoding (family-wise error (FWE)correction, threshold p=0.05).
Abbreviations: SMA= supplementary motor area

Visual Attention

In the visual search task used to functionally identify regions related to sustained attention, the behavioural results confirmed that participants responded significantly more slowly to difficult trials (μ=675 msec) than to easy trials (μ=521 msec; $t(23)=-6.63$, $p<0.001$). In addition, imaging results demonstrate that difficult trials generated signification activation in both the FEF and IPS, bilaterally, regions critical for spatial attention and visual search (Bedini & Baldauf, 2021; Donner et al., 2002; Esterman et al., 2015; Kincade et al., 2005; Leonards et al., 2000; Muggleton et al., 2003). The activation extended to bilateral anterior cingulate cortex and bilateral anterior insula, possibly reflecting increased cognitive control and attentional demands during difficult trials (Ischebeck et al., 2024; van Veen et al., 2001; Wu et al., 2017). Bilateral activations in the precentral gyrus and right middle frontal gyrus further support the engagement of oculomotor and attentional control processes during the task (Corbetta et al., 1998; Pierrot-Deseilligny et al., 2004). The right superior occipital gyrus also showed significant activation.

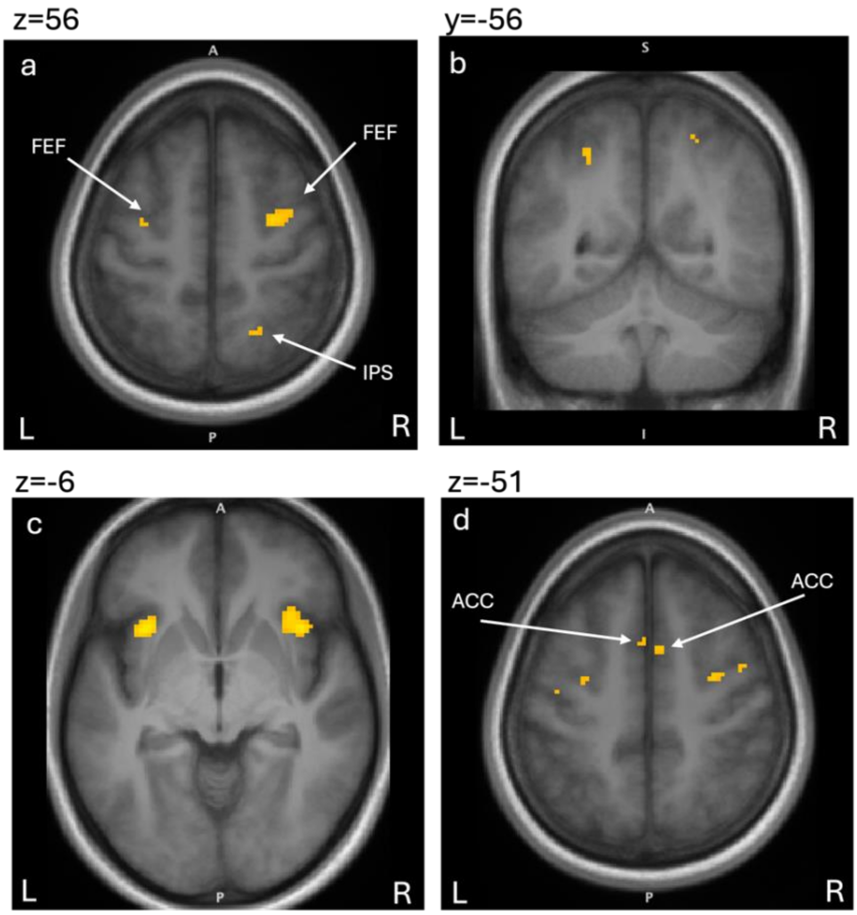

Figure 3.8. Activations for difficult relative to easy visual search trials, inclusively masked with the difficult relative to rest contrast at p<0.001. a) right and left frontal eye fields; right intraparietal sulcus b) right and left intraparietal sulci c) right and left anterior insula d) right and left anterior cingulate (p<0.05 FWE).

Table 3.6. Activation for difficult > easy visual search trials inclusively masked this with the difficult > rest contrast.

Region	X	Y	Z	Z-score	*k*
Frontal lobe					
R. FEF	28	-6	56	5.43	79
L. FEF	-32	-8	54	5.00	12
R. anterior cingulate	6	8	52	5.08	10
L. anterior cingulate	-2	12	50	5.24	18
R. anterior insula	38	18	-6	5.76	127
L. anterior insula	-36	16	-4	5.90	95
R. precentral gyrus	44	8	32	5.38	99
L. precentral gyrus	-40	-12	48	5.23	9
R. middle frontal gyrus	42	0	52	5.00	5
L. superior frontal gyrus	-12	-2	74	4.84	4
Parietal lobe					
R. IPS	20	-58	56	5.03	12
L. IPS	-26	-56	48	5.12	22
Occipital lobe					
R. superior occipital gyrus	30	-70	32	5.46	25

This analysis looked at the effects of difficult>easy trials inclusively masked this with the difficult > rest trials (at p>0.001), to establish common areas involved in sustained visual attention (family-wise error (FWE)correction, threshold p=0.05).
Abbreviations: IPS=intraparietal sulcus; FEF=frontal eye fields.

Overall, the functional localiser scans successfully identified key brain regions associated with the cognitive processes of interest. Specifically, regions of the nucleus accumbens (NAc) linked to reward processing, the amygdala associated with emotional processing, and the hippocampus involved in memory encoding and retrieval were identified. Additionally, bilateral clusters in the frontal eye fields and intraparietal sulcus were localised, reflecting their role in sustained visual attention. These regions were therefore used as the four regions ROIs - reward, emotion, memory, and attention - in the analysis of the main experimental data.

Main Task

The main experiment examined how reward, emotion, memory and attention systems were affected by advertisements. Bar graphs were used to visualise neural activation (observed means) in the regions extracted from the ROI masks when participants watched addressable and nonaddressable ads compared to the TV show in two different contexts. Bars above zero represent increased neural activity during ad viewing relative to the TV show, while bars below zero indicate decreased neural activity. Error bars represent the standard error of the mean (SEM), reflecting variability across participants and providing an estimate of the precision of the mean for each condition

Reward

Brain activity within the reward-processing ROI (NAc) was extracted for addressable and non-addressable ads relative to watching the TV show. The results demonstrate in an increase in reward-related activity when watching ads during TV shows that the participant chose for themselves (M = 0.04) relative to those during shows chosen for them (M = -0.10). A 2 (Addressable vs. Nonaddressable) x 2 (Choice vs. No Choice) repeated measures ANOVA confirmed a main effect of Choice ($F(1, 23) = 5.23$, $p = 0.032$; see Figure 3.9). When participants chose their own TV show, advertisements evoked similar reward-related activity as the TV show itself. On the other hand, when the show was chosen for them, there was a clear reduction in reward-related activity. The main effect of Addressability was not significant, $F(1, 23) = 0.06$, $p = 0.81$, indicating no substantial difference in NAc activity in subjects when watching ads that were relevant to them (M = -0.03) and irrelevant ads (M = -0.03) when collapsing across choice conditions. Furthermore, the Addressability x Choice interaction was non-significant, $F(1, 23) = 1.28$, $p = 0.27$, suggesting that the choice context did not meaningfully modulate the addressability effect.

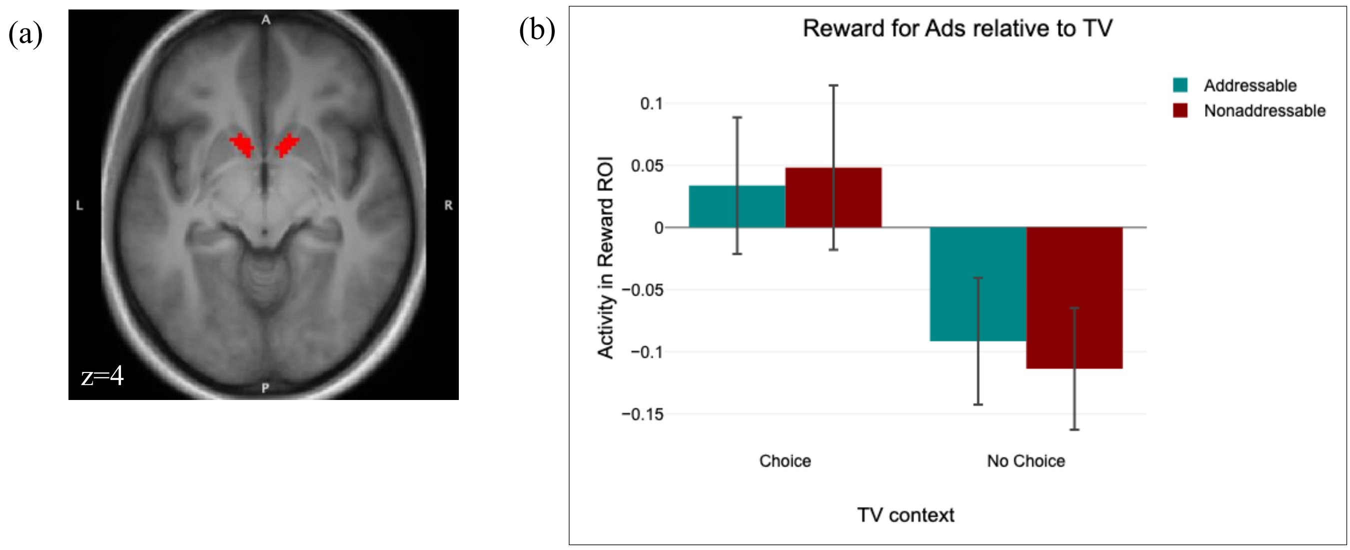

Figure 3.9. a) Bilateral NAc ROI mask shown on an axial slice. **b)** Bar plot showing mean neural activation (effect sizes) within the reward ROI when participants viewed addressable and nonaddressable ads compared to the TV show, across choice and no-choice contexts. Bars above zero indicate increased activation relative to the TV show, while bars below zero indicate decreased activation. Error bars represent the standard error of the mean (SEM) for each condition.

Emotion

Brain activity within the emotion-processing ROI, specifically the amygdala, was extracted for addressable and non-addressable ads relative to watching the TV show. The results indicate a decrease in emotion-related activity when watching ads compared to watching the TV show in both context conditions. A 2x2 repeated-measures ANOVA revealed no significant main effect of Choice, $F(1, 23) = 0.297$, $p = 0.591$ (see Figure 3.10). That is, participants showed no significant difference in amygdala activity when watching ads during TV shows they chose themselves ($M = -0.03$) compared to those during shows that were chosen for them ($M = -0.06$). Similarly, there was no significant main effect of Addressability, $F(1, 23) = 0.067$, $p = 0.799$, indicating no substantial difference in amygdala activity when watching personally relevant ads ($M = 0.00$) versus irrelevant ads ($M = -0.05$), when collapsing across choice conditions. The results suggest that the ads were less emotionally engaging than the TV shows, which could be driven by the stronger narrative building of TV shows. Finally, the Addressability × Choice interaction approached significance, $F(1, 23) = 4.093$, $p = 0.055$, suggesting a moderate effect size. This result indicates a potential trend where the impact of Addressability on emotion-related activity may depend on the presence of Choice. However, since the p-value did not meet the conventional significance threshold ($p < .05$), this effect should be interpreted with caution.

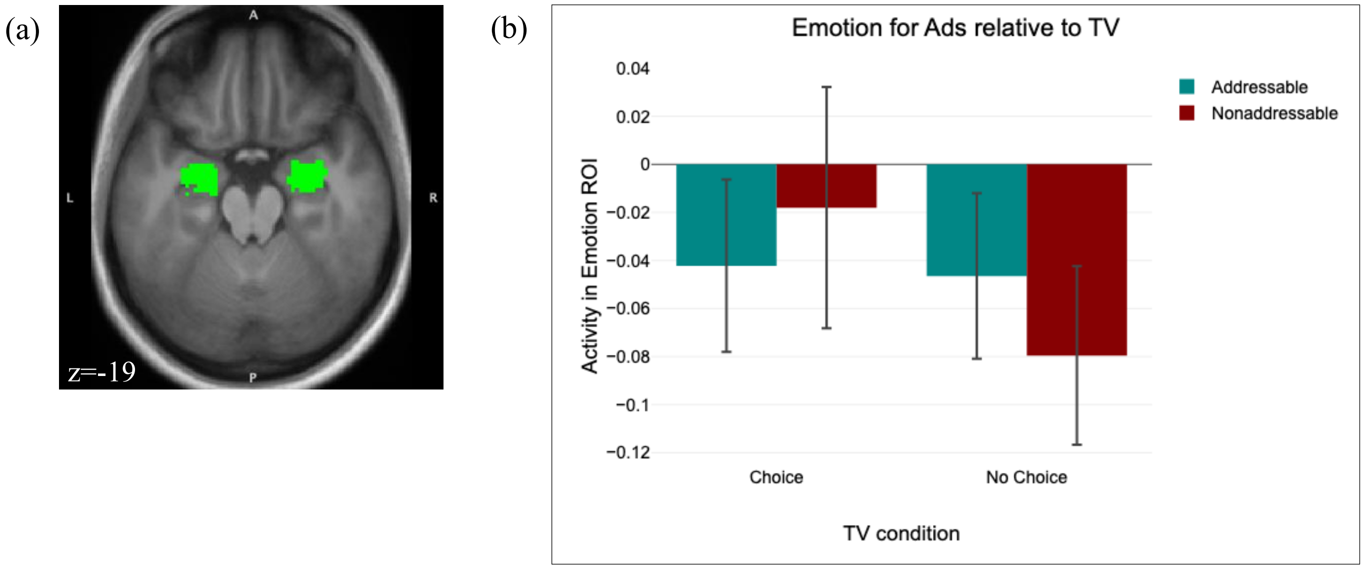

Figure 3.10. (a) Bilateral amygdala ROI mask shown on an axial slice. (b) Bar plot showing mean neural activation (effect sizes) within the emotion ROI when participants viewed addressable and nonaddressable ads compared to the TV show, across choice and no-choice contexts.

Memory

Brain activity within the memory-related ROI (hippocampus) was extracted for addressable and non-addressable ads relative to watching the TV show. A 2x2 repeated measures ANOVA revealed a significant Addressability × Choice interaction, $F(1, 23) = 4.706$, $p = 0.041$; see Figure 3.11, suggesting that the effect of addressability on memory-related activity depends on whether the participant had a choice over the TV show they watched. Memory-related activity when participants watched ads during TV shows they chose for themselves ($M = 0.02$) compared to shows chosen for them ($M = -0.04$), did not show significant difference ($F(1, 23) = 1.263$, $p = 0.273$). Additionally, the main effect of Addressability was not significant, $F(1, 23) = 0.138$, $p = 0.713$, indicating no substantial difference in memory-related activity when watching personally relevant ads (M=−0.01) versus non-relevant ads (M=−0.01).

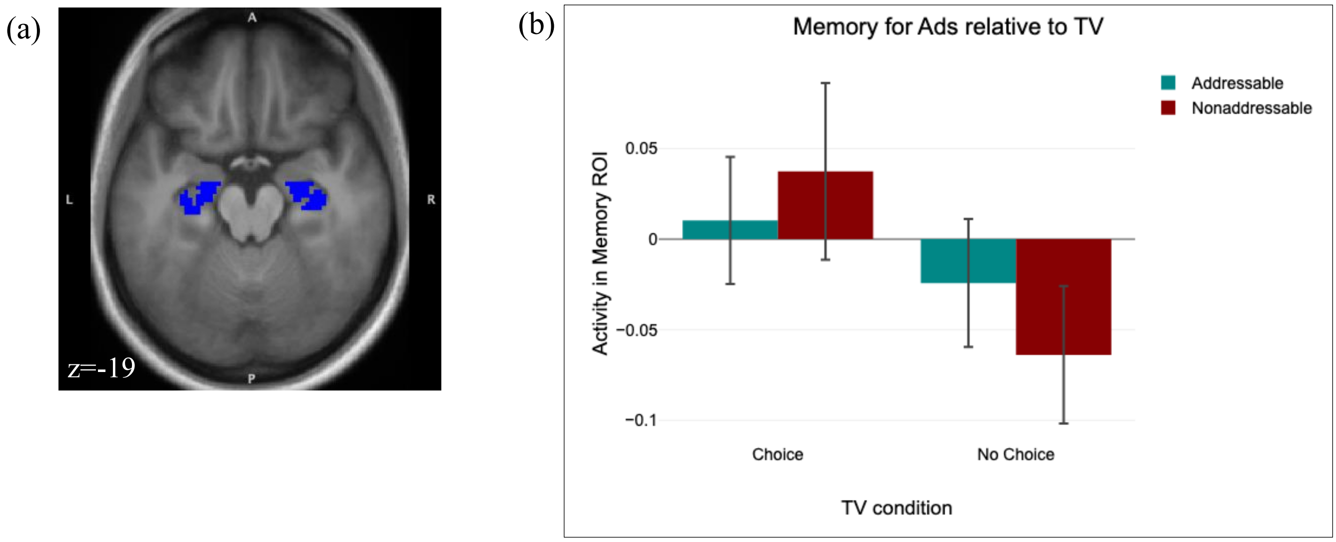

Figure 3.11. (a) Memory ROI mask shown on an axial slice. (b) Bar plot showing mean neural activation (effect sizes) within the memory ROI when participants viewed addressable and nonaddressable ads compared to the TV show, across choice and no-choice contexts.

Attention

Brain activity within the attention-processing region of interest, specifically the FEF and IPS, was extracted for addressable and non-addressable ads relative to watching the TV show. The results indicate an increase in attention-related activity when watching ads compared to watching the TV show, and decreased activity when ads are embedded in a TV show not selected by the participant. A 2x2 repeated-measures ANOVA revealed no significant main effect of Addressability, $F(1, 23) = 0.756$, $p = 0.394$ (see Figure 3.12), indicating no substantial difference in activity in the FEF and IPS when watching personally relevant ads (M = 0.04) versus irrelevant ads (M = 0.07), when collapsing across choice conditions. Similarly, no significant main effect of Choice, $F(1, 23) = 2.08$, $p = 0.163$. That is, participants showed no significant difference in the attention network activity when watching ads during TV shows they chose themselves (M = 0.13) compared to those during shows that were chosen for them (M = −0.02). Lastly, the Addressability × Choice interaction showed no meaningful effect, $F(1, 23) = 0.065$, $p = 0.801$, suggesting that the choice context did not meaningfully modulate the addressability effect.

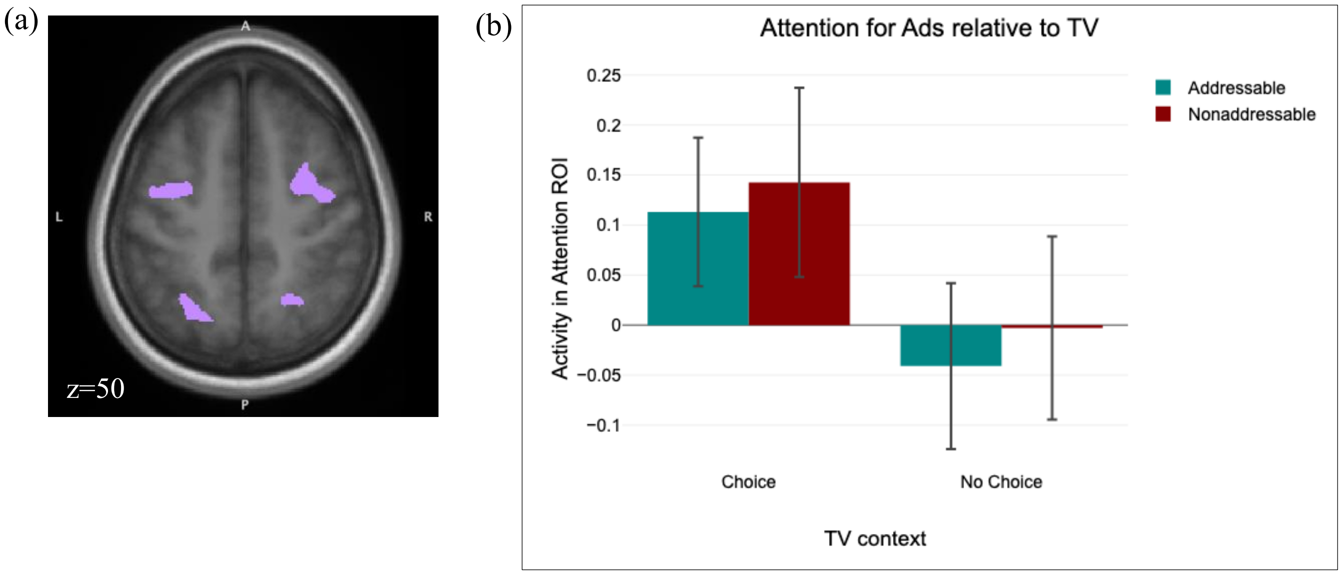

Figure 3.12. (a) Visual attention ROI mask shown on an axial slice. (b) Bar plot showing mean neural activation (effect sizes) within the attention ROI when participants viewed addressable and nonaddressable ads compared to the TV show, across choice and no-choice contexts.

Exploratory ROIs: Self-Related Processing

In addition to the four functionally defined ROIs (reward, emotion, memory, and attention), I conducted a post-hoc exploratory analysis in regions previously implicated in self-related processing. The rationale for this analysis was that personal relevance may be mediated not only by reward, memory, attention, and emotion systems, but also by neural mechanisms associated with self-referential thought. Neuroimaging research has consistently shown that personally meaningful information engages the medial prefrontal cortex (mPFC) and temporoparietal junction (TPJ), regions implicated in self-related thought and perspective-taking (Northoff et al., 2006; Schmitz & Johnson, 2007). The mPFC has been linked to the integration of self-related information, including the self-reference effect in memory (Kelley et al., 2002; Kim & Johnson, 2012), and may play a critical role in representing personally salient cues such as one's own personal information (Northoff & Panksepp, 2008). Furthermore, the TPJ is often recruited when adopting another's perspective or reasoning about social relevance (Saxe & Kanwisher, 2003; Schurz et al., 2014). If addressable advertisements enhance engagement by aligning with self-schema or perceived identity, these regions might also be expected to differentiate addressable from non-addressable content. Although not part of the original design, I therefore conducted exploratory analyses targeting the mPFC and TPJ to test this possibility.

For the mPFC ROI, I created a 10-mm radius spherical mask centred on the MNI coordinates [2, 52, –4], based on peak activation reported in Kim and Johnson (2012). A 2×2 repeated-measures ANOVA (Addressability × Choice) on effect sizes revealed no significant main effect of Addressability, $F(1,23) < 0.01$, $p = 0.983$ (see Figure 3.13), with addressable (M=0.00) and non-addressable ads (M=0.00) showing virtually identical responses indicating no substantial difference in activity in the mPFC when watching personally relevant ads. There was, however, a significant main effect of Choice, $F(1,23) = 4.82$, $p = 0.038$, suggesting greater activation when participants viewed advertisements in self-chosen (M=0.19) rather than imposed (M=-0.19) context. No interaction was observed, $F(1,23) = 0.90$, $p = 0.353$.

(a) (b)

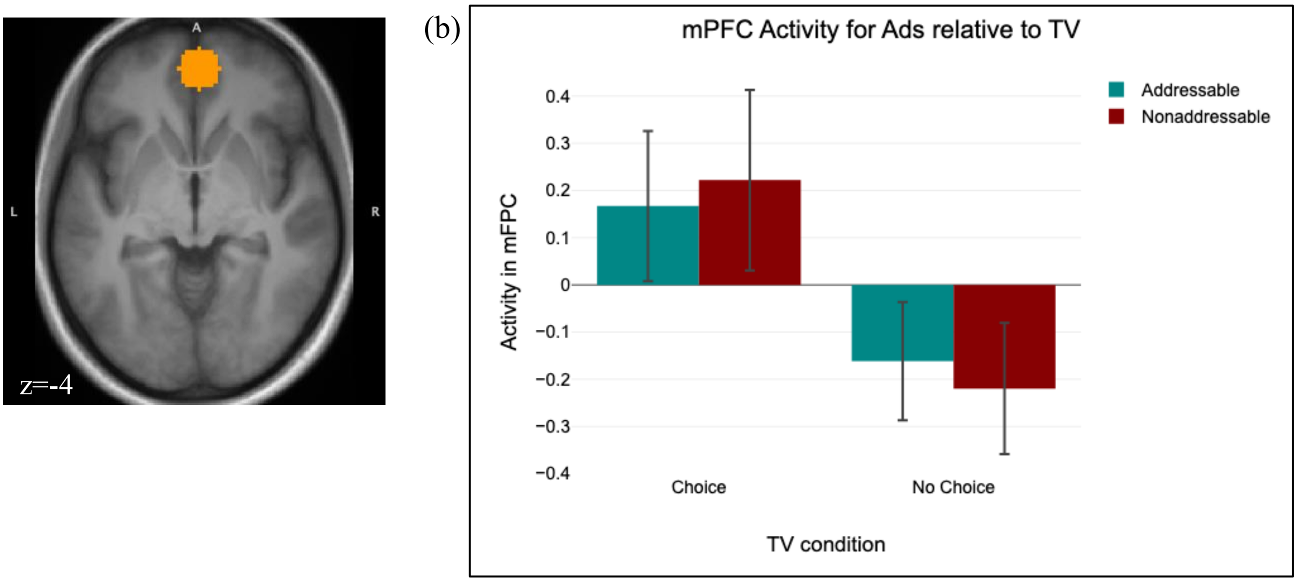

Figure 3.13. (a) mPFC ROI mask shown on an axial slice. (b) Bar plot showing mean neural activation (effect sizes) within the mPFC ROI when participants viewed addressable and nonaddressable ads compared to the TV show, across choice and no-choice contexts.

For the TPJ ROI, 10-mm spherical masks were centred on [51, –54, 27] (right) and [–54, –60, 21] (left), as reported by Saxe & Kanwisher (2003). These coordinates reflect peak activations in response to false belief reasoning tasks and are widely used in social cognition research. A 2×2 ANOVA revealed no significant main effects of Addressability, $F(1,23) = 0.47$, $p = 0.50$, with addressable ads (M=-0.55) and non-addressable ads (M=-0.51) producing similar responses. The main effect of Choice was also non-significant, $F(1,23) = 0.05$, $p = 0.832$, with choice (M=-0.55) and no-choice (M=-0.51) conditions showing no meaningful difference. The interaction was likewise non-significant, $F(1,23) = 0.12$, $p = 0.730$ (see Figure 3.14). This indicates that TPJ activity did not differ according to whether advertisements were relevant or irrelevant to the participant, nor whether they were viewed in a choice or no-choice TV context, suggesting that self-related perspective-taking processes were not strongly engaged by addressability in this study.

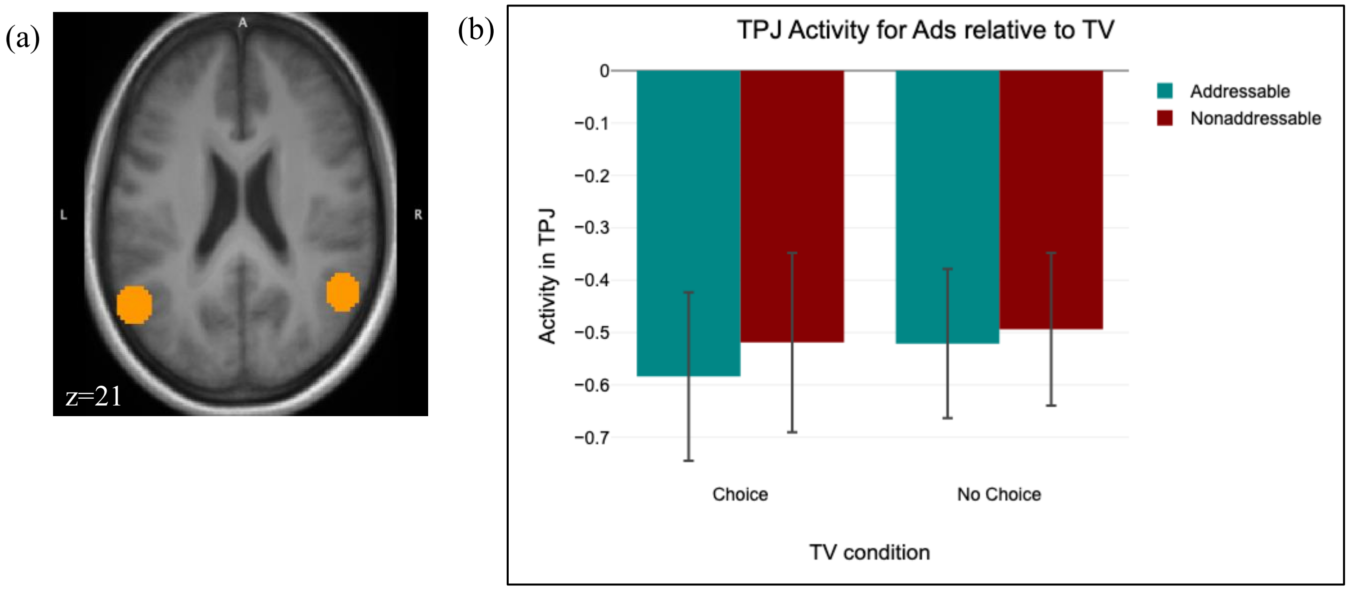

Figure 3.14. (a) Bilateral PTJ ROI mask shown on an axial slice. (b) Bar plot showing mean neural activation (effect sizes) within the TPJ ROI when participants viewed addressable and nonaddressable ads compared to the TV show, across choice and no-choice contexts.

Overall, these exploratory analyses provide limited evidence for a role of self-related neural mechanisms in addressable advertising. While no effects of Addressability were observed in either ROI, the mPFC showed increased activation when participants had control over their viewing context, consistent with prior findings linking autonomy and self-referential processing.

Whole-Brain Analysis

In order not to miss any regions outside of the hypothesised systems, an exploratory whole-brain random-effects analysis was also conducted contrasting addressable versus non-addressable advertisements. No clusters survived correction for multiple comparisons ($p < .05$, FWE-corrected across the whole brain). For completeness, results were also inspected at a more liberal threshold of $p < .001$ uncorrected, but no suprathreshold clusters were observed.

Post-Scan Behavioural Results

As a manipulation check, participants rated their interest in the previously viewed advertisements on a scale ranging from 0-100. This revealed a clear distinction between addressable and non-addressable advertisements. A paired-samples t-test confirmed that participants exhibited significantly higher interest in addressable advertisements ($M = 53$, $SD = 24$) compared to non-addressable advertisements ($M = 35$, $SD = 18$), $t(23) = 4.51$, $p < .001$). This difference validates the successful operationalisation of the addressability variable in the design, demonstrating that addressable advertisements were indeed more personally relevant, and were of greater interest, to participants.

Next, they completed a post-scan memory task about the advertisement they saw during the TV show. A d-prime (d′) score close to 0 indicates poor discrimination, meaning participants performed at chance level and struggled to distinguish between previously seen and unseen advertising stimuli. As d′ increases, sensitivity improves, with values around 1 indicating moderate discrimination and values approaching 3 reflecting high recognition accuracy and strong memory performance. The participants' d'-prime scores for correctly identified items were higher for addressable advertisements ($M = 0.96$, $SD = 0.46$) compared to non-addressable advertisements ($M = 0.81$, $SD = 0.47$), although the difference was not statistically significant, $t(46) = 1.13$, $p = 0.265$. In other words, there was no behavioural evidence that addressability impacted memory recall in this memory task.

The violin plots in Figure 3.15 illustrate this pattern, showing the complete distribution of accuracy (d') scores across conditions, with width representing the density of observations at each accuracy score. The embedded boxplots indicate the median and quartile ranges, while the white dot within each plot represents the mean for the corresponding condition. The wider bulge in the addressable condition centred at a slightly higher d' score visually demonstrates both the higher average d' and the consistency of this pattern across participants

In addition to explicit recall for the ads, I recorded response times of correct identifications as an implicit measure of memory recall. Prior to analysis, reaction time data were screened for outliers using a 3 standard deviations (SD) criterion applied within each participant's responses. Outliers were defined as trials where reaction times (RT) deviated by more than 3 SDs from the participant's mean. This resulted in the removal of 194 trials (6.45% of the total trials). An independent samples t-test was conducted to examine the effect of addressability on RT. The mean reaction time for addressable ads ($M = 1958$ ms, $SD = 244$) was slightly faster than for non-addressable ads ($M = 2006$ ms, $SD = 264$). However, this difference was not statistically significant, $t(46) = -0.4$, $p = 0.706$. These results provide no evidence that addressability influenced the speed at which participants recalled information about the ads they saw.

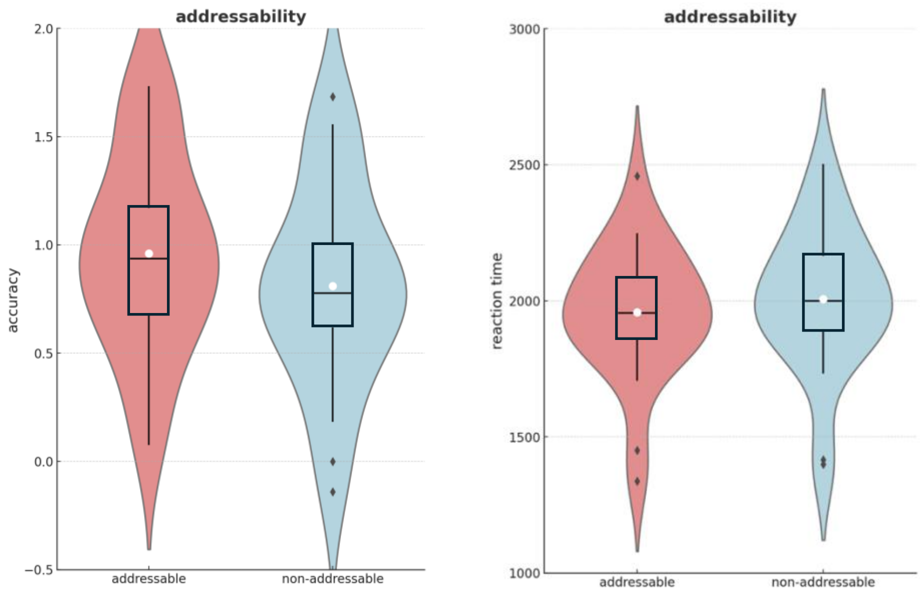

Figure 3.15. a) Participant accuracy scores on the post-experiment memory test, separated by addressability conditions. Accuracy scores were calculated using participants' d-prime values, reflecting their ability to correctly recognise stills and logos from the ads they viewed and reject those they did not. No significant difference in accuracy on the recognition task was observed between addressable and non-addressable conditions. **b)** Participant reaction times for correctly identified items during the post-experiment memory test, measured in milliseconds, separated by addressability conditions. Reaction times represent the interval from the starting point to the response, as measured by mouse cursor movement. Participants were significantly faster to recognise ads that were relevant to them compared to those that were not.

Finally, participants were asked to rate how much they liked each of the 16 advertisements they saw. Overall, participants liked ads that were relevant to them ($M = 1.4$, $SD = 3.0$) more than ads that were not personally relevant ($M=0.0$, $SD = 2.9$; $t(23) = 2.93$, $p < .01$). The violin plots in Figure 3.16 illustrate this pattern. The distribution of the addressable condition is notably shifted toward the positive end of the scale, while the non-addressable condition centres near the neutral point, visually demonstrating the more favourable evaluation of addressable advertisements.

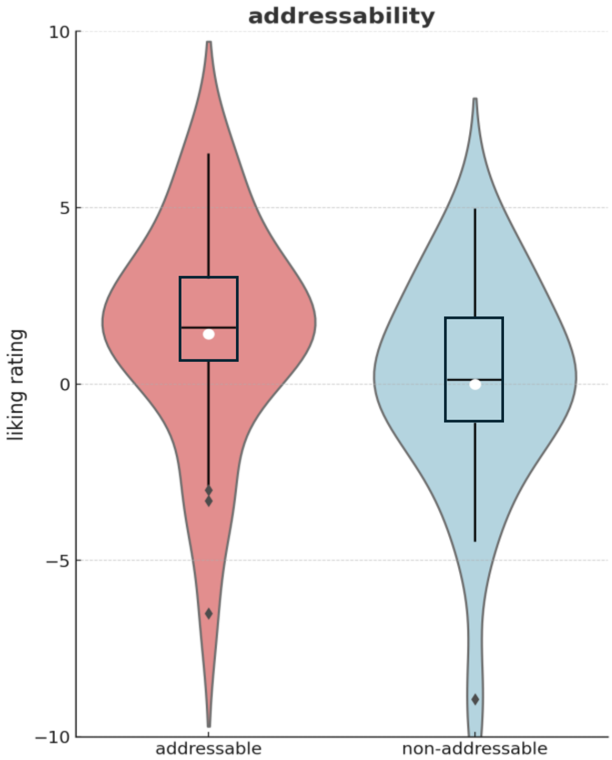

Figure 3.16. Participants self-reported how the advertisement changed their level of interest in the product or service from -10 (less) to +10 (more). Participants' reported liking of their addressable ads was much higher overall, with the plot showing a greater distribution of participants rating the addressable ads in the upper ranges in comparison with non-addressable ads. Note that 0 on this scale would be the average liking score that participant gave to all ads.

3.4. Discussion

This study investigated the neural mechanisms underlying the addressability uplift observed in TV advertisements, building on the behavioural findings from my previous chapter. I examined how personal relevance in advertising influenced four key cognitive systems: reward, emotion, memory, and attention. Using functional localisers to precisely identify regions of interest specific this set of participants, I observed patterns of neural activation that reveal a more complex picture of how addressability and viewing context interact in advertisement processing.

In addition to the ROI analyses, I conducted an exploratory whole-brain random-effects analysis contrasting addressable versus non-addressable advertisements. This revealed no significant clusters of activation after correction for multiple comparisons, and no effects were observed even at a liberal threshold of $p < .001$. This absence of whole-brain effects is not unexpected. Both addressable and non-addressable advertisements were embedded in naturalistic television viewing, which is a baseline condition that already engages overlapping cognitive systems. Given this overlap, only relatively subtle neural differences were anticipated. For this reason, and consistent with best practice in fMRI research (Devlin & Poldrack, 2007; Saxe et al., 2006), an ROI approach based on independent functional localisers was focused on to maximise sensitivity to these hypothesised effects.

My results did not fully support my hypotheses. There was no evidence that addressable advertisements elicited significantly greater neural engagement in any of these domains compared to non-addressable ads. However, a key contextual factor emerged: the choice of TV content, in which the ads were embedded, played a significant role in shaping neural responses to ads, specifically within reward and memory systems. Advertisements shown during self-selected TV shows led to greater reward-related activation relative to ads seen during randomly assigned shows. Similarly, memory-related activity showed a significant interaction, indicating that addressability effects on memory depended on whether participants had control over their viewing content. Even though attention-related activity was generally elevated for ads, this was not influenced by addressability or choice. These findings suggest that the neural mechanisms of addressability may be more context-dependent than previously assumed, with choice playing a role in modulating audience engagement.

Interestingly, addressability did not significantly enhance activation in key neural systems associated with reward, memory, attention, or emotion, despite prior behavioural evidence suggesting an uplift in engagement. There are several possible explanations for this null finding.

One possibility is that the present study lacked sufficient statistical power to detect reliable neural differences due to the relatively small sample size, a common limitation in neuroimaging research (Button et al., 2013; Poldrack et al., 2017). Low power reduces the likelihood of detecting true effects, particularly when variability in individual responses is high. In this study, substantial between-subject variability, as indicated by the large error bars in the data, may have further contributed to increased noise, making it more difficult to observe significant effects. As a result, it is possible that addressability-related neural effects exist but could not be reliably detected due to limited sensitivity and statistical power.

In addition to potential power limitations, it is also possible that the neural mechanisms underpinning addressability may not primarily involve classical regions linked to memory, attention, or emotion. Instead, recent research suggests that personal relevance may be more closely associated with the default mode network (DMN), particularly the medial prefrontal cortex (mPFC), which has been shown to respond spontaneously to stimuli of personal significance, even in the absence of explicit self-referential processing (Abraham, 2013). The DMN is commonly associated with internally oriented mental processes, such as self-referential thinking, autobiographical memory, and theory of mind (Buckner et al., 2008; Rameson & and Lieberman, 2007; Spreng & Grady, 2010). The DMN is commonly associated with internally oriented processes such as self-referential thinking, autobiographical memory, and theory of mind (Northoff et al., 2006; Schmitz & Johnson, 2007). Within this network, the mPFC has been strongly implicated in the integration of self-related information, including the self-reference effect in memory (Kelley et al., 2002; Kim & Johnson, 2012), and in the processing of personally salient cues (Northoff & Panksepp, 2008). Furthermore, neuroimaging studies of tailored health communications have directly shown that personalised messages elicit greater mPFC activation than generic ones, and that this activity predicts downstream behaviour change such as smoking cessation or reduced sedentary behaviour (Chua et al., 2009; Falk et al., 2011; Whelan et al., 2017). This suggests that the mPFC is not only responsive to personalised input, but that its engagement may directly affect for how information influences future attitudes and behaviour. The temporoparietal junction (TPJ), meanwhile, is consistently implicated in perspective-taking and theory of mind (Saxe & Kanwisher, 2003). In principle, TPJ could be engaged if personalised advertising prompts participants to reflect on their own position within a broader social or consumer group, or to consider the intentions behind why a specific ad is directed at them. Together, this literature raises the possibility that addressability effects might be mediated by neural mechanisms related to self-referential and social-cognitive processing, rather than exclusively by the cognitive systems targeted in my functional localisers.

To test this possibility more directly, I conducted exploratory ROI analyses in the mPFC and TPJ. In the mPFC, there was no effect of Addressability, though a significant main effect of Choice was observed, with greater activation when advertisements were embedded in self-selected compared to imposed TV show contexts. No interaction between Addressability and Choice was detected. For the TPJ, neither Addressability nor Choice significantly modulated activation, and no interaction was observed. Taken together, these exploratory analyses provide no evidence that addressability effects were mediated by self-referential or theory-of-mind regions, suggesting that the addressability uplift observed in Chapter 2 is unlikely to reflect recruitment of DMN processes. Evidently, this may indicate that the way addressability was operationalised in the present experiment did not strongly engage self-related or mentalising mechanisms, or alternatively that the statistical power of the current sample was insufficient to detect what are likely to be subtle neural effects.

From a reward processing perspective, my findings indicate that a self-selected TV show, rather than the personal relevance of an ad, is the stronger determinant of reward-related engagement. Participants' choice of TV content significantly modulated NAc activation, suggesting that self-selected media environments create a more rewarding viewing experience that extends to embedded advertisements, regardless of whether they're targeted or not. This is consistent with self-determination theory (Ryan & Deci, 2000), which suggests that autonomy enhances intrinsic motivation and engagement.

Beyond immediate reward responses, self-selection itself may have enhanced the subjective value of chosen content, a phenomenon known as choice-induced preference change (Brehm, 1956; Sharot et al., 2009). Research has shown that once a choice between multiple options is made, the selected option is typically assigned greater subjective value, likely as a means of reinforcing commitment to the decision (Sharot et al., 2009). This effect was first demonstrated by Brehm's (1956) free-choice paradigm, where participants rated household items, made a choice between similarly valued options, and later re-rated them. The previously chosen item was rated higher, while the rejected item was assigned lower value, suggesting that choice can actually shape preference. Neuroimaging evidence suggests that this post-choice re-evaluation is supported by activity in the vmPFC and striatum (caudate nucleus), regions implicated in value-based decision-making and reward (Izuma et al., 2010; Sharot et al., 2009). In this context, the increased NAc activation observed for ads embedded in self-selected TV content may reflect that greater subjective value was assigned to self-selected TV shows, which in turn spilled over to the advertisements.

However, the absence of a main effect of addressability in the NAc contradicts prior findings which have shown that self-relevant stimuli activate reward-related regions, including the NAc and vmPFC (de Greck et al., 2008b). One possibility is that addressability effects on reward processing may be more implicit or delayed, emerging through brand and product preferences down the line.

Similarly, addressability did not significantly enhance amygdala activation, suggesting that personal relevance alone did not elicit heightened emotional arousal. However, this does not mean that the ads were processed purely in an informational manner, instead, it likely suggests that participants exhibited relatively low physiological engagement with the ads compared to the TV show, regardless of addressability. Given that the amygdala is highly sensitive to emotionally intense stimuli, the lower activation for ads may reflect the naturally stronger emotional salience of TV content, given that long-form narratives prompt immersive storytelling (Bettiga & Noci, 2024). This interpretation aligns with earlier research showing that emotionally engaging contexts (e.g., self-selected TV shows) can either amplify or suppress ad-related emotional processing, depending on whether attention is focused and how relevant the ad feels in comparison (J. Wang & Calder, 2006).

One possible explanation is that in the no-choice condition, addressable ads stood out more due to their personal relevance, leading to stronger emotional processing. Conversely, in the choice condition, where participants were already highly engaged with self-selected content, personally relevant ads may have felt less emotionally salient. Instead, non-addressable ads may have been perceived as novel or unexpected, eliciting greater amygdala activation. This aligns with (Broach Jr. et al., 1995), who found that TV programme arousal shapes ad perception through either assimilation or contrast effects. High-arousal TV content can increase ad engagement when emotional intensity is matched, whereas mismatched or lower-arousal contexts can decrease ad-related emotional responses. In the choice condition, stronger engagement with self-selected content may have reduced the impact of addressable ads because the content already satisfied the viewer's needs or interests, while in the no-choice condition, lower engagement with the TV show may have made addressable ads stand out more. This fit within affective transfer theory in media (Goldberg & Gorn, 1987) and selective attention research (J. Wang & Calder, 2006), which suggest that the emotional response and engagement with ads depends on broader context in which they are embedded and attentional states rather than their addressability alone.

Interestingly, hippocampal activation results suggest that ad memory processing depended on both choice and addressability in unexpected ways. Neither TV-choice nor addressability had a significant main effect on hippocampal activation, but their interaction was significant. Specifically, in the choice condition, ads that weren't relevant to the participant elicited greater hippocampal activation than ads that held relevance, whereas in the no-choice condition, relevant ads showed relatively higher activation than irrelevant ones. Prior research suggests that memory encoding is influenced by both stimulus distinctiveness and attentional focus (Chun & Turk-Browne, 2007; Kafkas & Montaldi, 2018; Uncapher & Rugg, 2009). This may explain why ads in the choice condition - particularly the non-addressable ones - elicited stronger hippocampal activation, as they stood out against self-selected, engaging content and distracted the participant from their viewing experience. Conversely, in the no-choice condition, where participants were assigned a TV show rather than selecting one based on personal preference, relevant ads may have stood out more due to their resonance with personal interests, leading to stronger memory-related processing. Given the limited literature on how personalisation and autonomy interact to shape ad memory at a neural level, these results warrant further replication to determine the robustness of this effect.

Lastly, I observed greater activation in frontoparietal attention networks (FEF, IPS) for ads compared to TV content in the choice condition, but not in the no-choice condition. However, neither addressability, choice nor their interaction had a significant main effect on attention. Instead, both ad types elicited stronger attentional engagement in the choice condition, while in the no-choice condition, attentional responses to ads were reduced relative to TV content.

One possible explanation is that frequent shifts between TV content and advertisements helped sustain attention, particularly in the choice condition. Research suggests that task switching can enhance cognitive engagement by preventing attentional fatigue and activating the brain's orienting system (Monsell, 2003; Waskom et al., 2014). Specifically, switching between content types may have triggered an orienting response that kept attentional networks engaged, while also enhancing focus (Dreisbach & Wenke, 2011). This may explain why ads in the choice condition elicited greater attentional activation. Participants may have been more engaged overall, and the transitions between TV content and ads helped sustain focus. In contrast, in the no-choice condition, where TV engagement may have been lower, switching may have been less effective at maintaining attentional engagement, leading to weaker ad-related activation.

This contrasts with my initial expectation that addressable ads would elicit stronger attentional engagement in dorsal attention regions (FEF, IPS), given evidence that personal relevance enhances selective attention in advertising (Bang & Wojdynski, 2016; Jung, 2017). A possible explanation is that addressability effects rely less on the dorsal, goal-directed attention network and more on the ventral network, which supports bottom-up capture by motivationally salient stimuli. In this account, personally relevant ads may draw attention automatically rather than through effortful, top-down allocation, with higher-order valuation regions such as the orbitofrontal cortex and anterior cingulate cortex further modulating their perceived significance (Rolls, 2023).

Limitations

As mentioned, future research may benefit from employing a larger sample size to increase statistical power or adopting a more individualised design that accounts for participant-specific differences in attentional and neural responses. Such approaches could enhance sensitivity to detect subtle effects of addressability and choice on the present cognitive systems. Given the small sample size in this fMRI study, it remains unclear whether the observed neural effects translate into consistent behavioural outcomes. To address this, the next chapter will conduct a larger behavioural study to replicate the positive effects of addressability observed in Chapter 2 and further explore the role of choice in shaping ad engagement and memory. By employing a larger sample, the study will provide a more comprehensive understanding of how personal relevance and viewing autonomy interact to influence audience responses to advertising.

A further limitation concerns the use of functional localisers and the reliance on "rest" as a baseline condition within them. Functional localisers are widely regarded as good practice because they allow ROIs to be defined in an independent way, increasing sensitivity to hypothesised effects (Saxe et al., 2006; Fedorenko et al., 2010). However, this approach comes with several limitations. The functional localisers in this study were successful in identifying the expected regions of interest, indicating that the tasks engaged the intended neural systems. However, because the localisers were necessarily brief due to scanning time constraints, the resulting activation maps were not always reliable at the individual level. For this reason, ROIs were defined using group-level maps rather than participant-specific activations. While this ensured that canonical regions were captured consistently across participants, it reduced sensitivity to individual variability and may have limited the detection of more subtle effects of addressability.

In addition, the use of "rest" as a baseline contrast introduces interpretive challenges. Although often treated as a neutral baseline, "rest" is associated with regular neural activity, particularly within the DMN (Buckner et al., 2008; Raichle, 2015). Contrasts against "rest" therefore risk conflating real task-related activations with more generic task-rest differences, which reduces the functional specificity of the resulting ROIs. A more robust approach could instead use control conditions matched for perceptual and attentional demands, which allow the cognitive process of interest to be isolated more accurately. In the present study, the choice of "rest" as a baseline was a practical but imperfect solution, reflecting the need to accommodate multiple localisers within a limited scanning session. While this limits the interpretability of the localiser results, "rest" nevertheless provided a straightforward and robust contrast that allowed ROIs to be identified consistently across participants.

Lastly, the screen size used for stimulus presentation in the MRI scanner may have been a limiting factor of the study design. In Chapter 2, larger screens were associated with greater overall engagement, although there was no interaction between screen size and addressability. On this basis, I expected addressability effects to emerge in the scanner regardless of the restricted display. Indeed, advertisements elicited significant activation in the hypothesised ROIs relative to the TV show baseline, confirming that the task engaged the relevant neural systems. Nevertheless, the relatively small visual field due to the mirror-screen setup likely reduced immersion compared to naturalistic viewing conditions. This may have weakened the strength of engagement, making differences between addressable and non-addressable ads more subtle and harder to detect. Whilst this limitation is inherent to most fMRI studies, it should be considered when interpreting the present findings.

To summarise, this Chapter's findings contribute to both theory and practice. Theoretically, they enhance the understanding of how personal relevance shapes neural processing, integrating consumer psychology with cognitive neuroscience. By examining multiple cognitive systems within a unified framework, this study extends theories of advertising engagement beyond traditional behavioural measures. Practically, these insights inform advertising strategies by revealing the neural mechanisms underlying the addressability uplift. By bridging behavioural and neural evidence, this study attempted to clarify how personal relevance shapes consumer responses at a fundamental level.

4. Effects of Addressability and Content Choice on Emotional and Cognitive Engagement with TV Advertising

4.1. Introduction

The purpose of this study was to further investigate the effects of addressability and viewing context on TV ad processing, with a primary focus on ad recall. Building on the findings of the previous chapters, this experiment aimed to test whether the addressability uplift for relevant TV advertising would replicate in a larger sample. The behavioural results from Chapter 2 showed strong benefits of addressable TV advertising that included compelling evidence that people both prefer and remember relevant ads more than irrelevant ads. Here, I aimed to first test whether the addressability uplift for relevant TV advertising would replicate with a large sample of participants and using a new set of advertising stimuli. Second, I added an investigation into whether the TV context affected the addressability uplift. While the previous neuroimaging study found some evidence that the context of the surrounding TV programme affected how rewarding people found ads, there was no corresponding behavioural advantage. As a result, this experiment sought to explore this finding further by utilising a larger and more demographically diverse sample, covering a wider range of age groups.

Real-world advertising exposure occurs within a broader viewing environment that shapes how advertisements are processed and evaluated. Audiences do not always have full control over the content they watch. Sometimes they actively choose a programme based on their preferences, while other times, they watch something selected for them, whether by a streaming algorithm, a pre-set TV schedule, or another person. This shift encourages to question the role of viewer agency in media consumption, particularly in how active choice influences engagement with surrounding content, including advertising. Much of the research on advertising effectiveness primarily examines the quality of the message or the product being advertised (e.g., (Malthouse et al., 2007). While some studies have explored the role of advertising execution creativity, their findings often lack generalisability across different contexts (Hartnett et al., 2016). However, recent changes in the media landscape highlight the need to shift focus toward the context in which advertisements are presented, as it may play a crucial role in their effectiveness.

A particularly relevant aspect of viewing context is viewer autonomy - whether audiences actively select their content or passively receive it. Self-Determination Theory (Ryan & Deci, 1985) suggests that autonomy in media choice enhances intrinsic motivation and engagement. When applied to television viewing, programme choice may increase enjoyment and immersion through enhanced psychological ownership of the viewing experience. These positive psychological states could then transfer to subsequent advertisements, potentially enhancing their effectiveness through emotional spillover effects. Marketing research has studied spillover effects, which refer to changes in consumer evaluation of a stimulus due to their perception of another related stimulus (Raufeisen et al., 2019). The emotional mechanism underlying these effects is explained by excitation transfer theory (Zillmann, 1971), which suggests that residual arousal from one experience, such as watching a film or a TV show, can carry over and intensify the emotional response to another experience, such as an embedded brand or advertisement (Cummins, 2017; Li et al., 2023).

The evidence for such context effects is substantial. Studies have consistently shown that the emotional appeal of viewing context moderates responses to brand or ad (Janssens & and Pelsmacker, 2005; Li et al., 2023). Dimensions of emotion, arousal and valence play a particularly crucial role in shaping reactions to advertising messages (Eijlers et al., 2020; Jiang et al., 2020). For example, studies have demonstrated that positive mood induction from TV content enhances subsequent ad evaluations (De Pelsmacker et al., 2002; France & and Park, 1997), supporting the transfer hypothesis. Physiological evidence further confirms that arousal levels from prior content directly influence ad processing. (Z. Wang & Lang, 2012) found that ads following positively arousing programs were associated with higher cognitive effort (measured by heart rate deceleration), improved recognition, and better free recall compared to ads following negatively arousing content.

A recent neurophysiological study provides additional support for these context effects. Bettiga and Noci (2024) employed multiple neurophysiological measures - EEG, heart rate, and skin conductance - to demonstrate that attention, arousal, and memory responses to TV content significantly influence processing of subsequent advertisements. Their findings revealed a clear halo effect. Advertisements embedded within engaging programmes benefited from enhanced attention, memory, and positive evaluation. This aligns with theories of affect transfer (Mattes & Cantor, 1982) and excitation transfer (Zillmann, 2008), suggesting that programme-induced emotional states extend to and influence ad processing. Moreover, Wang & Lang (2012) demonstrated that residual activation from an engaging programme declines gradually over time, meaning that advertisements appearing immediately after a viewer-selected programme may experience a heightened engagement effect before motivational activation decays. These findings suggest that if viewers select a TV show they find engaging, their sustained cognitive activation may further enhance ad processing and memory, strengthening the link between addressable advertising and recall

However, competing theoretical frameworks suggest that there might be a more complex relationship between programme engagement and advertising effectiveness. The limited capacity model (Lang, 2000) proposes that highly engaging programmes may actually impair ad processing by consuming available cognitive resources (Norris & Colman, 1993). This connects to the consistency effect, where positive programme-induced emotions might create resistance to interrupting advertisements, potentially leading to avoidance behaviours (Kamins et al., 1991). These theoretical tensions highlight the need for careful investigation of how viewing context moderates advertising effectiveness.

The type of engagement also plays a role in shaping these outcomes. As Wang and Lang (2012) argue, arousing content can activate either the appetitive or aversive motivational systems depending on its emotional valence. Positively arousing programmes, such as comedies or light entertainment, tend to trigger appetitive activation, which is associated with information intake and increased cognitive effort, as indicated by heart rate deceleration and improved recognition and recall. In contrast, negatively arousing programmes, such as horror or other fear-inducing content, are more likely to elicit aversive activation. At moderate levels, these programmes can still facilitate information intake, but at higher levels, the motivational system engages a defensive mode, limiting cognitive capacity for stimuli like advertisement, potentially reducing encoding (Wang & Lang, 2012; Lang, 2006). Therefore, while self-selected content may boost engagement and therefore strengthen advertising effectiveness, its impact on ad processing depends on the direction and intensity of the motivational activation it creates. Therefore, it is plausible to say that not all engagement is equal. TV shows that are highly engaging but negatively valanced may actually impair ad effectiveness, depending on their emotional and physiological consequences.

The interaction between viewing context and personal relevance (addressability) remains particularly underexplored. While some evidence points towards positively engaging TV context enhancing general ad effectiveness (Bettiga & Noci, 2024), the role of viewer autonomy in moderating responses to personally relevant advertisements requires further investigation. If, as Wang & Lang (2012) suggest, residual cognitive engagement from chosen content enhances recall, then selecting a TV show might similarly increase cognitive processing of relevant advertisements. This would mean that addressable advertising could be particularly effective when viewers choose their programme, as their active engagement state might heighten ad salience. On the other hand, forced exposure to both content and ads may induce cognitive overload, leading to lower recall and increased ad avoidance - a pattern similar to the negative effects observed with intrusive ad formats, such as non-skippable or autoplay mobile ads (T. Kim et al., 2023; Mancini et al., 2023). Additionally, because physiological responses to arousal decay over time, ads placed immediately after a chosen TV programme may benefit the most, reinforcing the importance of placement strategies in addressable advertising (Wang & Lang, 2012). These distinctions raise an important question: does the act of choosing what to watch affect engagement with embedded advertising, and does this relationship differ across age groups?

Cognitive processing abilities undergo significant transformations across the lifespan, with well-documented changes in attention allocation, information processing, and memory encoding (Cabeza et al., 2018). Despite these established neuropsychological patterns, there remains a significant research gap in understanding how these age-related cognitive differences influence advertising effectiveness, particularly within audiovisual contexts. This gap is especially noteworthy given the substantial demographic shift occurring globally, with adults over 55 representing an increasingly dominant consumer segment with strong buying power. Research from Boston Consulting Group (*Don't Overlook Your Mature Consumers*, 2023) highlights that mature consumers not only exhibit stronger brand loyalty and higher per-purchase spending than younger demographics but also demonstrate resilience during economic fluctuations while influencing younger consumers' purchasing decisions.

Age-related differences in advertising recall are well documented, with substantial evidence pointing to distinct patterns in how older and younger adults process and respond to advertising content (Dubow, 1995; Johnson & Cobb-Walgren, 1994; Stephens, 1991). Younger viewers, particularly teenagers and young adults, demonstrate significantly higher levels of ad memory across metrics like brand recall, recognition, and day-after recall. Dubow (1995) found a consistent age decline, with teens outperforming younger adults, who in turn outperformed older adults, even when the same ads were shown across groups. These effects are not merely due to exposure. That is, even when older and younger viewers are shown the same advertisements under identical conditions, age differences in recall persist.

Therefore, this points towards cognitive and motivational changes with age. For instance, older adults exhibit slower cognitive processing speeds (Johnson & Cobb-Walgren, 1994), making it harder to encode and retrieve information from fast-paced or cluttered media environments such as television. They are more affected by ad clutter and tend to struggle more with externally paced stimuli like broadcast ads. In addition, Stephens (1991) highlights the role of cognitive age, which is how old individuals feel. This can further moderate responses to advertising. Older adults who feel younger tend to be more receptive to new messages and more likely to engage with advertising content, suggesting that subjective age, not just chronological age, plays a role in ad effectiveness. While these differences have been established in traditional advertising contexts, the current study is unique in its focus on addressable ads embedded in varying viewing contexts.

At the core of these differences lies the cognitive aging process, which affects various aspects of information processing and memory (*The Aging Consumer*, 2021). While the rate of decline varies among individuals, research consistently shows age-related reductions in processing speed and working memory capacity (Park et al., 2002; Salthouse, 2012). Long-term memory performance also declines, particularly for novel or arbitrary information. However, this decline is not uniform and when older adults can rely on prior knowledge and schematic support, their memory for associative information can be matched to that of younger adults (Castel, 2005).

Cognitive Load Theory (Sweller, 1988) further suggests that as cognitive resources decline with age, older adults process information more efficiently when extraneous cognitive load is minimised. Extraneous load refers to the cognitive effort created by cluttered or irrelevant information, such as fast pacing, unnecessary detail, or content that lacks personal relevance, which can interfere with effective learning and memory (Sweller, 1988). Thus, cognitive efficiency may be enhanced when the ads themselves are personally relevant. Addressable ads, by targeting viewers' specific interests and needs, may require less cognitive effort to process and encode into memory.

Socioemotional Selectivity Theory (SST) is another valuable framework for understanding age-related differences in advertising processing. According to SST, as people age and perceive their time as more limited, their motivational priorities shift: older adults prioritise emotionally meaningful experiences over purely factual knowledge acquisition (Carstensen et al., 1999; Castel, 2007; Fung & Carstensen, 2003). This shift influences attention and memory, making older adults more likely to engage with content that aligns with personal goals and values. As such, advertising presented within a self-selected or personally relevant context may be especially resonant and better encoded in memory. In contrast, younger adults, who typically perceive time as more abundant, remain motivated by novelty and exploration. For them, externally selected but stimulating content may be just as engaging.

These theoretical patterns are supported by empirical findings. (Phillips & Stanton, 2004) demonstrated that younger consumers are typically better at recalling advertising content but less likely to be persuaded by it, while older consumers exhibit poorer recall but greater susceptibility to be persuaded by the messages that they do process. Similarly, (van der Goot et al., 2015) found that older adults had stronger recall for brands presented in calm TV ads, which they also preferred, whereas younger adults showed better memory and higher appreciation for arousing commercials. These trends are consistent with the Yerkes-Dodson law(Yerkes & Dodson, 1908), which describes an inverted U-shaped relationship between arousal and performance. For older adults, high-arousal content may lead to cognitive overload and reduced ad effectiveness (Buijzen et al., 2010; A. Lang et al., 2005), whereas younger adults often benefit from moderate arousal, which can enhance both memory and liking. These age-related processing patterns intersect in compelling ways with addressable advertising and viewing autonomy. If older adults value autonomy and benefit from emotionally meaningful, self-chosen content, then will addressable ads placed within such contexts be particularly effective?

With this in mind, the present study investigates how the context of content selection - whether viewers choose their own TV show or have it externally selected - affects cognitive responses to addressable versus non-addressable advertising. Psychological theories suggest that actively making a choice enhances motivation, attention, and memory (Ryan & Deci, 1985; Sweller, 1988). If viewers are more engaged with content that they have personally selected, this engagement may extend to surrounding advertisements, potentially making addressable ads particularly effective in self-selected viewing contexts. Conversely, when a show is externally assigned - whether randomly or by another person - viewers may engage with it differently, influencing their cognitive and emotional responses to embedded ads.

Based on these considerations and my previous findings, I hypothesise that participants who choose their own TV show will exhibit higher recall of advertisements than those who have their show externally selected (H1), and that addressable ads will be recalled better than non-addressable ads, regardless of content selection (H2). Additionally, I explore whether age moderates these effects, with older adults potentially showing a stronger benefit from both self-selected content and addressable ads due to increased personal relevance and cognitive processing differences. This investigation contributes to theoretical models of information processing and advertising effectiveness, while providing empirical insights for optimising ad placement strategies across diverse demographic groups.

4.2. Methods

Pre-screening

An identical pre-screening survey to the one in the previous fMRI study was sent out to 999 UK-based individuals through Prolific (https://www.prolific.com). In brief, this on-line survey asked people to give their opinions about different leisure time activities and was designed to identify individuals who fit exactly two of the four addressability categories: cars, cruises, dogs, and video gaming. I removed the question about attending an experiment in London, and asked if participants would take part in a further experiment online. I invited them to take part in a 40 minute online behavioural experiment in which they would watch a TV programme with advertising breaks and then answer a few questions about it. Half of them were in the choice condition, and were asked to choose which TV show they wanted to watch during the study. The other half were in the random condition, and the show was selected for them at random.

Participants

The pre-screening procedure identified a total of 340 individuals who were willing to take part in a further experiment and who fitted one of the six profiles of being addressable for exactly two of the four addressability categories. A subset of 201 of these individuals was identified, such that each category had a roughly equal number of participants for whom it was in the addressable and non-addressable condition. Identifying individuals who fit exactly two of the categories ensured that half of the ads in the experiment would be relevant to each participant. A total of six groups (A-F) of participants were formed with *N*=39 in group A, *N=30* in group B, *N=24* in group C, *N*=33 in group D, *N*=34 in group E, and *N=41* in group F. Data were analysed from 201 people (106 M, 95 F), of which, 66 were between the ages of 18-34; 104 were between the ages of 35-54; and 31 were between the ages of 55-65 (Mean age= 40.16; SD= 12.31). This research was approved by the university's Research Ethics Committee (EP/2019/003).

Table 4.1. Participant groups based on addressability categories and demographic characteristics. Each group contained participants who were addressable for two out of four interest categories. Gender and age distributions are also shown.

Group	Addressable Categories	N	Male (N)	Female (N)	Age (Mean ± SD)
A	Dogs Games	39	27	12	34.7 ± 9.0
B	Cruises Games	30	21	9	36.7 ± 9.6
C	Cruises Dogs	24	7	17	42.4 ± 15.1
D	Cars Games	33	23	10	43.6 ± 11.6
E	Cars Dogs	34	11	23	43.1 ± 13.3
F	Cars Cruises	41	17	24	41.4 ± 13.0

Stimuli and Materials

The online experiment was implemented on the Gorilla platform (Anwyl-Irvine et al., 2019). I used the same TV show episodes and TV advertisements as I did in Chapter 3. Note that an additional TV show (Swimming with Sharks) was included in the current study that was not used in the fMRI study in Chapter 3. This show was excluded from the fMRI experiment due to some inclusion of explicit content, which I wanted to avoid presenting in the scanner environment for practical reasons. For the current behavioural study, this concern was less pronounced, allowing me to expand the selection of stimuli to increase content variability. A total of sixteen TV advertisements were used in this experiment and ranged from 20 to 30 seconds in length, four in each of the addressability categories. Each advertisement was chosen because it was addressable to a specific demographic group. The advertisements were embedded in a TV program that was either chosen by each participant or randomly allocated to them by the computer from a set of six options: *The Bold and the Beautiful, Carp Wars, Dog the Bounty Hunter, Married with Children*, and *Modern Family, Swimming with Sharks*. A brief description of each TV show was provided to participants prior to the experiment.

Procedure

After reading information about the experiment, participants provided their consent to take part. In this experiment, participants were randomly assigned to one of two context conditions. 102 participants were in the choice context condition, where they read a brief description of the six TV shows and made a choice of what to watch during the study (*The Bold and the Beautiful*, n=0, *Carp Wars*, n=7, *Dog the Bounty Hunter*, n=31, *Married with Children,* n=26*, Modern Family,* n=38, or *Swimming with Sharks,* n=0). The other 99 participants were in the random context condition, and the TV show was selected for them by the computer at random (*The Bold and the Beautiful*, n=17, *Carp Wars*, n=16, *Dog the Bounty Hunter*, n=16, *Married with Children,* n=18*, Modern Family*, n=17, or *Swimming with Sharks,* n=15). Participants then watched the TV show episode with the advertisements embedded in the video in naturalistic manner. The ads were presented in a fully randomised order. Finally, participants completed a short behavioural experiment, identical to the one in Study 2, that tested their memory for the ads they saw, their liking for each of the ads, and how much they were interested in the four categories as a manipulation check for the addressability group assignment.

The first part tested participants' memory for the advertisements that they had seen during the TV watching task while a second part of the experiment assessed participants' liking for the ads they saw. Finally, a manipulation check tested whether the recruitment paradigm successfully identified the categories of advertisements relevant to each participant. On completion of the behavioural tasks, the participant was fully debriefed about the aims of the experiment and thanked for their participation.

Analysis

To ensure memory data quality, reaction times (RTs) were screened for outliers using the same procedure as in previous Chapters. For memory accuracy, again, d-prime (d') scores were computed using signal detection theory to quantify participants' ability to distinguish between previously seen and unseen advertisements. This was done by aggregating hit, miss, false alarm, and correct rejection counts for each participant and experimental condition before calculating d' as a measure of memory sensitivity.

A Bayesian mixed model approach was used to directly quantify the effects of addressability and context on behavioural measures and assess the strength of evidence for any differences. This approach overcomes some of the limitations associated with null hypothesis significance testing (Kruschke, 2010; Wagenmakers et al., 2011). Analyses were conducted in R (version 3.4.3) using the *eyethinkbayes* package, which facilitates Bayesian modelling of behavioural data.

Bayesian mixed models were implemented using Markov Chain Monte Carlo sampling to estimate the posterior distributions of model parameters. From 4000 samples, I derived estimates that quantified the strength of evidence that each experimental condition influenced behaviour in a consistent manner. The Maximum Probability of Effect (MPE) is reported, which represents the probability that the effect is positive or negative, depending on the direction of the median estimate. In other words, the MPE quantifies the likelihood that independent variables influenced behavioural responses.

For each dependent variable, a hierarchical Bayesian model was fitted with random effects for participants, advertisements, and the shows watched, and fixed effects for addressability, choice context, and advertisement category specified as:

Dependent variable ~ addressability + choice context + advertisement category + (1 | participant) + (1 | advertisement)

To examine the moderating effects of context and age (as a continuous predictor), I used a similar Bayesian mixed model, including age as a predictor and its interaction with addressability and TV context, specified as:

Dependent variable ~ age * addressability * choice context + advertisement category + (1 | participant) + (1 | advertisement)

4.3. Results

As a manipulation check, participants rated their interest in the previously viewed advertisements during the TV show on a scale ranging from 0-100. There was strong evidence that participants rated their interest level higher for addressable ads rather than non-addressable ads (MPE=100%). Participants' interest in addressable ads (M=56.5) was greater than participants' interest in non-addressable ads (M=34.8). In other words, the addressability variable in the design was successfully operationalised; addressable ads were indeed more relevant to the participants than non-addressable ads.

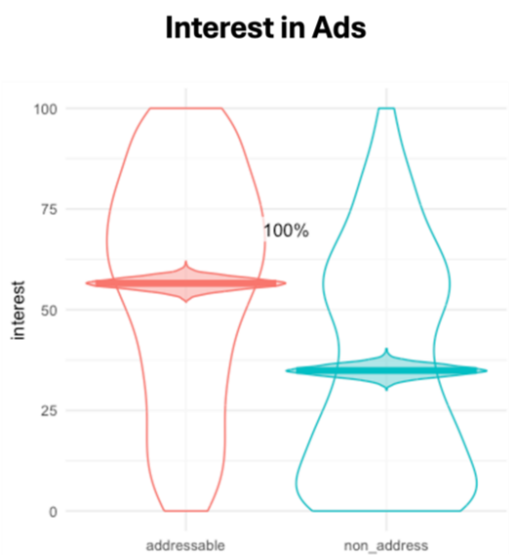

Figure 4.1. Participants' self-rated interest level in addressable and non-addressable advertisements. If the addressability manipulation worked, then there should be a clear difference between the ratings for addressable and non-addressable ads. Indeed, there is strong evidence that participants were more interested in ads that were assigned to them as being relevant (shown in red on the left) and expressed lower interest in ads that were treated as irrelevant to them (shown in yellow on the right).

Then, I looked at self-reported ratings of the ads across conditions. Participants reported liking ads that were relevant to them more than those that were not (MPE=100%). On average, participants reported becoming more interested in the addressable relative to the non-addressable ads (1.74 vs. 0.03 on a scale ranging from -10 [less] to +10 [more], see Figure 4.2a). In contrast, there was no meaningful difference in how much they liked the ads when viewed in the context of a TV show selected by themselves or by somebody else (MPE=73%). However, there was a clear interaction between addressability and TV context on ad liking, see Figure 4.2b. In the choice context, addressable ads received higher ratings (M = 1.99) than non-addressable ads (M = 0.00; MPE=100%). In the random context, addressable ads were again rated more positively (M = 1.51) than non-addressable ads (M = 0.06; 100%), although the difference between conditions was smaller than in the choice condition. These results suggest that addressable ads are generally liked more, and this effect is amplified when participants have choice over the content they view.

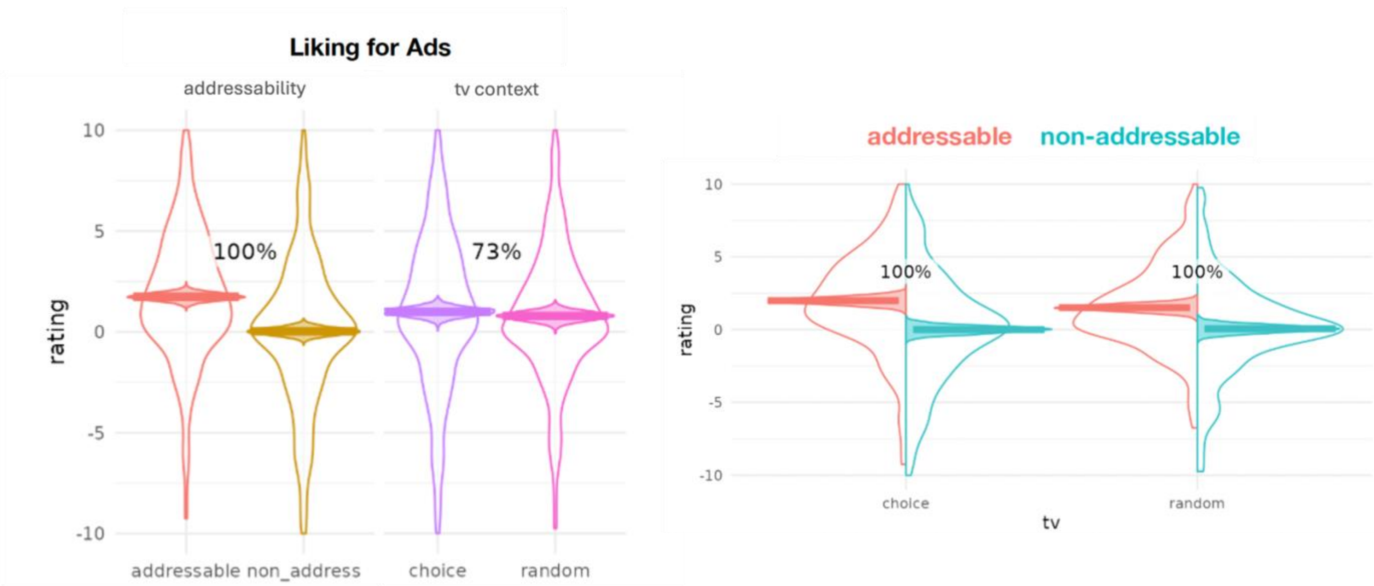

Figure 4.2 a) Participants self-reported how the advertisement changed their level of interest in the product or service from -10 (less) to +10 (more). The results are split between addressability conditions (shown in red and yellow on the left) and TV context conditions (shown in purple and pink on the right). The shape of the distribution (skinny on each end and wide in the middle) indicates the liking ratings are highly concentrated around the mean. **b)** Interaction between addressability and TV context for ad liking ratings. Plots show that addressable ads were rated more positively than non-addressable ads across both viewing contexts, with the difference particularly pronounced in the choice condition.

To measure conscious recall for the advertisements seen during the show, I examined participants' accuracy for images they had previously seen, using d-prime. Average d-prime scores revealed that responses on the memory test were more accurate for the addressable ads (M = 0.77) than the non-addressable ads (M = 0.61, MPE = 100%, Figure 4.3a), indicating better recollection for ads that were personally relevant. There was no meaningful main effect of choice context on memory (M = 0.65 for choice vs. M = 0.69 for random; MPE = 54%). However, an interaction between addressability and context showed that addressable ads were remembered more accurately than non-addressable ads in both the choice (0.75 vs. 0.62, MPE = 98.7%) and random (0.80 vs. 0.59, MPE = 99.98%) contexts.

To further examine how addressability influenced memory across viewing contexts, I analysed the interaction between ad type and TV context, see Figure 4.3b. In the choice condition, participants showed better memory for addressable ads (M = 0.75) than for non-addressable ads (M = 0.62), with strong evidence of a difference (MPE = 98.7%). In the random condition, the memory advantage for addressable ads was even larger (M = 0.80 vs. 0.59; MPE = 100%). These results indicate that addressability enhanced memory for ads regardless of whether participants chose the TV content themselves or not, with slightly stronger effects when content was assigned.

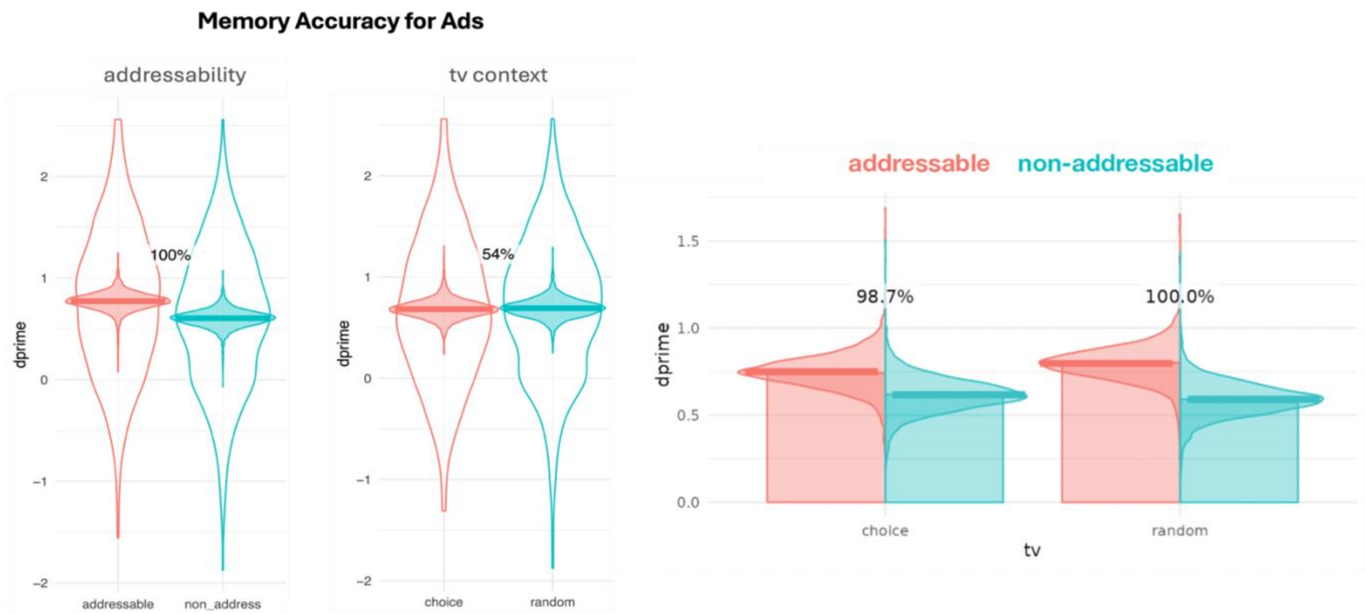

Figure 4.3. a) Participant accuracy score on the memory test, split between addressability conditions and TV context conditions. Participant accuracy scores were obtained by calculating the proportion of correct responses to seeing an advertisement image/brand image that did in fact appear in the experiment. **b)** Interaction between addressability and TV context for ad memory (d′) scores. Addressable ads were remembered more accurately than non-addressable ads across both viewing contexts, with the difference slightly larger in the random condition.

Reaction time (RT) was used as an implicit index of memory, with faster responses suggesting better recognition. Participants were slightly quicker to respond to addressable ads (M = 1477 ms) than to non-addressable ones (M = 1499 ms; MPE = 91.7%), indicating evidence of a recognition advantage for addressable content. RTs were similar regardless of whether ads were viewed during a self-selected show (M = 1469 ms) or a randomly assigned one (M = 1485 ms; MPE = 61.9%), suggesting that choice of content did not reliably influence recognition speed.

The interaction between addressability and context was also weak and uncertain (interaction MPE = 56.9%), indicating that the small RT benefit for addressable ads did not clearly vary depending on the viewing context. While addressable ads tended to elicit faster responses in both conditions (e.g., 1470 ms in the choice context vs. 1484 ms in the random), the size of this advantage was not meaningfully larger when participants had selected the show themselves. This suggests that although addressability may facilitate slightly more efficient recognition, this effect is not substantially enhanced by contextual factors such as agency over viewing, see Figure 4.4.

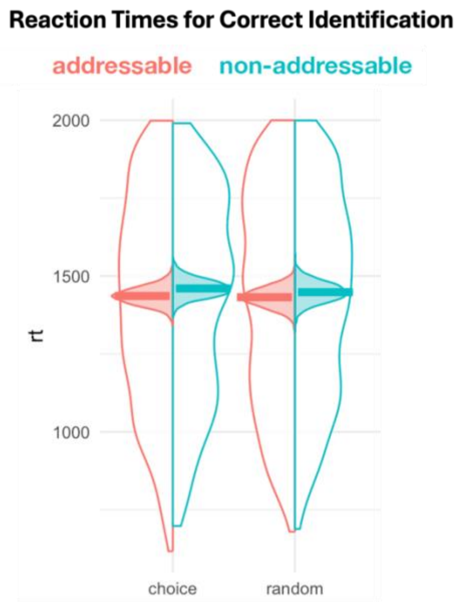

Figure 4.4. Participant reaction time score during the post-experiment memory test shown in milliseconds, split between addressability conditions and TV context conditions. This was the time taken for the mouse-cursor to move from the starting point to response on the screen.

Next, I investigated participants' memory performance by examining the moderating effect of age on d-prime scores for addressable and non-addressable ads, see Figure 4.5a. Memory for both ad types increased with age, but more sharply for addressable content. There was strong evidence for a positive slope for addressable ads (MPE = 97.6%) and weaker, though still credible, evidence for non-addressable ads (MPE = 92.2%). This pattern reflects an interaction between age and ad type (MPE = 99.8%), suggesting that addressable advertising becomes increasingly effective with age, while memory for non-addressable ads shows a more modest improvement. Older participants exhibited a clear advantage for addressable content, suggesting that personalised ads may become more effective as individuals age.

To explore this further, the analysis was split by TV context (Figure 4.5b). When participants chose the TV show they watched, memory for addressable and non-addressable ads was similar among younger participants (under 30). However, as age increased, a clear difference emerged. Older participants showed a strong memory improvement for addressable ads

(MPE = 98.9%), suggesting that the effectiveness of personalised advertising increases with age in a self-selected context. In contrast, there was little evidence of an age-related improvement for non-addressable ads (MPE = 71.7%), indicating that memory for non-personalised ads remained relatively stable across age groups in the choice context.

A different pattern was observed when participants watched a randomly assigned TV show. Here, memory for addressable content remained consistent across age, while memory for non-addressable content improved with age (MPE = 92.8%). In other words, for older individuals, addressable advertising is most effective when they choose their own TV show, whereas for younger individuals, it is more effective when the show is chosen for them.

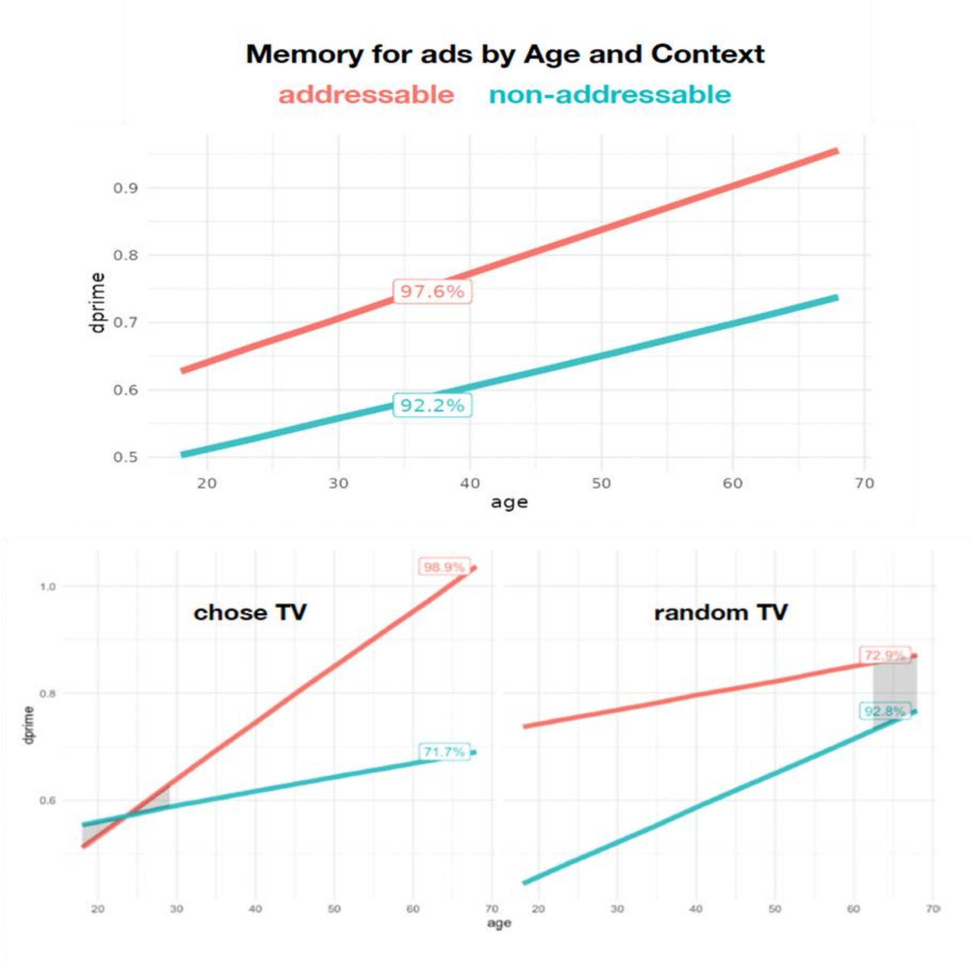

Figure 4.5. a) Participant accuracy scores on the memory test plotted as a function of age and addressability. Plot shows strong evidence for a positive slope for age with addressable content, but weaker evidence for non-addressable content. **b)** Participant accuracy scores plotted as a function of age, addressability, and TV context. The figure shows that age had an effect on memory, for each type of ad in each context. The left panel represents the choice conditions, while the right panel represents the random condition. The shaded areas represent uncertainty intervals (i.e., weak or no evidence (MPE<90) that there is a difference between conditions). Memory for addressable ads improved with age, particularly when participants chose their own TV show, whereas memory for non-addressable ads improves with age primarily when the show is assigned at random.

I also explored RT data to examine whether the addressability benefit varied across age and context. The model revealed moderate evidence for an age × addressability interaction (MPE = 93.7%), with slightly stronger evidence in the random context (MPE = 92.2%) than in the choice context (MPE = 91.5%). In other words, as participant age increased, they were somewhat faster to recognise addressable ads compared to non-addressable ones in randomly assigned TV contexts, while this difference was slightly less pronounced in the choice condition.

These findings should be interpreted cautiously. Due to relatively low d-prime scores overall (weak memory strength), RTs were less informative in this context, as they are most meaningful when accuracy is high. Moreover, RT analyses were limited to correct trials, and the resulting reduction in trial count led to greater variability and noise in the estimates. As such, interaction trends in the RT data were less robust than those observed for d-prime. Despite these limitations, comparing the two measures revealed an interesting divergence: whereas d-prime showed stronger addressability effects with age in self-selected contexts, RT showed the opposite trend; a slightly larger addressability benefit with age in random contexts. This suggests that memory strength and processing efficiency may be influenced by different contextual and cognitive factors, and that personalisation can shape recognition in multiple, distinct ways.

4.4. Discussion

The present study extends my research from prior Chapters on addressable advertising by demonstrating that its effectiveness is shaped not only by personal relevance but also by the broader viewing context and audience characteristics. While previous findings established that addressable ads are generally liked and remembered better, the current findings reveal that these effects are amplified when viewers have control over what they watch. Overall, participants tended to rate addressable ads more positively than non-addressable ones, but this difference was more pronounced when the TV content was self-selected. Similarly, memory performance was stronger for addressable ads overall but increased most sharply with age in the 'choice' condition, suggesting that the combination of viewer autonomy and personal relevance enhances cognitive processing especially with age. In contrast, when the viewing context was externally assigned, the addressability effect on memory remained stable across age, and the benefit shifted to non-addressable ads among older viewers. These findings indicate that addressability interacts with both contextual and individual-level factors, highlighting the importance of tailoring ad strategies not only to the viewer's preferences but also to their media environment and demographic characteristics.

One limitation of the present modelling is that age was treated as a strictly linear predictor. While this approach produced positive slopes for memory accuracy with increasing age, this pattern may be somewhat misleading. Cognitive aging research typically reports declines in memory performance, particularly for arbitrary or externally paced information, suggesting that a purely linear improvement is unlikely across the lifespan (Lezak et al., 2012). Including quadratic age terms in future analyses could capture more realistic non-linear trajectories. For instance, high performance among younger adults, potential dips in mid-life, and selective improvements in older adults when content is personally relevant. Such analyses would help clarify whether the apparent improvement observed here reflects a genuine age advantage or the interaction of personal relevance with cognitive aging processes.

Regarding context effects, the hypothesis that self-selection would enhance engagement, and specifically ad recall, was not supported. Despite previous literature suggesting that contextual engagement can spill over into ad perception (Bettiga & Noci, 2024; Mattes & Cantor, 1982), this study found no evidence that choosing one's own content significantly influenced memory or liking outcomes on embedded advertising stimuli.

However, an interesting interaction emerged in the analysis. The effectiveness of addressable advertising varied not only by age but also by viewing context. Specifically, older adults showed enhanced memory for addressable ads when they were embedded within self-selected content, but this benefit diminished in externally assigned contexts. This interaction of age and context is a novel finding and suggests that the benefits of personalisation depend not just on who the viewer is, but also on the amount of control they have over their media environment. This pattern can be interpreted in light of Socioemotional Selectivity Theory (Carstensen et al., 1999), which suggests that as people age, they become more motivated to engage with information that is personally meaningful and emotionally relevant. When older participants were able to choose the content they watched, the combination of personally selected media and personalised advertising likely increased the perceived relevance of the content and ads, prompting deeper engagement and stronger memory encoding.

It is also worth noting that reaction times are known to systematically increase with age, which may partially explain the variability observed in the RT data and the weaker interaction effects compared to memory accuracy performance. This general slowing highlights why treating age as a strictly linear predictor can be misleading. While response speed tends to decline with age, memory for personally relevant content may remain stable or even improve under certain conditions. A quadratic model could therefore better capture the trajectory of age-related differences, distinguishing overall slowing from selective advantages in older adulthood.

This means that in high-agency contexts, older adults may have engaged more deeply with the viewing experience overall, leading to greater elaboration of both the TV show and the embedded ads. Indeed, some prior research has suggested that older adults prefer greater control over their information intake and tend to process information more selectively compared to younger adults, particularly when the information aligns with their goals (Hess et al., 2012). In my study, this selective processing likely enhanced the impact of addressable ads when paired with self-selected TV content. The ads may have been seen not just as relevant, but also as aligned with the goals and values that guided their content choice in the first place, thereby boosting cognitive engagement. In contrast, when content was randomly assigned, older adults may have found it less meaningful or less aligned with their priorities, reducing motivation to attend to or encode the accompanying ads. Meanwhile, younger participants showed relatively consistent memory performance across conditions, perhaps due to greater cognitive flexibility or less reliance on motivational selectivity.

Additionally, according to the previously discussed LC4MP (Lang, 2000), viewers allocate finite cognitive resources between TV content and advertisements. When cognitive demands are high, processing resources may be devoted primarily to the primary task (watching TV content), leaving fewer resources available for encoding secondary stimuli such as embedded advertisements. If self-selected content required greater cognitive engagement, due to increased interest and involvement, it may have absorbed a disproportionate amount of cognitive resources, thereby reducing the attentional capacity available for processing advertisements.

Findings from Li et al. (2023) provide further support for this explanation. Their study demonstrated that when primary media content was cognitively demanding, subsequent advertisements were processed with lower neural engagement, as indicated by reduced P300 amplitude in EEG measures. This suggests that advertising effectiveness is dependent on available attentional resources rather than merely the emotional valence of preceding content. In the current study, if self-selected content engaged participants more deeply than assigned content, a drop in available cognitive resources may have occurred, preventing any meaningful enhancement in ad recall. While previous research (e.g., Bettiga & Noci, 2024) found stronger contextual spillover effects when ads were placed within highly engaging TV content, their findings may reflect a different underlying mechanism, such as narrative alignment, rather than cognitive load. In contrast, my results suggest that under conditions of high cognitive demand, the benefits of self-selection may be undermined by reduced capacity to process subsequent advertising. It could be that cognitive load may have interfered with the expected memory boost from self-selection.

Beyond cognitive resources, the Affect Transfer Hypothesis (Mattes & Cantor, 1982) suggests that stimuli following highly engaging or pleasurable content are expected to be better received, as emotional arousal from the primary content transfers to subsequent stimuli. However, this process is not automatic and relies on the intensity of the initial affective response. Findings from (Yegiyan, 2015) provide further support for this explanation. In that study, physiological measures (e.g., heart rate, skin conductance) were used to demonstrate how arousing emotional content can create residual activation that interferes with the processing of subsequent advertisements. Specifically, highly arousing content was shown to either overload or shift attentional resources away from ad encoding, depending on whether it activated the appetitive or aversive motivational systems. In relation to my study, this may suggest that *if* self-selected content was more engaging, it may have also demanded greater cognitive or emotional resources, limiting the availability of those resources for encoding ads that followed. If participants were still consolidating meaningful TV show content, the cognitive system may have had fewer resources left to assign to ad processing, thus explaining the absence of a strong self-selection benefit in memory performance.

However, it is important to note that in the context of this study, I did not measure participants' emotional or physiological responses to the TV content directly, so it remains unclear whether the self-selected shows were emotionally arousing and more engaging and would elicit affective transfer. This limits my ability to determine whether the absence of spillover effects was due to low emotional intensity or other factors. Future research could explore whether different shows produce stronger context effects, particularly when participants watch high-arousal vs. low-arousal content in self-selected vs. assigned conditions. Future work could also measure physiological arousal directly (e.g., heart rate, skin conductance) to assess whether it predicts the strength of affective transfer in this context.

Another point concerns potential primacy and recency effects in the memory test. Although the advertisements were counterbalanced across participants and presented in varied orders to minimise such influences, it remains possible that serial position could have contributed to recall patterns. Explicitly modelling these effects would provide additional reassurance that the age and context related differences reported here are not simply artefacts of order. Moreover, although all participants viewed the same set of advertisements and addressability was defined by pre-screened relevance categories, some ads may nonetheless have been inherently more distinctive or better aligned with broader demographic tendencies (e.g., cruise ads resonating more strongly with older viewers regardless of pre-screening). Conducting an item-level analysis would therefore help disentangle stimulus-driven variance from participant-level factors, helping clarify the basis of the more complex interactions observed

In sum, this study examined whether self-selected TV content enhances ad memory and liking, with a particular focus on how age differences influence these effects. Consistent with evidence from my previous chapters, addressable advertising improved memory and preference for advertisements across conditions, reinforcing the idea that personally relevant content enhances cognitive processing. However, the role of context was more complex than initially expected. While self-selection of the surrounding TV show alone did not boost ad memory or liking across the board, its interaction with age and personal relevance revealed important patterns in how engagement and cognitive processing works across different viewer profiles and media environments.

5. General Discussion

The aim of this doctoral thesis was to systematically evaluate the role that personal relevance plays in information processing. This was motivated by the recent development of novel methods leveraging personal data to deliver targeted communication, particularly in the domain of TV advertising. I evaluated the effects of personal relevance on cognitive and emotional engagement at both a behavioural and neurophysiological level. Rather than simply asking *if* personalisation is effective, this thesis asks *how* it has an impact. This feels especially important today, when we are all exposed to personalised content everywhere, shaping how we think, feel, and make decisions in our everyday lives. My work found that:

- Personally relevant ads were preferred over ones that were not as relevant and relevant ads were remembered better.

- Although there was no evidence that larger screens created more positive ratings of ads; however, they facilitated increased motivation to attend to the message and improve memory recall, relative to smaller, hand-held screens.

- There was no evidence that personally relevant ads enhanced brain activity in regions associated with reward (NAc), emotion (amygdala), memory (hippocampus), and attention (FEF and IPS). That is, these regions did not show significantly heightened bilateral activation in response to relevant vs. irrelevant advertising.

- There was, however, evidence that ads that occurred in shows chosen by the viewer, produced stronger activation in the NAc, a region strongly linked with reward processing. In addition, within the hippocampus, a significant interaction effect was present, where bilateral hippocampus activity was greater for ads that were relevant and also embedded in a self-selected context.

- Age also influenced these effects. Older participants showed better memory for personally relevant ads, particularly when they had chosen the TV show themselves, whereas younger participants benefitted more from personally relevant ads in the random TV show condition.

In general, the goal of personalised advertising has been to create greater value for consumers and provide them with an improved customer experience by recommending and delivering content that accurately matches their needs and wants. The use of personal relevance in creating advertisement delivery intends to not only maximise profitability for brands, but also increase satisfaction and usefulness for their audiences (Ur et al., 2012). However, in practice, personalised advertising exists on a continuum, varying in the extent and type of consumer data used to tailor content; from basic demographic targeting to more sophisticated behavioural hyper-targeting. This comes with benefits and costs to consumers therefore their response to personalisation is not always the same. Consumer reactions often depend on the perceived intrusiveness, transparency, and relevance of the targeting strategy (e.g., (Aguirre et al., 2015) On one hand, people have been found to appreciate the usefulness, increased convenience and reduced cognitive overload that comes with personally curated ads (e.g., (Ansari & Mela, 2003; McDonald & Cranor, 2010; Segijn & van Ooijen, 2022). On the other hand, people are also apprehensive about their compromised privacy, experiencing a sense of loss of control over personal data, especially when they feel like the high level of personal data retrieval is unjustified (Acquisti et al., 2015; Strycharz et al., 2019). The rise of negative attitudes can lead to reactance, ad avoidance and diminished trust in the brand (e.g., Bleier & Eisenbeiss, 2015). Studying human cognitive and neural response to personally meaningful ads is an important step to understanding the threshold at which personalisation becomes and stays effective. This may help inform where the middle-ground lies (between advertising meeting our demands as consumers who want personally, and motivationally meaningful information help us reach our goals and feeling negatively about being tracked and manipulated).

In this thesis, I operationalised personalisation through the concept of addressability, defined as the delivery of audiovisual content tailored to individuals based on broad-level demographic and behavioural characteristics. This form of personalisation sits somewhere in the middle of the personalisation continuum. It is more sophisticated than generic mass advertising but does not rely on highly sensitive personal data. This framing allowed for an exploration of how relatively low-level use of personally relevant data impacts cognitive processing.

To better situate this thesis within the wider personalisation landscape, Figure 5.1 illustrates a continuum of advertising approaches. At one end lies generic, untargeted mass communication; at the other, hyper-personalised content based on fine-grained behavioural and psychographic data, such as that delivered through social media platforms. Addressable advertising, as studied here, occupies a middle ground: it offers enhanced relevance while avoiding the privacy intrusiveness associated with hyper-targeting. This framing highlights the contribution of the present work in clarifying how moderate levels of personalisation are processed cognitively and neurally.

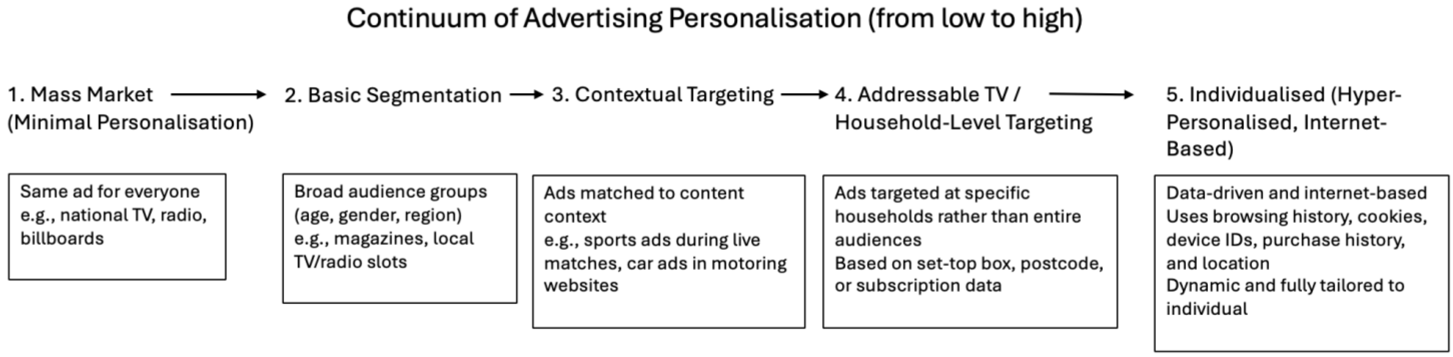

Figure 5.1. Continuum of advertising personalisation.
The spectrum illustrates the progression from minimal targeting (mass market advertising) through segmentation, contextual, and household-level targeting (e.g., addressable TV), to fully individualised hyper-personalisation based on internet activity and behavioural data.

While a lot of the existing literature on personalised communication has focused on attitudes, purchase intentions, and privacy concerns, less attention has been paid to how personalised content is processed at a cognitive, and especially neural**,** level. Understanding how attention and memory respond to addressable advertising offers important insight into the mechanisms through which relevance creates its effects. These mechanisms may not always be easily captured by self-report. For example, an ad may be perceived and reported as intrusive but still be remembered well, or conversely, it may be rated positively but quickly forgotten. A key benefit of using physiological measures is that they allow to track how attention is distributed in real time as viewers are exposed to advertising content (Bolls et al., 2003). Furthermore, exploring neural responses added additional insight by revealing whether effects of personalisation can be explained by the engagement of systems involved in relevance detection, memory encoding, affective processing, and value formation even when these effects are not consciously reported.

My findings highlight the complexity of how personal relevance influences information processing in advertising. While strong effects on memory and liking were replicated across studies, other hypothesised effects, particularly those in attentional and neural domains, were less robust. For example, heart rate data did not indicate enhanced sustained attention to personally relevant content (Chapter 2), and fMRI results did not reveal consistent activation in key *a priori* regions associated with reward, emotion, memory, or attention in response to addressable compared to non-addressable ads (Chapter 3). Still, the presence of null effects doesn't take away from the value of these findings. Instead, it may help reveal that effects of personalisation may be more subtle than predicted. One possible explanation for enhanced recall of personally relevant ads observed in the behavioural studies (Chapters 2 and 4) is that such content aligned with existing self-schemas, which are known to facilitate memory encoding (Markus, 1977). However, direct neural evidence for self-referential processing was not observed in the present fMRI data (Chapter 3), likely due to limited statistical power. Thus, while schema-based explanations remain plausible, they cannot be confirmed here. Moreover, personally relevant content may have reduced cognitive load by aligning with pre-existing knowledge or interests, making the information easier to process and recall. Furthermore, this interpretation is supported by the strong effect of addressable ads being consistently rated more favourably, aligning with previously found evidence that self-reference can influence consumer attitudes towards the ad and brand (Iyer & Mallika, 2023; Martin et al., 2004). The fact that participants liked relevant advertisements more suggests that personal relevance influenced preferential judgments in a way that may also reflect underlying schema activation or identity alignment, rather than heightened arousal or conscious effort. Together, these findings point to the possibility that relevance operates through subtle mechanisms and not just traditional models of attention and emotion.

What makes addressable advertising especially interesting is that it seems to offer a compromise between generic mass advertising and hyper-personalised targeting. It doesn't rely on deeply personal or sensitive data, but instead tailors content based on more broad and observable characteristics (e.g., household demographics), finding a balance between relevance and intrusiveness. This could also explain the positive evaluations of addressable ads across my studies. The addressability is perceived as relevant and engaging without being 'creepy' or overly invasive.

With respect to additional factors like screen size, viewing context, and age; they also played a role in my findings, suggesting that the impact of personalisation depends not only on the content itself, but also on who is watching, how they're watching, and on what device. While some of these effects, such as larger screen size benefits for attention and recall build on previous findings (Reeves et al., 1999; Detenber & Reeves, 1996), the age or viewing context outcomes, suggest the presence of a more nuanced relationship that is less well-documented in literature. For example, as participants got older, they generally showed better memory for personally relevant ads, especially when they had control over what they were watching. This effect was not present for non-addressable ads. In contrast, younger participants benefitted more from addressable ads in a viewing context randomly selected for them. These patterns suggest that personal relevance interacts with both age and autonomy. Rather than simply asking *if* personalisation is effective, this thesis also found that *when* and for *whom* also matters.

This research makes several contributions to the growing field of addressable advertising. Behavioural data point to the conclusion that personal relevance reliably affects cognitive outcomes, particularly in the form of enhanced recall and more positive evaluations of the ads. This directly shows that personal relevance matters, because it changes how we process and respond to incoming messages. Interestingly, the present findings also reveal that personal relevance does not necessarily work through the commonly assumed mechanisms. Particularly in Chapter 3, I found little evidence that reward, visual attention, emotional engagement, or even memory-related neural activity could explained these effects. The potential explanations for null effects will be addressed in the limitations section of this Chapter, however, it is important to practitioners to consider that the success of addressable advertising may not always be driven by overt emotional or attentional engagement.

The present findings also carry implications for theory. For instance, models positing that personal relevance primarily enhances advertising effectiveness through sustained attention (e.g., Bolls et al., 2003) are not strongly supported by this work. Neither heart-rate data (Chapter 2) nor fMRI activation in attentional regions (Chapter 3) showed consistent differences for personally relevant versus irrelevant ads. While these null effects must be interpreted cautiously given power limitations, they nonetheless suggest that attentional engagement may not be the sole or primary driver of the "addressability uplift."

Similarly, theories emphasising self-referential processing and schema activation (e.g., Markus, 1977; Northoff, 2016) remain plausible but were not directly confirmed in this work. In particular, no significant differences were observed in recognised self-referential regions such as mPFC or TPJ (Chapter 3). A falsifiable prediction that follows is that if self-referential mechanisms truly underlie addressability effects, then future studies with larger samples and more sensitive designs should reveal reliable enhancement in these regions, alongside behavioural recall benefits. If such evidence fails to emerge, schema-based accounts would require revision.

Limitations & Future Directions

Needless to say, the mixed findings in this thesis may have been driven by some limiting aspects of the current research design. The main limitation in Chapter 3 is the relatively small sample size, which likely reduced statistical power and may have contributed to the null findings in the hypothesised brain regions. The expected activation differences in regions associated with reward processing, emotion, memory, and attention may have been too subtle to detect within a small sample of participants. As a result, the absence of significant neural effect should be interpreted with caution, and future work with larger samples will be beneficial to determine whether these mechanisms in fact do not drive the engagement with personalised advertising or were simply underpowered in my study.

Furthermore, the use of heart rate as a sole physiological measure in Chapter 2 may have been limiting for fully understanding engagement with advertising. For example, Hartnett et al. (2025) recently found that although heart rate was the most reliable physiological measure for distinguishing high vs. low attention to video ads, it still failed to capture certain aspects of arousal and engagement that are reflected in other measures like electrodermal activity (EDA). They suggest that EDA may offer a more sensitive index of orienting responses and sympathetic arousal, which are useful measures of attention and ad processing (Koruth et al., 2015; Potter & Bolls, 2012). Heightened EDA response have been associated with more effective advertising driven by better subsequent memory for ad content (Bellman et al., 2019; Vecchiato et al., 2014), therefore, a more comprehensive psychophysiological assessment including EDA alongside heart rate would likely provide a fuller understanding of how personalised content engages consumers in future work.

Another limitation is that this research focused exclusively on audiovisual advertisements. Whilst this reflects the typical format of addressable TV advertising, the concept of personal relevance is not limited to this modality Personalised advertising appears in many other forms, including text-based messages, interactive online banner ads, social media posts, radio, and more recently, podcast ads. Earlier research has shown that different media formats engage the mind in different ways. For example, an early study by (Chaudhuri & Buck, 1995) directly compared TV and print ads and found that the TV ad format tends to evoke more emotional involvement, while print ads lead to more analytical, effortful processing. These differences suggest that the psychological effects of personal relevance may vary depending on the medium; therefore, considering other ad formats should be integrated into future research to determine the applicability of my findings beyond TV. As media continue to evolve, there are both parallels with traditional formats such as radio and television, and meaningful differences, which scientific research is suited to examine in order to understand how personalised advertising functions across platforms.

Conclusion

Personal relevance in advertising offers clear advantages for both advertisers and consumers, but its effectiveness depends on striking a careful balance between relevance and perceived intrusiveness. While personalisation can enhance engagement, the cognitive and neural mechanisms that underlie this so-called "addressability uplift" remain poorly understood. The four specific mechanisms examined in this thesis did not show consistent or strong enhancements in response to personal relevance, suggesting that other factors may be driving the effect, and additional research is required to identify them. Although my findings are most directly applicable to audio-visual formats such as television, streaming platforms, and social media, other modalities, such as print or audio, have yet to be systematically examined and represent important avenues for future research. Nonetheless, the present work contributes to a clearer understanding of how and when personal relevance exerts its influence on information processing, and highlights the need for a more nuanced, evidence-based approach to personalised advertising.

References

Aaker, D. A., Stayman, D. M., & Hagerty, M. R. (1986). Warmth in advertising: Measurement, impact, and sequence effects. *Journal of Consumer Research*, *12*(4), 365–381. https://doi.org/10.1086/208524

Abe, N., & Greene, J. D. (2014). Response to Anticipated Reward in the Nucleus Accumbens Predicts Behavior in an Independent Test of Honesty. *Journal of Neuroscience*, *34*(32), 10564–10572. https://doi.org/10.1523/JNEUROSCI.0217-14.2014

Abercrombie, H. C., Chambers, A. S., Greischar, L., & Monticelli, R. M. (2008). Orienting, emotion, and memory: Phasic and tonic variation in heart rate predicts memory for emotional pictures in men. *Neurobiology of Learning and Memory*, *90*(4), 644–650. https://doi.org/10.1016/j.nlm.2008.08.001

Abraham, A. (2013). The World According to Me: Personal Relevance and the Medial Prefrontal Cortex. *Frontiers in Human Neuroscience*, *7*.

Acquisti, A., Brandimarte, L., & Loewenstein, G. (2015). Privacy and human behavior in the age of information. *Science*, *347*(6221), 509–514.

Adolphs, R., Russell, J. A., & Tranel, D. (1999). A Role for the Human Amygdala in Recognizing Emotional Arousal from Unpleasant Stimuli. *Psychological Science*, *10*(2), 167–171.

Aguirre, E., Mahr, D., Grewal, D., de Ruyter, K., & Wetzels, M. (2015). Unraveling the Personalization Paradox: The Effect of Information Collection and Trust-Building Strategies on Online Advertisement Effectiveness. *Journal of Retailing*, *91*(1), 34–49. https://doi.org/10.1016/j.jretai.2014.09.005

Alba, J. W., & Hutchinson, J. W. (1987). Dimensions of consumer expertise. *Journal of Consumer Research*, *13*(4), 411–454. https://doi.org/10.1086/209080

Alexopoulos, T., Muller, D., Ric, F., & Marendaz, C. (2012). I, me, mine: Automatic attentional capture by self-related stimuli. *European Journal of Social Psychology*, *42*(6), 770–779. https://doi.org/10.1002/ejsp.1882

Ambler, T., & Burne, T. (1999). The impact of affect on memory of advertising. *Journal of Advertising Research*. https://www.semanticscholar.org/paper/The-impact-of-affect-on-memory-of-advertising-Ambler-Burne/3de136829ba5084ae307bd30eab306564aa8167a

Anderson, J. R. (1983). Retrieval of information from long-term memory. *Science*, *220*(4592), 25–30. https://doi.org/10.1126/science.6828877

Ansari, A., & Mela, C. F. (2003). E-Customization. *Journal of Marketing Research*, *40*(2), 131–145. https://doi.org/10.1509/jmkr.40.2.131.19224

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2019). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*. https://doi.org/10.3758/s13428-019-01237-x

Arrondo, G., Segarra, N., Metastasio, A., Ziauddeen, H., Spencer, J., Reinders, N. R., Dudas, R. B., Robbins, T. W., Fletcher, P. C., & Murray, G. K. (2015). Reduction in ventral striatal activity when anticipating a reward in depression and schizophrenia: A replicated cross-diagnostic finding. *Frontiers in Psychology*, *6*, 1280. https://doi.org/10.3389/fpsyg.2015.01280

Baik, J. S., & Famularo, J. (2024). Contextual integrity of loyalty programs, compromised? Interrogating consumer health data practices and networked actors in the U.S. retail sector. *Telecommunications Policy*, *48*(7), 102780. https://doi.org/10.1016/j.telpol.2024.102780

Bang, H., Choi, D., Wojdynski, B. W., & Lee, Y.-I. (2019). How the level of personalization affects the effectiveness of personalized ad messages: The moderating role of narcissism. *International Journal of Advertising: The Review of Marketing Communications*, *38*(8), 1116–1138. https://doi.org/10.1080/02650487.2019.1590069

Bang, H., & Wojdynski, B. W. (2016). Tracking users' visual attention and responses to personalized advertising based on task cognitive demand. *Computers in Human Behavior*, *55*(Part B), 867–876. https://doi.org/10.1016/j.chb.2015.10.025

Bartholow, B. D., & Bolls, P. (2013). Media psychophysiology: The brain and beyond. In *The Oxford handbook of media psychology* (pp. 474–495). Oxford University Press.

Bartra, O., McGuire, J. T., & Kable, J. W. (2013). The valuation system: A coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value. *NeuroImage*, *76*, 412–427. https://doi.org/10.1016/j.neuroimage.2013.02.063

Bayer, M., Ruthmann, K., & Schacht, A. (2017). The impact of personal relevance on emotion processing: Evidence from event-related potentials and pupillary responses. *Social Cognitive and Affective Neuroscience*, *12*(9), 1470–1479. https://doi.org/10.1093/scan/nsx075

Bedini, M., & Baldauf, D. (2021). Structure, function and connectivity fingerprints of the frontal eye field versus the inferior frontal junction: A comprehensive comparison. *The European Journal of Neuroscience*, *54*(4), 5462–5506. https://doi.org/10.1111/ejn.15393

Beerli, A., & and Santana, J. D. M. (1999). Design and Validation of an Instrument for Measuring Advertising Effectiveness in the Printed Media. *Journal of Current Issues & Research in Advertising*, *21*(2), 11–30. https://doi.org/10.1080/10641734.1999.10505092

Bellman, S., Nenycz-Thiel, M., Kennedy, R., Hartnett, N., & Varan, D. (2019). Best Measures of Attention To Creative Tactics in TV Advertising. *Journal of Advertising Research*, *59*(3), 295–311. https://doi.org/10.2501/JAR-2019-002

Berns, G. S., & Moore, S. E. (2012). A neural predictor of cultural popularity. *Journal of Consumer Psychology*, *22*(1), 154–160. https://doi.org/10.1016/j.jcps.2011.05.001

Bettiga, D., & Noci, G. (2024). The influence of television content on advertisement: A neurophysiological study. *Frontiers in Psychology*, *15*, 1266906. https://doi.org/10.3389/fpsyg.2024.1266906

Bleier, A., & Eisenbeiss, M. (2015). The importance of trust for personalized online advertising. *Journal of Retailing*, *91*(3), 390–409. https://doi.org/10.1016/j.jretai.2015.04.001

Blom, J. (2000). Personalization: A taxonomy. *CHI '00 Extended Abstracts on Human Factors in Computing Systems*, 313–314. https://doi.org/10.1145/633292.633483

Bolls, P. D., Lang, A., & Potter, R. F. (2001). The effects of message valence and listener arousal on attention, memory, and facial muscular responses to radio advertisements. *Communication Research*, *28*(5), 627–651. https://doi.org/10.1177/009365001028005003

Bolls, P. D., Muehling ,Darrel D., & and Yoon, K. (2003). The effects of television commercial pacing on viewers' attention and memory. *Journal of Marketing Communications*, *9*(1), 17–28. https://doi.org/10.1080/1352726032000068032

Bonnet, L., Comte, A., Tatu, L., Millot, J., Moulin, T., & Medeiros de Bustos, E. (2015). The role of the amygdala in the perception of positive emotions: An "intensity detector". *Frontiers in Behavioral Neuroscience*, *9*. https://doi.org/10.3389/fnbeh.2015.00178

Bradley, M. M., Greenwald, M. K., Petry, M. C., & Lang, P. J. (1992). Remembering pictures: Pleasure and arousal in memory. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *18*(2), 379–390. https://doi.org/10.1037//0278-7393.18.2.379

Brehm, J. W. (1956). Postdecision changes in the desirability of alternatives. *The Journal of Abnormal and Social Psychology*, *52*(3), 384–389. https://doi.org/10.1037/h0041006

Brehm, J. W. (1966). *A theory of psychological reactance* (pp. x, 135). Academic Press.

Bressler, S. L., Tang, W., Sylvester, C. M., Shulman, G. L., & Corbetta, M. (2008). Top-down control of human visual cortex by frontal and parietal cortex in anticipatory visual spatial attention. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *28*(40), 10056–10061. https://doi.org/10.1523/JNEUROSCI.1776-08.2008

Brewer, J. B., Zhao, Z., Desmond, J. E., Glover, G. H., & Gabrieli, J. D. E. (1998). Making Memories: Brain Activity that Predicts How Well Visual Experience Will Be Remembered. *Science*, *281*(5380), 1185–1187. https://doi.org/10.1126/science.281.5380.1185

Bright, L. F., & Daugherty, T. (2012). Does customization impact advertising effectiveness? An exploratory study of consumer perceptions of advertising in customized online environments. *Journal of Marketing Communications*, *18*(1), 19–37. https://doi.org/10.1080/13527266.2011.620767

Broach Jr., V. C., Page Jr.,Thomas J., & and Wilson, R. D. (1995). Television Programming and Its Influence on Viewers' Perceptions of Commercials: The Role of Program Arousal and Pleasantness. *Journal of Advertising*, *24*(4), 45–54. https://doi.org/10.1080/00913367.1995.10673488

Brock, T. C., Brannon, L. A., & Bridgwater, C. (1990). Message effectiveness can be increased by matching appeals to recipients' self-schemas: Laboratory demonstrations and a national field experiment. In *Emotion in advertising: Theoretical and practical explorations* (pp. 285–315). Quorum Books.

Buckholtz, J. W., Treadway, M. T., Cowan, R. L., Woodward, N. D., Benning, S. D., Li, R., Ansari, M. S., Baldwin, R. M., Schwartzman, A. N., Shelby, E. S., Smith, C. E., Cole, D., Kessler, R. M., & Zald, D. H. (2010). Mesolimbic dopamine reward system hypersensitivity in individuals with psychopathic traits. *Nature Neuroscience*, *13*(4), 419–421. https://doi.org/10.1038/nn.2510

Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brain's default network: Anatomy, function, and relevance to disease. *Annals of the New York Academy of Sciences*, *1124*, 1–38. https://doi.org/10.1196/annals.1440.011

Buijzen, M., Van Reijmersdal, E. A., & Owen, L. H. (2010). Introducing the PCMC Model: An Investigative Framework for Young People's Processing of Commercialized Media Content. *Communication Theory*, *20*(4), 427–450. https://doi.org/10.1111/j.1468-2885.2010.01370.x

Burnkrant, R. E., & Unnava, H. R. (1995). Effects of self-referencing on persuasion. *Journal of Consumer Research*, *22*(1), 17–26. https://doi.org/10.1086/209432

Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J., & Munafò, M. R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, *14*(5), 365–376. https://doi.org/10.1038/nrn3475

Cabeza, R., Albert, M., Belleville, S., Craik, F. I. M., Duarte, A., Grady, C. L., Lindenberger, U., Nyberg, L., Park, D. C., Reuter-Lorenz, P. A., Rugg, M. D., Steffener, J., & Rajah, M. N. (2018). Maintenance, reserve and compensation: The cognitive neuroscience of healthy ageing. *Nature Reviews. Neuroscience*, *19*(11), 701–710. https://doi.org/10.1038/s41583-018-0068-2

Cahill, L., & McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neurosciences*, *21*(7), 294–299. https://doi.org/10.1016/s0166-2236(97)01214-9

Calhoun, V. D., Adali, T., Pearlson, G. D., & Pekar, J. J. (2001). A method for making group inferences from functional MRI data using independent component analysis. *Human Brain Mapping*, *14*(3), 140–151. https://doi.org/10.1002/hbm.1048

Cao, Z., Bennett, M., Orr, C., Icke, I., Banaschewski, T., Barker, G. J., Bokde, A. L. W., Bromberg, U., Büchel, C., Quinlan, E. B., Desrivières, S., Flor, H., Frouin, V., Garavan, H., Gowland, P., Heinz, A., Ittermann, B., Martinot, J., Nees, F., … Whelan, R. (2018). Mapping adolescent reward anticipation, receipt, and prediction error during the monetary incentive delay task. *Human Brain Mapping*, *40*(1), 262–283. https://doi.org/10.1002/hbm.24370

Cao, Z., Ottino-Gonzalez, J., Cupertino, R. B., Juliano, A., Chaarani, B., Banaschewski, T., Bokde, A. L. W., Quinlan, E. B., Desrivières, S., Flor, H., Grigis, A., Gowland, P., Heinz, A., Brühl, R., Martinot, J.-L., Martinot, M.-L. P., Artiges, E., Nees, F., Orfanos, D. P., … Garavan, H. (2021). Characterizing reward system neural trajectories from adolescence to young adulthood. *Developmental Cognitive Neuroscience*, *52*, 101042. https://doi.org/10.1016/j.dcn.2021.101042

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

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist*, *54*(3), 165–181. https://doi.org/10.1037/0003-066X.54.3.165

Castel, A. D. (2005). Memory for grocery prices in younger and older adults: The role of schematic support. *Psychology and Aging*, *20*(4), 718–721. https://doi.org/10.1037/0882-7974.20.4.718

Castel, A. D. (2007). The Adaptive and Strategic Use of Memory By Older Adults: Evaluative Processing and Value-Directed Remembering. In A. S. Benjamin & B. H. Ross (Eds.), *Psychology of Learning and Motivation* (Vol. 48, pp. 225–270). Academic Press. https://doi.org/10.1016/S0079-7421(07)48006-9

Celsi, R. L., & Olson, J. C. (1988). The role of involvement in attention and comprehension processes. *Journal of Consumer Research*, *15*(2), 210–224. https://doi.org/10.1086/209158

Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology*, *39*(5), 752–766. https://doi.org/10.1037/0022-3514.39.5.752

Chan, C. (2012). Marketing the academic library with online social network advertising. *Library Management*, *33*(8/9), 479–489. https://doi.org/10.1108/01435121211279849

Chandra, S., Verma, S., Lim, W. M., Kumar, S., & Donthu, N. (2022). Personalization in personalized marketing: Trends and ways forward. *Psychology & Marketing*, *39*(8), 1529–1562. https://doi.org/10.1002/mar.21670

Chaudhuri, A., & Buck, R. (1995). Affect, reason, and persuasion: Advertising strategies that predict affective and analytic-cognitive responses. *Human Communication Research*, *21*(3), 422–441. https://doi.org/10.1111/j.1468-2958.1995.tb00353.x

Chua, H. F., Liberzon, I., Welsh, R. C., & Strecher, V. J. (2009). Neural correlates of message tailoring and self-relatedness in smoking cessation programming. *Biological Psychiatry, 65*(2), 165–168. https://doi.org/10.1016/j.biopsych.2008.08.030

Chun, M. M., Golomb, J. D., & Turk-Browne, N. B. (2011). A Taxonomy of External and Internal Attention. *Annual Review of Psychology*, *62*(Volume 62, 2011), 73–101. https://doi.org/10.1146/annurev.psych.093008.100427

Chun, M. M., & Turk-Browne, N. B. (2007). Interactions between attention and memory. *Current Opinion in Neurobiology*, *17*(2), 177–184. https://doi.org/10.1016/j.conb.2007.03.005

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language*, *53*(4), 594–628. https://doi.org/10.1016/j.jml.2005.08.005

Cook, I. A., Warren, C., Pajot, S. K., Schairer, D., & Leuchter, A. F. (2011). Regional brain activation with advertising images. *Journal of Neuroscience, Psychology, and Economics*, *4*(3), 147–160. https://doi.org/10.1037/a0024809

Corbetta, M., Akbudak, E., Conturo, T. E., Snyder, A. Z., Ollinger, J. M., Drury, H. A., Linenweber, M. R., Petersen, S. E., Raichle, M. E., Van Essen, D. C., & Shulman, G. L. (1998). A common network of functional areas for attention and eye movements. *Neuron*, *21*(4), 761–773. https://doi.org/10.1016/s0896-6273(00)80593-0

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, *3*(3), 201–215. https://doi.org/10.1038/nrn755

Costa, V. D., Lang, P. J., Sabatinelli, D., Versace, F., & Bradley, M. M. (2010). Emotional imagery: Assessing pleasure and arousal in the brain's reward circuitry. *Human Brain Mapping*, *31*(9), 1446–1457. https://doi.org/10.1002/hbm.20948

Critchley, H. D. (2002). Electrodermal responses: What happens in the brain. *The Neuroscientist: A Review Journal Bringing Neurobiology, Neurology and Psychiatry*, *8*(2), 132–142. https://doi.org/10.1177/107385840200800209

Culham, J. C., & Kanwisher, N. G. (2001). Neuroimaging of cognitive functions in human parietal cortex. *Current Opinion in Neurobiology*, *11*(2), 157–163. https://doi.org/10.1016/S0959-4388(00)00191-4

Cummins, R. G. (2017). *Excitation Transfer Theory*. 1–9. https://doi.org/10.1002/9781118783764.wbieme0080

Cunningham, W. A., & Brosch, T. (2012). Motivational salience: Amygdala tuning from traits, needs, values, and goals. *Current Directions in Psychological Science*, *21*(1), 54–59. https://doi.org/10.1177/0963721411430832

Danaher, P. J., & Dagger, T. S. (2013). Comparing the Relative Effectiveness of Advertising Channels: A Case Study of a Multimedia Blitz Campaign. *Journal of Marketing Research*, *50*(4), 517–534. https://doi.org/10.1509/jmr.12.0241

Daniel, R., & Pollmann, S. (2014). A universal role of the ventral striatum in reward-based learning: Evidence from human studies. *Neurobiology of Learning and Memory*, *114*, 90–100. https://doi.org/10.1016/j.nlm.2014.05.002

Davidson, R. J. (2004). What does the prefrontal cortex “do” in affect: Perspectives on frontal EEG asymmetry research. *Biological Psychology*, *67*(1), 219–234. https://doi.org/10.1016/j.biopsycho.2004.03.008

de Greck, M., Rotte, M., Paus, R., Moritz, D., Thiemann, R., Proesch, U., Bruer, U., Moerth, S., Tempelmann, C., Bogerts, B., & Northoff, G. (2008a). Is our self based on reward? Self-relatedness recruits neural activity in the reward system. *NeuroImage*, *39*(4), 2066–2075. https://doi.org/10.1016/j.neuroimage.2007.11.006

de Greck, M., Rotte, M., Paus, R., Moritz, D., Thiemann, R., Proesch, U., Bruer, U., Moerth, S., Tempelmann, C., Bogerts, B., & Northoff, G. (2008b). Is our self based on reward? Self-relatedness recruits neural activity in the reward system. *NeuroImage*, *39*(4), 2066–2075. https://doi.org/10.1016/j.neuroimage.2007.11.006

De Keyzer, F., van Noort, G., & Kruikemeier, S. (2022). Going too far? How consumers respond to personalized advertising from different sources. *Journal of Electronic Commerce Research*, *23*. https://dare.uva.nl/search?identifier=3e8b3e64-6c18-484d-a879-377e4db9f6a0

De Pelsmacker, P., Geuens ,Maggie, & and Anckaert, P. (2002). Media Context and Advertising Effectiveness: The Role of Context Appreciation and Context/Ad Similarity. *Journal of Advertising*, *31*(2), 49–61. https://doi.org/10.1080/00913367.2002.10673666

Debevec, K., & Iyer, E. (1988). Self-referencing as a mediator of the effectiveness of sex-role portrayals in advertising. *Psychology & Marketing*, *5*(1), 71–84. https://doi.org/10.1002/mar.4220050106

Delgado, M. R., Miller, M. M., Inati, S., & Phelps, E. A. (2005). An fMRI study of reward-related probability learning. *NeuroImage*, *24*(3), 862–873. https://doi.org/10.1016/j.neuroimage.2004.10.002

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience*, *18*, 193–222. https://doi.org/10.1146/annurev.ne.18.030195.001205

Dessart, L., Veloutsou, C., & Morgan-Thomas, A. (2016). Capturing consumer engagement: Duality, dimensionality and measurement. *Journal of Marketing Management*, *32*(5–6), 399–426. https://doi.org/10.1080/0267257X.2015.1130738

Devlin, J. T., & Poldrack, R. A. (2007). In praise of tedious anatomy. *NeuroImage*, *37*(4), 1033–1041; discussion 1050-1058. https://doi.org/10.1016/j.neuroimage.2006.09.055

Dillon, D. G., Holmes, A. J., Jahn, A. L., Bogdan, R., Wald, L. L., & Pizzagalli, D. A. (2008). Dissociation of neural regions associated with anticipatory versus consummatory phases of incentive processing. *Psychophysiology*, *45*(1), 36–49. https://doi.org/10.1111/j.1469-8986.2007.00594.x

Dolan, R. J., & Fletcher, P. C. (1997). Dissociating prefrontal and hippocampal function in episodic memory encoding. *Nature*, *388*(6642), 582–585. https://doi.org/10.1038/41561

Donner, T. H., Kettermann, A., Diesch, E., Ostendorf, F., Villringer, A., & Brandt, S. A. (2002). Visual Feature and Conjunction Searches of Equal Difficulty Engage Only Partially Overlapping Frontoparietal Networks. *NeuroImage*, *15*(1), 16–25. https://doi.org/10.1006/nimg.2001.0951

Don't Overlook Your Mature Consumers. (2023, July 3). BCG Global. https://www.bcg.com/publications/2023/marketing-to-mature-consumers

Donthu, N., Cherian, J., & Bhargava, M. (1993). Factors influencing recall of outdoor advertising. *Journal of Advertising Research*, *33*(3), 64–72.

Dreisbach, G., & Wenke, D. (2011). The shielding function of task sets and its relaxation during task switching. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(6), 1540–1546. https://doi.org/10.1037/a0024077

Drolet, A., & Yoon, C. (Eds.). (2021). *The aging consumer: Perspectives from psychology and marketing, 2nd ed*. Routledge/Taylor & Francis Group.

Dubow, J. S. (1995). Advertising recognition and recall by age—Including teens. *Journal of Advertising Research*, *35*(5), 55–61.

Eichenbaum, H., Yonelinas, A. P., & Ranganath, C. (2007a). The Medial Temporal Lobe and Recognition Memory. *Annual Review of Neuroscience*, *30*(Volume 30, 2007), 123–152. https://doi.org/10.1146/annurev.neuro.30.051606.094328

Eichenbaum, H., Yonelinas, A. R., & Ranganath, C. (2007b). The Medial Temporal Lobe and Recognition Memory. *Annual Review of Neuroscience*, *30*, 123. https://doi.org/10.1146/annurev.neuro.30.051606.094328

Eijlers, E., Boksem, M. A. S., & Smidts, A. (2020). Measuring Neural Arousal for Advertisements and Its Relationship With Advertising Success. *Frontiers in Neuroscience*, *14*. https://doi.org/10.3389/fnins.2020.00736

Eisend, M., & and Tarrahi, F. (2016). The Effectiveness of Advertising: A Meta-Meta-Analysis of Advertising Inputs and Outcomes. *Journal of Advertising*, *45*(4), 519–531. https://doi.org/10.1080/00913367.2016.1185981

Elliot, A. J. (Ed.). (2013). *Handbook of Approach and Avoidance Motivation*. Psychology Press. https://doi.org/10.4324/9780203888148

Enzi, B., Greck, M. de, Prösch, U., Tempelmann, C., & Northoff, G. (2009). Is Our Self Nothing but Reward? Neuronal Overlap and Distinction between Reward and Personal Relevance and Its Relation to Human Personality. *PLOS ONE*, *4*(12), e8429. https://doi.org/10.1371/journal.pone.0008429

Esterman, M., Liu, G., Okabe, H., Reagan, A., Thai, M., & DeGutis, J. (2015). Frontal eye field involvement in sustaining visual attention: Evidence from transcranial magnetic stimulation. *NeuroImage*, *111*, 542–548. https://doi.org/10.1016/j.neuroimage.2015.01.044

Falk, E. B., Berkman, E. T., Whalen, D., & Lieberman, M. D. (2011). Neural activity during health messaging predicts reductions in smoking above and beyond self-report. *Health Psychology, 30*(2), 177–185. https://doi.org/10.1037/a0022259

Fernández, D., Ros, L., Sánchez-Reolid, R., Ricarte, J. J., & Latorre, J. M. (2020). Effectiveness of the level of personal relevance of visual autobiographical stimuli in the induction of positive emotions in young and older adults: Pilot study protocol for a randomized controlled trial. *Trials*, *21*, 663. https://doi.org/10.1186/s13063-020-04596-5

Fernández, G., Weyerts, H., Schrader-Bölsche, M., Tendolkar, I., Smid, H. G. O. M., Tempelmann, C., Hinrichs, H., Scheich, H., Elger, C. E., Mangun, G. R., & Heinze, H.-J. (1998). Successful Verbal Encoding into Episodic Memory Engages the Posterior Hippocampus: A Parametrically Analyzed Functional Magnetic Resonance Imaging Study. *Journal of Neuroscience*, *18*(5), 1841–1847. https://doi.org/10.1523/JNEUROSCI.18-05-01841.1998

France, K. R., & and Park, C. W. (1997). The Impact of Program Affective Valence and Level of Cognitive Appraisal on Advertisement Processing and Effectiveness. *Journal of Current Issues & Research in Advertising*, *19*(2), 1–21. https://doi.org/10.1080/10641734.1997.10524434

Friston, K. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience*, *11*(2), 127–138. https://doi.org/10.1038/nrn2787

Fung, H. H., & Carstensen, L. L. (2003). Sending memorable messages to the old: Age differences in preferences and memory for advertisements. *Journal of Personality and Social Psychology*, *85*(1), 163–178. https://doi.org/10.1037/0022-3514.85.1.163

Garavan, H., Pendergrass, J. C., Ross, T. J., Stein, E. A., & Risinger, R. C. (2001). Amygdala response to both positively and negatively valenced stimuli. *NeuroReport*, *12*(12), 2779.

GhorbanTanhaei, H., Boozary, P., Sheykhan, S., Rabiee, M., Rahmani, F., & Hosseini, I. (2024). Predictive analytics in customer behavior: Anticipating trends and preferences. *Results in Control and Optimization*, *17*, 100462. https://doi.org/10.1016/j.rico.2024.100462

Gilboa, A., & Marlatte, H. (2017). Neurobiology of Schemas and Schema-Mediated Memory. *Trends in Cognitive Sciences*, *21*(8), 618–631. https://doi.org/10.1016/j.tics.2017.04.013

Glover, G. H. (1999). Deconvolution of impulse response in event-related BOLD fMRI. *NeuroImage*, *9*(4), 416–429. https://doi.org/10.1006/nimg.1998.0419

Goldberg, M. E., & Gorn, G. J. (1987). Happy and Sad TV Programs: How They Affect Reactions to Commercials. *Journal of Consumer Research*, *14*(3), 387–403.

Gómez-Carmona, D., Marín-Dueñas, P. P., Tenorio, R. C., Domínguez, C. S., Muñoz-Leiva, F., & Liébana-Cabanillas, F. J. (2022). Environmental concern as a moderator of information processing: A fMRI study. *Journal of Cleaner Production*, *369*, 133306. https://doi.org/10.1016/j.jclepro.2022.133306

Grady, C. L., McIntosh, A. R., Horwitz, B., Maisog, J. M., Underleider, L. G., Mentis, M. J., Pietrini, P., Schapiro, M. B., & Haxby, J. V. (1995). Age-related reductions in human recognition memory due to impaired encoding. *Science*, *269*(5221), 218–222.

Griffanti, L., Douaud, G., Bijsterbosch, J., Evangelisti, S., Alfaro-Almagro, F., Glasser, M. F., Duff, E. P., Fitzgibbon, S., Westphal, R., Carone, D., Beckmann, C. F., & Smith, S. M. (2017). Hand classification of fMRI ICA noise components. *NeuroImage*, *154*, 188–205. https://doi.org/10.1016/j.neuroimage.2016.12.036

Guixeres, J., Bigné, E., Ausín Azofra, J. M., Alcañiz Raya, M., Colomer Granero, A., Fuentes Hurtado, F., & Naranjo Ornedo, V. (2017). Consumer Neuroscience-Based Metrics Predict Recall, Liking and Viewing Rates in Online Advertising. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.01808

Haber, S. N., & Knutson, B. (2010). The reward circuit: Linking primate anatomy and human imaging. *Neuropsychopharmacology: Official Publication of the American College of Neuropsychopharmacology*, *35*(1), 4–26. https://doi.org/10.1038/npp.2009.129

Hajcak, G., & Olvet, D. M. (2008). The persistence of attention to emotion: Brain potentials during and after picture presentation. *Emotion*, *8*(2), 250–255. https://doi.org/10.1037/1528-3542.8.2.250

Haley, R. I., & Baldinger, A. L. (2000). The ARF Copy Research Validity Project. *Journal of Advertising Research*, *40*(6), 114–135.

Hamann, S. B., Ely, T. D., Hoffman, J. M., & Kilts, C. D. (2002). Ecstasy and agony: Activation of the human amygdala in positive and negative emotion. *Psychological Science*, *13*(2), 135–141. https://doi.org/10.1111/1467-9280.00425

Hamelin, N., Moujahid, O. E., & Thaichon, P. (2017). Emotion and advertising effectiveness: A novel facial expression analysis approach. *Journal of Retailing and Consumer Services*, *36*, 103–111. https://doi.org/10.1016/j.jretconser.2017.01.001

Hariri, A. R., Brown, S. M., Williamson, D. E., Flory, J. D., Wit, H. de, & Manuck, S. B. (2006). Preference for Immediate over Delayed Rewards Is Associated with Magnitude of Ventral Striatal Activity. *Journal of Neuroscience*, *26*(51), 13213–13217. https://doi.org/10.1523/JNEUROSCI.3446-06.2006

Harris, J. M., Ciorciari ,Joseph, & and Gountas, J. (2018). Public health social media communications and consumer neuroscience. *Cogent Psychology*, *5*(1), 1434058. https://doi.org/10.1080/23311908.2018.1434058

Hartnett, N., Bellman ,Steven, Beal ,Virginia, Kennedy ,Rachel, Charron ,Claire, & and Varan, D. (2025). How to accurately measure attention to video advertising. *International Journal of Advertising*, *44*(1), 184–207. https://doi.org/10.1080/02650487.2024.2435164

Hartnett, N., Kennedy, R., Sharp, B., & Greenacre, L. (2016). Creative that sells: How advertising execution affects sales. *Journal of Advertising*, *45*(1), 102–112. https://doi.org/10.1080/00913367.2015.1077491

Heath, R. (2009). Emotional engagement: How television builds big brands at low attention. *Journal of Advertising Research*, *49*(1), 62–73. https://doi.org/10.2501/s0021849909090060

Hess, T. M., Emery, L., & Neupert, S. D. (2012). Longitudinal Relationships Between Resources, Motivation, and Functioning. *The Journals of Gerontology: Series B*, *67B*(3), 299–308. https://doi.org/10.1093/geronb/gbr100

Ho, S., & Tam, K. (2005). An Empirical Examination of the Effects of Web Personalization at Different Stages of Decision Making. *Int. J. Hum. Comput. Interaction*, *19*, 95–112. https://doi.org/10.1207/s15327590ijhc1901_7

Hong, J. W., & Zinkhan, G. M. (1995). Self-concept and advertising effectiveness: The influence of congruency, conspicuousness, and response mode. *Psychology & Marketing*, *12*(1), 53–77. https://doi.org/10.1002/mar.4220120105

Hopfinger, J. B., Buonocore, M. H., & Mangun, G. R. (2000). The neural mechanisms of top-down attentional control. *Nature Neuroscience*, *3*(3), 284–291. https://doi.org/10.1038/72999

Ischebeck, A., Kreilinger, H., Peiris Miller, J., Höfler, M., Gilchrist, I. D., & Körner, C. (2024). Fixating targets in visual search: The role of dorsal and ventral attention networks in the processing of relevance and rarity. *Imaging Neuroscience*, *2*, 1–16. https://doi.org/10.1162/imag_a_00229

Iyer, K. V., & Mallika, M. (2023). A generational study on self-referential advertising: How it affects attitude toward brands. *Innovative Marketing*, *19*(4), 40–53. https://doi.org/10.21511/im.19(4).2023.04

Izuma, K., Matsumoto, M., Murayama, K., Samejima, K., Sadato, N., & Matsumoto, K. (2010). Neural correlates of cognitive dissonance and choice-induced preference change. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(51), 22014–22019. https://doi.org/10.1073/pnas.1011879108

Janak, P. H., & Tye, K. M. (2015). From circuits to behaviour in the amygdala. *Nature*, *517*(7534), 284–292. https://doi.org/10.1038/nature14188

Janssens, W., & and Pelsmacker, P. D. (2005). Emotional or informative? Creative or boring?: The effectiveness of different types of radio commercial. *International Journal of Advertising*, *24*(3), 373–394. https://doi.org/10.1080/02650487.2005.11072930

Jenkinson, M., Bannister, P., Brady, M., & Smith, S. (2002). Improved optimization for the robust and accurate linear registration and motion correction of brain images. *NeuroImage*, *17*(2), 825–841. https://doi.org/10.1016/s1053-8119(02)91132-8

Jiang, H., Tan, H., Liu, Y., Wan, F., & Gursoy, D. (2020). The impact of power on destination advertising effectiveness: The moderating role of arousal in advertising. *Annals of Tourism Research*, *83*. https://doi.org/10.1016/j.annals.2020.102926

Johansson, P., Hall, L., Sikström, S., Tärning, B., & Lind, A. (2006). How something can be said about telling more than we can know: On choice blindness and introspection. *Consciousness and Cognition*, *15*(4), 673–692. https://doi.org/10.1016/j.concog.2006.09.004

Johnson, R. L., & Cobb-Walgren, C. J. (1994). Aging and the problem of television clutter. *Journal of Advertising Research*, *34*(4), 54–62.

Jung, A.-R. (2017a). The influence of perceived ad relevance on social media advertising: An empirical examination of a mediating role of privacy concern. *Computers in Human Behavior*, *70*, 303–309. https://doi.org/10.1016/j.chb.2017.01.008

Jung, A.-R. (2017b). The influence of perceived ad relevance on social media advertising: An empirical examination of a mediating role of privacy concern. *Computers in Human Behavior*, *70*, 303–309. https://doi.org/10.1016/j.chb.2017.01.008

Kafkas, A., & Montaldi, D. (2018). Expectation affects learning and modulates memory experience at retrieval. *Cognition*, *180*, 123–134. https://doi.org/10.1016/j.cognition.2018.07.010

Kahneman, D., & Riis, J. (2005). Living, and thinking about it: Two perspectives on life. In *The science of well-being* (pp. 285–304). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198567523.003.0011

Kalyanaraman, S., & Sundar, S. S. (2006). The Psychological Appeal of Personalized Content in Web Portals: Does Customization Affect Attitudes and Behavior? *Journal of Communication*, *56*(1), 110–132. https://doi.org/10.1111/j.1460-2466.2006.00006.x

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The Fusiform Face Area: A Module in Human Extrastriate Cortex Specialized for Face Perception. *Journal of Neuroscience*, *17*(11), 4302–4311. https://doi.org/10.1523/JNEUROSCI.17-11-04302.1997

Kaspar, K., Weber, S. L., & Wilbers, A.-K. (2019). Personally relevant online advertisements: Effects of demographic targeting on visual attention and brand evaluation. *PLOS ONE*, *14*(2), e0212419. https://doi.org/10.1371/journal.pone.0212419

Kastner, S., & Ungerleider, L. G. (2000). Mechanisms of visual attention in the human cortex. *Annual Review of Neuroscience*, *23*, 315–341. https://doi.org/10.1146/annurev.neuro.23.1.315

Kawagoe, R., Takikawa, Y., & Hikosaka, O. (1998). Expectation of reward modulates cognitive signals in the basal ganglia. *Nature Neuroscience*, *1*(5), 411–416. https://doi.org/10.1038/1625

Kawala-Sterniuk, A., Browarska, N., Al-Bakri, A., Pelc, M., Zygarlicki, J., Sidikova, M., Martinek, R., & Gorzelanczyk, E. J. (2021). Summary of over Fifty Years with Brain-Computer Interfaces—A Review. *Brain Sciences*, *11*(1), 43. https://doi.org/10.3390/brainsci11010043

Keller, K. L. (1987). Memory factors in advertising: The effect of advertising retrieval cues on brand evaluations. *Journal of Consumer Research*, *14*(3), 316–333. https://doi.org/10.1086/209116

Kelley, T. A., Serences, J. T., Giesbrecht, B., & Yantis, S. (2008). Cortical mechanisms for shifting and holding visuospatial attention. *Cerebral Cortex (New York, N.Y. : 1991)*, *18*(1), 114–125. https://doi.org/10.1093/cercor/bhm036

Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding the self: An event-related fMRI study. *Journal of Cognitive Neuroscience, 14*(5), 785–794. https://doi.org/10.1162/08989290260138672

Kelly, G. A. (1955). *The psychology of personal constructs. Vol. 1. A theory of personality. Vol. 2. Clinical diagnosis and psychotherapy*. W. W. Norton.

Kelly, R. E., Alexopoulos, G. S., Wang, Z., Gunning, F. M., Murphy, C. F., Morimoto, S. S., Kanellopoulos, D., Jia, Z., Lim, K. O., & Hoptman, M. J. (2010). Visual inspection of independent components: Defining a procedure for artifact removal from fMRI data. *Journal of Neuroscience Methods*, *189*(2), 233–245. https://doi.org/10.1016/j.jneumeth.2010.03.028

Kim, T., Barasz, K., & John, L. K. (2019). Why Am I Seeing This Ad? The Effect of Ad Transparency on Ad Effectiveness. *Journal of Consumer Research*, *45*(5), 906–932. https://doi.org/10.1093/jcr/ucy039

Kim, T., Lee, J., & Suh, J. (2023). L-Shape advertising for mobile video streaming services: Less intrusive while still effective. *Displays*, *78*, 102436. https://doi.org/10.1016/j.displa.2023.102436

Kim, Y., Kang, M., Choi, S. M., & Sung, Y. (2016). To Click or Not to Click? Investigating Antecedents of Advertisement Clicking on Facebook. *Social Behavior and Personality: An International Journal*, *44*(4), 657–667. https://doi.org/10.2224/sbp.2016.44.4.657

Kincade, J. M., Abrams, R. A., Astafiev, S. V., Shulman, G. L., & Corbetta, M. (2005). An Event-Related Functional Magnetic Resonance Imaging Study of Voluntary and Stimulus-Driven Orienting of Attention. *Journal of Neuroscience*, *25*(18), 4593–4604. https://doi.org/10.1523/JNEUROSCI.0236-05.2005

Kircher, T., Weis, S., Leube, D., Freymann, K., Erb, M., Jessen, F., Grodd, W., Heun, R., & Krach, S. (2008). Anterior hippocampus orchestrates successful encoding and retrieval of non-relational memory: An event-related fMRI study. *European Archives of Psychiatry and Clinical Neuroscience*, *258*(6), 363–372. https://doi.org/10.1007/s00406-008-0805-z

Klein, S. B., & Kihlstrom, J. F. (1986). Elaboration, organization, and the self-reference effect in memory. *Journal of Experimental Psychology: General*, *115*(1), 26–38. https://doi.org/10.1037/0096-3445.115.1.26

Klucharev, V., Smidts, A., & Fernández, G. (2008). Brain mechanisms of persuasion: How ‘expert power’ modulates memory and attitudes. *Social Cognitive and Affective Neuroscience*, *3*(4), 353–366. https://doi.org/10.1093/scan/nsn022

Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001a). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *21*(16), RC159. https://doi.org/10.1523/JNEUROSCI.21-16-j0002.2001

Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001b). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *21*(16), RC159. https://doi.org/10.1523/JNEUROSCI.21-16-j0002.2001

Knutson, B., & Cooper, J. C. (2005). Functional magnetic resonance imaging of reward prediction. *Current Opinion in Neurology*, *18*(4), 411–417. https://doi.org/10.1097/01.wco.0000173463.24758.f6

Knutson, B., & Genevsky, A. (2018). Neuroforecasting Aggregate Choice. *Current Directions in Psychological Science*, *27*(2), 110–115. https://doi.org/10.1177/0963721417737877

Knutson, B., Westdorp, A., Kaiser, E., & Hommer, D. (2000). FMRI visualization of brain activity during a monetary incentive delay task. *NeuroImage*, *12*(1), 20–27. https://doi.org/10.1006/nimg.2000.0593

Koruth, K. J., Lang ,Annie, Potter ,Robert F., & and Bailey, R. L. (2015). A Comparative Analysis of Dynamic and Static Indicators of Parasympathetic and Sympathetic Nervous System Activation During TV Viewing. *Communication Methods and Measures*, *9*(1–2), 78–100. https://doi.org/10.1080/19312458.2014.999752

Köster, M., Rüth, M., Hamborg, K.-C., & Kaspar, K. (2015). Effects of Personalized Banner Ads on Visual Attention and Recognition Memory. *Applied Cognitive Psychology*, *29*(2), 181–192. https://doi.org/10.1002/acp.3080

Kriegeskorte, N., Simmons, W. K., Bellgowan, P. S. F., & Baker, C. I. (2009). Circular analysis in systems neuroscience: The dangers of double dipping. *Nature Neuroscience*, *12*(5), 535–540. https://doi.org/10.1038/nn.2303

Krugman, H. E. (1965). The impact of television advertising: Learning without involvement. *Public Opinion Quarterly*, *29*(3), 349–356. https://doi.org/10.1086/267335

Lambrecht, A., & Tucker, C. (2013). When Does Retargeting Work? Information Specificity in Online Advertising. *Journal of Marketing Research*, *50*(5), 561–576. https://doi.org/10.1509/jmr.11.0503

Lang, A. (2000). The Limited Capacity Model of Mediated Message Processing. *Journal of Communication*, *50*(1), 46–70. https://doi.org/10.1111/j.1460-2466.2000.tb02833.x

Lang, A., Chung, Y., Lee, S., Schwartz, N., & Shin, M. (2005). It's an arousing, fast-paced kind of world: The effects of age and sensation seeking on the information processing of substance-abuse PSAs. *Media Psychology*, *7*(4), 421–454. https://doi.org/10.1207/S1532785XMEP0704_6

Lang, P. (1995). *International Affective Picture System (IAPS): Technical Manual and Affective Ratings*. https://www.semanticscholar.org/paper/International-Affective-Picture-System-(IAPS)-%3A-and-Lang/09bb229a610acdd3150b8e0176194e7b7cf471b7

Lang, P. J., & Bradley, M. M. (2010). Emotion and the motivational brain. *Biological Psychology*, *84*(3), 437–450. https://doi.org/10.1016/j.biopsycho.2009.10.007

Lang, P. J., Bradley, M. M., Fitzsimmons, J. R., Cuthbert, B. N., Scott, J. D., Moulder, B., & Nangia, V. (1998). Emotional arousal and activation of the visual cortex: An fMRI analysis. *Psychophysiology*, *35*(2), 199–210. https://doi.org/10.1111/1469-8986.3520199

Lauritzen, T. Z., D'Esposito, M., Heeger, D. J., & Silver, M. A. (2009). Top-down flow of visual spatial attention signals from parietal to occipital cortex. *Journal of Vision*, *9*(13), 18.1-14. https://doi.org/10.1167/9.13.18

LeDoux, J. (2003). The emotional brain, fear, and the amygdala. *Cellular and Molecular Neurobiology*, *23*(4–5), 727–738. https://doi.org/10.1023/a:1025048802629

Leonards, U., Sunaert, S., Van Hecke, P., & Orban, G. A. (2000). Attention Mechanisms in Visual Search—An fMRI Study. *Journal of Cognitive Neuroscience*, *12*(Supplement 2), 61–75. https://doi.org/10.1162/089892900564073

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5th ed.). Oxford University Press

Li, S., Lyu, T., Park, S., & Choi, Y. (2023). Spillover effects in destination advertising: An electroencephalography study. *Annals of Tourism Research*, *102*, 103623. https://doi.org/10.1016/j.annals.2023.103623

Liu, X., Hairston, J., Schrier, M., & Fan, J. (2010). Common and distinct networks underlying reward valence and processing stages: A meta-analysis of functional neuroimaging studies. *Neuroscience and Biobehavioral Reviews*, *35*(5), 1219. https://doi.org/10.1016/j.neubiorev.2010.12.012

MacInnis, D. J., Moorman, C., & Jaworski, B. J. (1991). Enhancing and measuring consumers' motivation, opportunity, and ability to process brand information from ads. *Journal of Marketing*, *55*(4), 32–53. https://doi.org/10.2307/1251955

Macrae, C. N., Moran, J. M., Heatherton, T. F., Banfield, J. F., & Kelley, W. M. (2004). Medial prefrontal activity predicts memory for self. *Cerebral Cortex (New York, N.Y.: 1991)*, *14*(6), 647–654. https://doi.org/10.1093/cercor/bhh025

Malheiros, M., Jennett, C., Patel, S., Brostoff, S., & Sasse, M. A. (2012). Too close for comfort: A study of the effectiveness and acceptability of rich-media personalized advertising. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 579–588. https://doi.org/10.1145/2207676.2207758

Malthouse, E. C., & Calder, B. J. (2018). From advertising to engagement. In *The Handbook of Communication Engagement* (pp. 411–420). Wiley-Blackwell. https://doi.org/10.1002/9781119167600.ch28

Malthouse, E. C., Calder, B. J., & Tamhane, A. (2007). The effects of media context experiences on advertising effectiveness. *Journal of Advertising*, *36*(3), 7–18. https://doi.org/10.2753/JOA0091-3367360301

Malthouse, E. C., Maslowska, E., & Franks, J. U. (2018). Understanding programmatic TV advertising. *International Journal of Advertising*, *37*(5), 769–784. https://doi.org/10.1080/02650487.2018.1461733

Mancini, M., Cherubino, P., Martinez, A., Vozzi, A., Menicocci, S., Ferrara, S., Giorgi, A., Aricò, P., Trettel, A., & Babiloni, F. (2023). What Is behind In-Stream Advertising on YouTube? A Remote Neuromarketing Study employing Eye-Tracking and Facial Coding techniques. *Brain Sciences*, *13*(10), 1481. https://doi.org/10.3390/brainsci13101481

Markus, H. (1977). Self-schemata and processing information about the self. *Journal of Personality and Social Psychology*, *35*(2), 63–78. https://doi.org/10.1037/0022-3514.35.2.63

Martin, B. A. S., Lee, C. K.-C., & Yang, F. (2004). The Influence of Ad Model Ethnicity and Self-Referencing on Attitudes: Evidence from New Zealand. *Journal of Advertising*, *33*(4), 27–37. https://doi.org/10.1080/00913367.2004.10639172

Mattes, J., & Cantor, J. (1982). Enhancing responses to television advertisements via the transfer of residual arousal from prior programming. *Journal of Broadcasting*, *26*(2), 553–566. https://doi.org/10.1080/08838158209364024

Matz, S. (2025). *Mindmasters: The Data-Driven Science of Predicting and Changing Human Behavior*. Harvard Business Review Press.

Matz, S. C., Kosinski, M., Nave, G., & Stillwell, D. J. (2017). Psychological targeting as an effective approach to digital mass persuasion. *Proceedings of the National Academy of Sciences*, *114*(48), 12714–12719. https://doi.org/10.1073/pnas.1710966114

McDonald, A., & Cranor, L. F. (2010). *Beliefs and Behaviors: Internet Users' Understanding of Behavioral Advertising* (SSRN Scholarly Paper 1989092). Social Science Research Network. https://papers.ssrn.com/abstract=1989092

McGaugh, J. L. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience*, *27*, 1–28. https://doi.org/10.1146/annurev.neuro.27.070203.144157

Meyers-Levy, J., & Peracchio, L. A. (1996). Moderators of the Impact of Self-Reference on Persuasion. *Journal of Consumer Research*, *22*(4), 408–423. https://doi.org/10.1086/209458

Micu, A. C., & Plummer, J. T. (2010). Measurable emotions: How television ads really work: Patterns of reactions to commercials can demonstrate advertising effectiveness. *Journal of Advertising Research*, *50*(2), 137–153. https://doi.org/10.2501/S0021849910091300

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, *36*(9), 809–848. https://doi.org/10.1016/S0005-7967(98)00063-1

Mohanty, A., Gitelman, D. R., Small, D. M., & Mesulam, M. M. (2008). The spatial attention network interacts with limbic and monoaminergic systems to modulate motivation-induced attention shifts. *Cerebral Cortex (New York, N.Y.: 1991)*, *18*(11), 2604–2613. https://doi.org/10.1093/cercor/bhn021

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences*, *7*(3), 134–140. https://doi.org/10.1016/s1364-6613(03)00028-7

Moorman, M., Neijens, P. C., & Smit, E. G. (2002). The effects of magazine-induced psychological responses and thematic congruence on memory and attitude toward the ad in a real-life setting. *Journal of Advertising*, *31*(4), 27–40. https://doi.org/10.1080/00913367.2002.10673683

Moorman, M., Willemsen, L. M., Neijens, P. C., & Smit, E. G. (2012). Program-Involvement Effects on Commercial Attention and Recall of Successive and Embedded Advertising. *Journal of Advertising*, *41*(2), 25–37.

Moray, N. (1959). Attention in Dichotic Listening: Affective Cues and the Influence of Instructions. *Quarterly Journal of Experimental Psychology*, *11*(1), 56–60. https://doi.org/10.1080/17470215908416289

Muggleton, N. G., Juan, C.-H., Cowey, A., & Walsh, V. (2003). Human frontal eye fields and visual search. *Journal of Neurophysiology*, *89*(6), 3340–3343. https://doi.org/10.1152/jn.01086.2002

Murayama, K., Matsumoto, M., Izuma, K., Sugiura, A., Ryan, R. M., Deci, E. L., & Matsumoto, K. (2015). How self-determined choice facilitates performance: A key role of the ventromedial prefrontal cortex. *Cerebral Cortex (New York, N.Y.: 1991)*, *25*(5), 1241–1251. https://doi.org/10.1093/cercor/bht317

N'Diaye, K., Sander, D., & Vuilleumier, P. (2009). Self-relevance processing in the human amygdala: Gaze direction, facial expression, and emotion intensity. *Emotion*, *9*(6), 798–806. https://doi.org/10.1037/a0017845

Norris, C. E., & Colman, A. M. (1993). Context effects on memory for television advertisements. *Social Behavior and Personality: An International Journal*, *21*(4), 279–296. https://doi.org/10.2224/sbp.1993.21.4.279

Northoff, G. (2016). Is the self a higher-order or fundamental function of the brain? The 'basis model of self-specificity' and its encoding by the brain's spontaneous activity. *Cognitive Neuroscience*, *7*(1–4), 203–222. https://doi.org/10.1080/17588928.2015.1111868

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain—A meta-analysis of imaging studies on the self. *NeuroImage*, *31*(1), 440–457. https://doi.org/10.1016/j.neuroimage.2005.12.002

Northoff, G., & Panksepp, J. (2008). The trans-species concept of self and the subcortical cortical midline system. *Trends in Cognitive Sciences, 12*(7), 259–264. https://doi.org/10.1016/j.tics.2008.04.007

Otamendi, F. J., & Sutil Martín, D. L. (2020). The Emotional Effectiveness of Advertisement. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.02088

Padoa-Schioppa, C. (2007). Orbitofrontal Cortex and the Computation of Economic Value. *Annals of the New York Academy of Sciences*, *1121*(1), 232–253. https://doi.org/10.1196/annals.1401.011

Pappas, I. O., Kourouthanassis, P. E., Giannakos, M. N., & Chrissikopoulos, V. (2017). Sense and sensibility in personalized e-commerce: How emotions rebalance the purchase intentions of persuaded customers. *Psychology & Marketing*, *34*(10), 972–986. https://doi.org/10.1002/mar.21036

Park, D. C., Lautenschlager, G., Hedden, T., Davidson, N. S., Smith, A. D., & Smith, P. K. (2002). Models of visuospatial and verbal memory across the adult life span. *Psychology and Aging*, *17*(2), 299–320. https://doi.org/10.1037/0882-7974.17.2.299

Paulhus, D. L. (1984). Two-component models of socially desirable responding. *Journal of Personality and Social Psychology*, *46*(3), 598–609. https://doi.org/10.1037/0022-3514.46.3.598

Peters, J., & Büchel, C. (2010). Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. *Neuron*, *66*(1), 138–148. https://doi.org/10.1016/j.neuron.2010.03.026

Petty, R., & Cacioppo, J. (1984). Source Factors and the Elaboration Likelihood Model of Persuasion. *Advances in Consumer Research. Association for Consumer Research (U.S.)*, *11*, 668–672.

Petty, R. E., Cacioppo, J. T., & Schumann, D. (1983). Central and peripheral routes to advertising effectiveness: The moderating role of involvement. *Journal of Consumer Research*, *10*(2), 135–146. https://doi.org/10.1086/208954

Pfiffelmann, J., Dens, N., & Soulez, S. (2020). Personalized advertisements with integration of names and photographs: An eye-tracking experiment. *Journal of Business Research*, *111*, 196–207. https://doi.org/10.1016/j.jbusres.2019.08.017

Phelps, E. A. (2004). Human emotion and memory: Interactions of the amygdala and hippocampal complex. *Current Opinion in Neurobiology*, *14*(2), 198–202. https://doi.org/10.1016/j.conb.2004.03.015

Phelps, E. A., & LeDoux, J. E. (2005). Contributions of the amygdala to emotion processing: From animal models to human behavior. *Neuron*, *48*(2), 175–187. https://doi.org/10.1016/j.neuron.2005.09.025

Phillips, D. M., & Stanton, J. L. (2004). Age-related differences in advertising: Recall and persuasion. *Journal of Targeting, Measurement and Analysis for Marketing*, *13*(1), 7–20. https://doi.org/10.1057/palgrave.jt.5740128

Pierrot-Deseilligny, C., Milea, D., & Müri, R. M. (2004). Eye movement control by the cerebral cortex. *Current Opinion in Neurology*, *17*(1), 17–25. https://doi.org/10.1097/00019052-200402000-00005

Pieters, R., Warlop, L., & Wedel, M. (2002). Breaking through the clutter: Benefits of advertisement originality and familiarity for brand attention and memory. *Management Science*, *48*(6), 765–781. https://doi.org/10.1287/mnsc.48.6.765.192

Pieters, R., & Wedel, M. (2004). Attention Capture and Transfer in Advertising: Brand, Pictorial, and Text-Size Effects. *Journal of Marketing*, *68*(2), 36–50. https://doi.org/10.1509/jmkg.68.2.36.27794

Plassmann, H., Ramsøy, T. Z., & Milosavljevic, M. (2012). Branding the brain: A critical review and outlook. *Journal of Consumer Psychology*, *22*(1), 18–36. https://doi.org/10.1016/j.jcps.2011.11.010

Plichta, M. M., Schwarz, A. J., Grimm, O., Morgen, K., Mier, D., Haddad, L., Gerdes, A. B. M., Sauer, C., Tost, H., Esslinger, C., Colman, P., Wilson, F., Kirsch, P., & Meyer-Lindenberg, A. (2012). Test-retest reliability of evoked BOLD signals from a cognitive-emotive fMRI test battery. *NeuroImage*, *60*(3), 1746–1758. https://doi.org/10.1016/j.neuroimage.2012.01.129

Poldrack, R. A., Baker, C. I., Durnez, J., Gorgolewski, K. J., Matthews, P. M., Munafò, M. R., Nichols, T. E., Poline, J.-B., Vul, E., & Yarkoni, T. (2017). Scanning the horizon: Towards transparent and reproducible neuroimaging research. *Nature Reviews. Neuroscience*, *18*(2), 115–126. https://doi.org/10.1038/nrn.2016.167

Postman, L., Bruner, J. S., & McGinnies, E. (1948). Personal values as selective factors in perception. *The Journal of Abnormal and Social Psychology*, *43*(2), 142–154. https://doi.org/10.1037/h0059765

Potter, R. F., & Bolls, P. D. (2012). *Psychophysiological measurement and meaning: Cognitive and emotional processing of media* (pp. xxiii, 285). Routledge/Taylor & Francis Group. https://doi.org/10.4324/9780203181027

Power, J. D., Mitra, A., Laumann, T. O., Snyder, A. Z., Schlaggar, B. L., & Petersen, S. E. (2014). Methods to detect, characterize, and remove motion artifact in resting state fMRI. *NeuroImage*, *84*, 320–341. https://doi.org/10.1016/j.neuroimage.2013.08.048

Pozharliev, R., Verbeke, W. J. M. I., & Bagozzi, R. P. (2017). Social Consumer Neuroscience: Neurophysiological Measures of Advertising Effectiveness in a Social Context. *Journal of Advertising*. https://www.tandfonline.com/doi/abs/10.1080/00913367.2017.1343162

Rameson, L., & and Lieberman, M. D. (2007). Thinking about the Self from a Social Cognitive Neuroscience Perspective. *Psychological Inquiry*, *18*(2), 117–122. https://doi.org/10.1080/10478400701416228

Ramsøy, T. Z. (2019). Building a Foundation for Neuromarketing And Consumer Neuroscience Research: How Researchers Can Apply Academic Rigor To the Neuroscientific Study of Advertising Effects. *Journal of Advertising Research*, *59*(3), 281–294. https://doi.org/10.2501/JAR-2019-034

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences, 98*(2), 676–682. https://doi.org/10.1073/pnas.98.2.676

Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *PsychologicalBulletin*, *114*(3), 510–532. https://doi.org/10.1037/0033-2909.114.3.510

Rathbone, C. J., & Moulin, C. J. A. (2024). Understanding the relationship between self and memory through the IAM task. *Memory*, *32*(6), 803–818. https://doi.org/10.1080/09658211.2024.2382285

Raufeisen, X., Wulf, L., Köcher, S., Faupel, U., & Holzmüller, H. H. (2019). Spillover effects in marketing: Integrating core research domains. *AMS Review*, *9*(3–4), 249–267. https://doi.org/10.1007/s13162-019-00143-x

Reimann, M., Schilke, O., Weber, B., Neuhaus, C., & Zaichkowsky, J. (2011). Functional magnetic resonance imaging in consumer research: A review and application. *Psychology & Marketing*, *28*(6), 608–637. https://doi.org/10.1002/mar.20403

Riefer, P. S., Prior, R., Blair, N., Pavey, G., & Love, B. C. (2017). Coherency Maximizing Exploration in the Supermarket. *Nature Human Behaviour*, *1*, 0017. https://doi.org/10.1038/s41562-016-0017

Riemer, H., & and Noel, H. (2021). The effect of emotionally-arousing ad appeals on memory: Time and fit matter. *International Journal of Advertising*, *40*(7), 1024–1046. https://doi.org/10.1080/02650487.2020.1822670

Robinson, H., Wysocka ,Anna, & and Hand, C. (2007). Internet advertising effectiveness: The effect of design on click-through rates for banner ads. *International Journal of Advertising*, *26*(4), 527–541. https://doi.org/10.1080/02650487.2007.11073031

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*(9), 677–688. https://doi.org/10.1037/0022-3514.35.9.677

Rolls, E. T. (2023). Emotion, motivation, decision-making, the orbitofrontal cortex, anterior cingulate cortex, and the amygdala. *Brain Structure & Function*, *228*(5), 1201–1257. https://doi.org/10.1007/s00429-023-02644-9

Rossiter, J. R., & Bellman, S. (1999). A Proposed Model for Explaining and Measuring Web Ad Effectiveness. *Journal of Current Issues & Research in Advertising*, *21*(1), 13–31. https://doi.org/10.1080/10641734.1999.10505086

Rossiter, J. R., & Eagleson, G. (1994). Conclusions from the ARF's Copy Research Validity Project. *Journal of Advertising Research*, *34*(3), 19–32.

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2004). Attentional control and self-regulation. In *Handbook of self-regulation: Research, theory, and applications* (pp. 283–300). The Guilford Press.

Rugg, M. D., & Vilberg, K. L. (2013). Brain networks underlying episodic memory retrieval. *Current Opinion in Neurobiology*, *23*(2), 255–260. https://doi.org/10.1016/j.conb.2012.11.005

Rushmore, R. J., Bouix, S., Kubicki, M., Rathi, Y., Yeterian, E., & Makris, N. (2022). HOA2.0-ComPaRe: A next generation Harvard-Oxford Atlas comparative parcellation reasoning method for human and macaque individual brain parcellation and atlases of the cerebral cortex. *Frontiers in Neuroanatomy*, *16*. https://doi.org/10.3389/fnana.2022.1035420

Rushworth, M. F. S., Noonan, M. P., Boorman, E. D., Walton, M. E., & Behrens, T. E. (2011). Frontal Cortex and Reward-Guided Learning and Decision-Making. *Neuron*, *70*(6), 1054–1069. https://doi.org/10.1016/j.neuron.2011.05.014

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Sabatinelli, D., Bradley, M. M., Fitzsimmons, J. R., & Lang, P. J. (2005). Parallel amygdala and inferotemporal activation reflect emotional intensity and fear relevance. *NeuroImage*, *24*(4), 1265–1270. https://doi.org/10.1016/j.neuroimage.2004.12.015

Sabatinelli, D., Frank, D. W., Wanger, T. J., Dhamala, M., Adhikari, B. M., & Li, X. (2014). The timing and directional connectivity of human frontoparietal and ventral visual attention networks in emotional scene perception. *Neuroscience*, *277*, 229–238. https://doi.org/10.1016/j.neuroscience.2014.07.005

Sahni, N. S., Wheeler, S. C., & Chintagunta, P. (2018). Personalization in email marketing: The role of noninformative advertising content. *Marketing Science*, *37*(2), 236–258. https://doi.org/10.1287/mksc.2017.1066

Salthouse, T. (2012). Consequences of age-related cognitive declines. *Annual Review of Psychology*, *63*, 201–226. https://doi.org/10.1146/annurev-psych-120710-100328

Santoso, I., Wright, M. J., Trinh, G., & Avis, M. (2021). Mind the attention gap: How does digital advertising impact choice under low attention? *European Journal of Marketing*, *56*(2), 442–466. https://doi.org/10.1108/EJM-01-2021-0031

Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: The role of the temporo-parietal junction in “theory of mind.” *NeuroImage, 19*(4), 1835–1842. https://doi.org/10.1016/S1053-8119(03)00230-1

Saxe, R., Brett, M., & Kanwisher, N. (2006). Divide and conquer: A defense of functional localizers. *NeuroImage*, *30*(4), 1088–1096; discussion 1097-1099. https://doi.org/10.1016/j.neuroimage.2005.12.062

Schacter, D. L., Addis, D. R., Hassabis, D., Martin, V. C., Spreng, R. N., & Szpunar, K. K. (2012). The future of memory: Remembering, imagining, and the brain. *Neuron*, *76*(4), 677–694. https://doi.org/10.1016/j.neuron.2012.11.001

Schall, J. D. (2004). On the role of frontal eye field in guiding attention and saccades. *Vision Research*, *44*(12), 1453–1467. https://doi.org/10.1016/j.visres.2003.10.025

Schmitz, T. W., & Johnson, S. C. (2007). Relevance to self: A brief review and framework of neural systems underlying appraisal. *Neuroscience and Biobehavioral Reviews*, *31*(4), 585–596. https://doi.org/10.1016/j.neubiorev.2006.12.003

Schumann, J. H., von Wangenheim, F., & Groene, N. (2014). Targeted Online Advertising: Using Reciprocity Appeals to Increase Acceptance among Users of Free Web Services. *Journal of Marketing*, *78*(1), 59–75. https://doi.org/10.1509/jm.11.0316

Schurz, M., Radua, J., Aichhorn, M., Richlan, F., & Perner, J. (2014). Fractionating theory of mind: A meta-analysis of functional brain imaging studies. *Neuroscience & Biobehavioral Reviews, 42*, 9–34. https://doi.org/10.1016/j.neubiorev.2014.01.009

Segijn, C. M., & and van Ooijen, I. (2022). Differences in consumer knowledge and perceptions of personalized advertising: Comparing online behavioural advertising and synced advertising. *Journal of Marketing Communications*, *28*(2), 207–226. https://doi.org/10.1080/13527266.2020.1857297

Sharot, T., Martino, B. D., & Dolan, R. J. (2009). How Choice Reveals and Shapes Expected Hedonic Outcome. *Journal of Neuroscience*, *29*(12), 3760–3765. https://doi.org/10.1523/JNEUROSCI.4972-08.2009

Shehu, E., Bijmolt, T. H. A., & Clement, M. (2016). Effects of likeability dynamics on consumers' intention to share online video advertisements. *Journal of Interactive Marketing*, *35*, 27–43. https://doi.org/10.1016/j.intmar.2016.01.001

Shrager, Y., & Squire, L. R. (2009). Medial temporal lobe function and human memory. In *The cognitive neurosciences, 4th ed* (pp. 675–690). Massachusetts Institute of Technology. https://doi.org/10.7551/mitpress/8029.003.0060

Sikora, S., Kuiken, D., & Miall, D. S. (2011). Expressive reading: A phenomenological study of readers' experience of Coleridge's The rime of the ancient mariner. *Psychology of Aesthetics, Creativity, and the Arts*, *5*(3), 258–268. https://doi.org/10.1037/a0021999

Sirgy, M. J. (2018). Self-congruity theory in consumer behavior: A little history. *Journal of Global Scholars of Marketing Science*, *28*(2), 197–207.

Sokolov, E. N., & Cacioppo, J. T. (1997). Orienting and defense reflexes: Vector coding the cardiac response. In *Attention and orienting: Sensory and motivational processes* (pp. 1–22). Lawrence Erlbaum Associates Publishers.

Spaniol, J., Davidson, P. S. R., Kim, A. S. N., Han, H., Moscovitch, M., & Grady, C. L. (2009). Event-related fMRI studies of episodic encoding and retrieval: Meta-analyses using activation likelihood estimation. *Neuropsychologia*, *47*(8), 1765–1779. https://doi.org/10.1016/j.neuropsychologia.2009.02.028

Spreng, R. N., & Grady, C. L. (2010). Patterns of brain activity supporting autobiographical memory, prospection, and theory of mind, and their relationship to the default mode network. *Journal of Cognitive Neuroscience*, *22*(6), 1112–1123. https://doi.org/10.1162/jocn.2009.21282

Stephens, N. (1991). Cognitive Age: A Useful Concept for Advertising? *Journal of Advertising*, *20*(4), 37–48.

Stern, C. E., Corkin, S., González, R. G., Guimaraes, A. R., Baker, J. R., Jennings, P. J., Carr, C. A., Sugiura, R. M., Vedantham, V., & Rosen, B. R. (1996). The hippocampal formation participates in novel picture encoding: Evidence from functional magnetic resonance imaging. *Proceedings of the National Academy of Sciences of the United States of America*, *93*(16), 8660–8665.

Strycharz, J., van Noort, G., Smit, E., & Helberger, N. (2019). Protective behavior against personalized ads: Motivation to turn personalization off. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, *13*(1). https://doi.org/10.5817/CP2019-2-1

Su, C., Zhou, H., Gong, L., Teng, B., Geng, F., & Hu, Y. (2021). Viewing personalized video clips recommended by TikTok activates default mode network and ventral tegmental area. *NeuroImage*, *237*, 118136. https://doi.org/10.1016/j.neuroimage.2021.118136

Sui, J., He, X., & Humphreys, G. W. (2012). Perceptual effects of social salience: Evidence from self-prioritization effects on perceptual matching. *Journal of Experimental Psychology. Human Perception and Performance*, *38*(5), 1105–1117. https://doi.org/10.1037/a0029792

Sui, J., & Humphreys, G. W. (2015). The Integrative Self: How Self-Reference Integrates Perception and Memory. *Trends in Cognitive Sciences*, *19*(12), 719–728. https://doi.org/10.1016/j.tics.2015.08.015

Sui, J., & Rotshtein, P. (2019). Self-prioritization and the attentional systems. *Current Opinion in Psychology*, *29*, 148–152. https://doi.org/10.1016/j.copsyc.2019.02.010

Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis. *Psychological Bulletin*, *121*(3), 371–394. https://doi.org/10.1037/0033-2909.121.3.371

Taylor, C. R. (2019). Over the Top, Connected, Programmatic and Addressable Television! What Does It All Mean? Definitions and a Call for Research. *International Journal of Advertising*, *38*(3), 343–344. https://doi.org/10.1080/02650487.2019.1599200

Thomas, L. A., & LaBar, K. S. (2005). Emotional arousal enhances word repetition priming. *Cognition and Emotion*, *19*(7), 1027–1047. https://doi.org/10.1080/02699930500172440

Thompson, K. G., Bichot, N. P., & Schall, J. D. (1997). Dissociation of Visual Discrimination From Saccade Programming in Macaque Frontal Eye Field. *Journal of Neurophysiology*, *77*(2), 1046–1050. https://doi.org/10.1152/jn.1997.77.2.1046

Tomkovick, C., Yelkur, R., & Christians, L. (2001). The USA's biggest marketing event keeps getting bigger: An in-depth look at Super Bowl advertising in the 1990s.

Journal of Marketing Communications, *7*(2), 89–108. https://doi.org/10.1080/13527260121725

Treisman, A. (1980). A feature integration theory of attention. *Cognitive Psychology*, *12*, 97–136.

Trivedi, M. A., Murphy, C. M., Goetz, C., Shah, R. C., Gabrieli, J. D. E., Whitfield-Gabrieli, S., Turner, D. A., & Stebbins, G. T. (2008). fMRI Activation Changes during Successful Episodic Memory Encoding and Recognition in Amnestic Mild Cognitive Impairment Relative to Cognitively Healthy Older Adults. *Dementia and Geriatric Cognitive Disorders*, *26*(2), 123–137. https://doi.org/10.1159/000148190

Ullsperger, M., Harsay, H. A., Wessel, J. R., & Ridderinkhof, K. R. (2010). Conscious perception of errors and its relation to the anterior insula. *Brain Structure & Function*, *214*(5–6), 629–643. https://doi.org/10.1007/s00429-010-0261-1

Uncapher, M. R., & Rugg, M. D. (2009). Selecting for memory? The influence of selective attention on the mnemonic binding of contextual information. *The Journal of Neuroscience*, *29*(25), 8270–8279. https://doi.org/10.1523/JNEUROSCI.1043-09.2009

Ur, B., Leon, P. G., Cranor, L. F., Shay, R., & Wang, Y. (2012). Smart, useful, scary, creepy: Perceptions of online behavioral advertising. *Proceedings of the Eighth Symposium on Usable Privacy and Security*, 1–15. https://doi.org/10.1145/2335356.2335362

van der Goot, M. J., van Reijmersdal, E. A., & Kleemans, M. (2015). Age differences in recall and liking of arousing television commercials. *Communications : The European Journal of Communication Research*, *40*. https://doi.org/10.1515/commun-2015-0013

van Doorn, J., & Hoekstra, J. C. (2013). Customization of online advertising: The role of intrusiveness. *Marketing Letters*, *24*(4), 339–351. https://doi.org/10.1007/s11002-012-9222-1 van Kesteren, M. T. R., Ruiter, D. J., Fernández, G., & Henson, R. N. (2012). How schema and novelty augment memory formation. *Trends in Neurosciences*, *35*(4), 211–219. https://doi.org/10.1016/j.tins.2012.02.001

Van Slyke, C., Shim, J. T., Johnson, R., & Jiang, J. J. (2006). Concern for Information Privacy and Online Consumer Purchasing. *Journal of the Association for Information Systems*, *7*(6). https://doi.org/10.17705/1jais.00092

van Veen, V., Cohen, J. D., Botvinick, M. M., Stenger, V. A., & Carter, C. S. (2001). Anterior Cingulate Cortex, Conflict Monitoring, and Levels of Processing. *NeuroImage*, *14*(6), 1302–1308. https://doi.org/10.1006/nimg.2001.0923

Varkevisser, T., Geuze, E., van den Boom, M. A., Kouwer, K., van Honk, J., & van Lutterveld, R. (2023). Pattern classification based on the amygdala does not predict an individual's response to emotional stimuli. *Human Brain Mapping*, *44*(12), 4452–4466. https://doi.org/10.1002/hbm.26391

Vecchiato, G., Maglione, A. G., Cherubino, P., Wasikowska, B., Wawrzyniak, A., Latuszynska, A., Latuszynska, M., Nermend, K., Graziani, I., Leucci, M. R., Trettel, A., & Babiloni, F. (2014). Neurophysiological tools to investigate consumer's gender differences during the observation of TV commercials. *Computational and Mathematical Methods in Medicine*, *2014*, 912981. https://doi.org/10.1155/2014/912981

Venkatraman, V., Dimoka, A., Pavlou, P. A., Vo, K., Hampton, W., Bollinger, B., Hershfield, H. E., Ishihara, M., & Winer, R. S. (2015). Predicting Advertising success beyond Traditional Measures: New Insights from Neurophysiological Methods and Market Response Modeling. *Journal of Marketing Research*, *52*(4), 436–452. https://doi.org/10.1509/jmr.13.0593

Viskontas, I. V., Quiroga, R. Q., & Fried, I. (2009). Human medial temporal lobe neurons respond preferentially to personally relevant images. *Proceedings of the National Academy of Sciences*, *106*(50), 21329–21334. https://doi.org/10.1073/pnas.0902319106

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Sciences*, *9*(12), 585–594. https://doi.org/10.1016/j.tics.2005.10.011

Wagner, A. D., Schacter, D. L., Rotte, M., Koutstaal, W., Maril, A., Dale, A. M., Rosen, B. R., & Buckner, R. L. (1998). Building Memories: Remembering and Forgetting of Verbal Experiences as Predicted by Brain Activity. *Science*, *281*(5380), 1188–1191. https://doi.org/10.1126/science.281.5380.1188

Wais, P. E., Squire, L. R., & Wixted, J. T. (2010). In Search of Recollection and Familiarity Signals in the Hippocampus. *Journal of Cognitive Neuroscience*, *22*(1), 109. https://doi.org/10.1162/jocn.2009.21190

Walker, D., & Dubitsky, T. M. (1994). Why liking matters. *Journal of Advertising Research*, *34*(3), 9–18.

Wang, J., & Calder, B. J. (2006). Media Transportation and Advertising. *Journal of Consumer Research*, *33*(2), 151–162. https://doi.org/10.1086/506296

Wang, Z., & Lang, A. (2012). Reconceptualizing excitation transfer as motivational activation changes and a test of the television program context effects. *Media Psychology*, *15*(1), 68–92. https://doi.org/10.1080/15213269.2011.649604

Waskom, M. L., Kumaran, D., Gordon, A. M., Rissman, J., & Wagner, A. D. (2014). Frontoparietal Representations of Task Context Support the Flexible Control of Goal-Directed Cognition. *Journal of Neuroscience*, *34*(32), 10743–10755. https://doi.org/10.1523/JNEUROSCI.5282-13.2014

Watson, D., Wiese, D., Vaidya, J., & Tellegen, A. (1999). The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *Journal of Personality and Social Psychology*, *76*(5), 820–838. https://doi.org/10.1037/0022-3514.76.5.820

Whelan, M. E., Morgan, P. S., Sherar, L. B., Orme, M. W., & Esliger, D. W. (2017). Can functional magnetic resonance imaging studies help with the optimization of health messaging for lifestyle behavior change: A systematic review. *Preventive Medicine, 99*, 185–196. https://doi.org/10.1016/j.ypmed.2017.02.004

Wickens, C. D. (1991). Processing resources and attention. In *Multiple Task Performance*. CRC Press.

Wijaya, B. (2012). The Development of Hierarchy of Effects Model in Advertising. *International Research Journal of Business Studies*. https://www.semanticscholar.org/paper/The-Development-of-Hierarchy-of-Effects-Model-in-Wijaya/0fbb577064039b3b9ba4a34b0ba4dbf621f3238a

Wilson, R., Baack, D., & Till, B. (2015). Creativity, attention and the memory for brands: An outdoor advertising field study. *International Journal of Advertising*, *34*, 232–261. https://doi.org/10.1080/02650487.2014.996117

Winter, S., Maslowska, E., & Vos, A. L. (2021). The effects of trait-based personalization in social media advertising. *Computers in Human Behavior*, *114*, 106525. https://doi.org/10.1016/j.chb.2020.106525

Worsley, K. J., & Friston, K. J. (1995). Analysis of fMRI time-series revisited—Again. *NeuroImage*, *2*(3), 173–181. https://doi.org/10.1006/nimg.1995.1023

Wu, D., Deng, H., Xiao, X., Zuo, Y., Sun, J., & Wang, Z. (2017). Persistent Neuronal Activity in Anterior Cingulate Cortex Correlates with Sustained Attention in Rats

Regardless of Sensory Modality. *Scientific Reports*, *7*(1), 43101. https://doi.org/10.1038/srep43101

Yankouskaya, A., Bührle, R., Lugt, E., Stolte, M., & Sui, J. (2020). Intertwining personal and reward relevance: Evidence from the drift-diffusion model. *Psychological Research*, *84*(1), 32–50. https://doi.org/10.1007/s00426-018-0979-6

Yegiyan, N. S. (2015). Explicating the emotion spillover effect: At the intersection of motivational activation, resource allocation, and consolidation. *Journal of Media Psychology: Theories, Methods, and Applications*, *27*(3), 134–145. https://doi.org/10.1027/1864-1105/a000164

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*(5), 459–482. https://doi.org/10.1002/cne.920180503

Yoo, C. Y. (2007). Implicit Memory Measures for Web Advertising Effectiveness. *Journalism & Mass Communication Quarterly*, *84*(1), 7–23. https://doi.org/10.1177/107769900708400102

Yu, U.-J. (2022). Exploring Effects of Self-Evaluative and Motivational Schema in Appearance on Advertising Effectiveness in Fashion Ads. *Clothing and Textiles Research Journal*, *40*(2), 123–138. https://doi.org/10.1177/0887302X20937793

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology*, *9*(2, Pt.2), 1–27. https://doi.org/10.1037/h0025848

Zillmann, D. (1971). Excitation transfer in communication-mediated aggressive behavior. *Journal of Experimental Social Psychology*, *7*(4), 419–434. https://doi.org/10.1016/0022-1031(71)90075-8

Zillmann, D. (2008). Excitation Transfer Theory. In *The International Encyclopedia of Communication*. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781405186407.wbiece049