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Addressable TV Advertising Enhances Advertising Effectiveness

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Abstract. *As TV consumption evolves from traditional linear programming to more on-demand viewing, advertising is also changing, seeking to tailor content to best match the interests of viewers. Addressable advertising is an interactive form of advertising that combines online data personalization with on-demand TV content with the aim of addressing individual viewers and improving advertising outcomes. This study investigated whether audience engagement with advertising (indexed by self-report liking, attention, and memory for an advertisement) was affected by addressability and the screen size on which the content was viewed. Using a limited capacity model of information processing and the elaboration likelihood model as its theoretical bases as well as a physiological measure of attention, we found that people both prefer and remember addressable advertisements more than those that are not relevant to them. In addition, viewing advertisements on large screens improved attention and retention for the content relative to smaller screens.*

Keywords: *memory, attention, engagement, mouse tracking, heart rate, addressable advertising, screen size*

1. Introduction

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, TV advertisers are calling for more effective methods to reach and engage their audiences. The new, emerging platform, referred to as *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. Although academic literature on the subject of addressable advertising is still very limited, the technology behind the concept seems to have tremendous potential for increasing the value of TV advertising and lowering costs for marketers.

Addressable TV advertising refers to a selective delivery of personalised advertising messages to individual households based on their personal data (Finecast, 2021). The addressable approach offers marketers the possibility to expose TV viewers with the most relevant messages at an appropriate time, by using available data about the consumers' screening device, household demographics, location etc. For instance, it can avoid a situation where single, childless consumers are exposed to ads for diapers and baby food while ensuring that parents of young children are. In contrast, traditional advertising, which has been dominant for many decades, is characterised as a mass-market, one-size-fits-all approach, designed to reach a large and unfragmented audi-

ence at a lower cost. The migration towards addressable advertising rests on the widely held presumption that targeting improves effectiveness of media communication.

Existing findings linked to the outcomes of personalised advertising fall into two opposing camps. Some scholars claim that consumers perceive targeted ads as more relevant, motivating, and appealing (Tucker, 2014). This view is empirically supported by studies revealing positive attitudes towards personalised advertising (Maslowska et al., 2011), higher click-through rates online (Yan et al., 2009) and increased purchase decision-making (Goldfarb & Tucker, 2012). In practice, advertising practitioners have found that addressable TV can considerably improve a campaign's impact by lowering channel switching, increasing resonance of brand messaging, improving recall, and enhancing purchase intent (Sky, 2019). In contrast, an increasing body of research shows that targeted advertising has potential to have the reverse effect if consumers perceive the content to be too personalised (Aguirre et al., 2015; Rosenthal et al., 2019). Consumers' feelings of privacy invasion lead to a drop in purchasing behaviour (Bambauer-Sachse & Heinzle, 2018) and an increase in ad avoidance (Baek & Morimoto, 2012). With such conflicting evidence, it is important to further investigate consumers' conscious and sub-conscious perceptions of addressable advertising.

As an advertising medium, not only can modern television reach a wide variety of audiences, 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. Generally, previous studies have found larger screens to produce higher emotional arousal and greater levels of attention (Reeves et al., 1999), better recall (Detenber & Reeves, 1996) and a greater feeling of immersion (Kim & Sundar, 2016). Media communication literature has evaluated information processing on small screens of handheld devices compared to larger laptop screens and found that smartphone-size screens constrain information processing (Dunaway & Soroka, 2021). With the rise in the use of hand-held devices (Pew Research Center, 2019b), it is important to know if TV advertising is perceived differently on screens of different sizes.

Many research techniques are currently used both by marketing practitioners and academics to create effective ads as well as evaluate their effectiveness. These methods range from traditional approaches such as focus groups and other self-report measures, to more complex autonomic and neuroimaging techniques (Ariely & Berns, 2010; Eijlers et al., 2020; Poels & Dewitte, 2006). In this study, we aim to examine the effects of addressability and screen size on audience engagement with TV advertising. We operationally define engagement as the level of attention, memory recall and liking towards an advertisement and assess it using both explicit and implicit physiological measurements. This study uses the elaboration likelihood model (ELM; Petty & Cacioppo, 1986) and the limited capacity model for motivated mediated processing (LC4MP; Lang, 2000, 2006, 2017) to explain findings in television advertising. The results can help marketing practitioners in the design of more effective TV advertisements, as well

as provide guidance about how the growing use of hand-held devices is influencing the effectiveness of their ads.

2. Theoretical Background

2.1 Consumer Neuroscience

The application of neuroscientific methods to consumer research, and in particular advertising, has significantly grown over the past decades in academic research and commercial practice (Plassmann et al., 2012). Traditionally, marketing and advertising research has used self-report measures, predominantly interviews, surveys, and focus groups, to assess and understand consumer attitudes and behaviour when exposed to advertising (Carrington et al., 2014; Plassmann et al., 2012). These techniques capture conscious responses and largely depend on the willingness and ability of consumers to self-evaluate their levels of attention, preferences, recall, or purchase intentions in relation to an advertising message. Although these simpler approaches are cheap and easy to implement, they provide incomplete and biased data due to multiple subconscious influences (Day, 1975; Griffin & Hauser, 1993; Kahneman, 2011). In search for more accurate measures, academic and business research has turned to techniques from psychology and neuroscience to study dimensions of advertising effectiveness. Consumer neuroscience, the integration of neurophysiological and biological methods in consumer research, offers an insight into consumers' cognitive and affective processes and thus can be used to complement traditional self-reported measures, overcoming many of their weaknesses (Ariely & Berns, 2010). Consumer behavior, marketing and advertising scholars are increasingly employing theories and methods from cognitive and affective neuroscience to inform their practice. Today, consumer neuroscience is commonly used to better understand the mind, brain and behavior of consumers including the role that mechanisms such as self-relevance, self-interest, memory or emotional engagement play in the success of marketing tools (Hubert & Kenning, 2008; Sánchez-Fernández et al., 2021). Furthermore, neurophysiological methods allow for the moment-by-moment collection of data, capturing the dynamic nature of television advertising (Venkatraman et al., 2012).

Prior to investing substantial amounts of money on the release of an advertisement, it is sometimes useful to measure consumers' engagement with it. Consumer engagement is a complex concept that includes consumers' attitude towards the advertisement, as well as levels of focused attention and subsequent recall, all of which have been found to be important indicators of advertising effectiveness (Baldo et al., 2022; Shapiro & Shanker Krishnan, 2013; Venkatraman et al., 2015). However, little is known about how personally addressing TV ads can influence consumer engagement. Similarly, with the rise of smartphone use, the question of whether screen size influences consumer engagement with advertising remains under-investigated but is crucial to consider when creating media content.

2.2 Consumer Engagement

Consumer engagement (also, audience engagement) has generated a growing body of studies since its first conceptualisation in consumer research and marketing (Brodie et al., 2011; Pansari & Kumar, 2017). Consumer engagement 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) but audience engagement more generally is defined differently across the literature (Beymer et al., 2018; Fredricks et al., 2014). So how do we operationalise and measure audience engagement? In some scientific literature, engagement refers to one's level of exerted cognitive operations such as effort, attention or agency when carrying out a task (Beymer et al., 2018; Richardson et al., 2020), while in others it refers more generally to participation in tasks and activities (Finn & Zimmer, 2012; Fredricks et al., 2014). In this paper, we measure audience engagement using behavioural data to measure people's liking and memory and using physiological data (heart rate) as an implicit measure of externally focused attention to understand audience experience with advertising.

Simply put, decreased heart rate can act as an indicator of enhanced external focus and attention and can serve as an indirect measure of cognitive and emotional engagement (Jola et al., 2011). Linking heart rate to specific cognitive states, however, is not straightforward. Andreassi (2007) claimed that heart rates increase when people focus more on internal information, while others have demonstrated that lowered heart rates are associated with a greater external focus and greater ability to encode external information (De Pascalis et al., 1995; Jennings, 1992).

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 we 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.

2.3 Addressable Advertising

Defined as "technologies that selectively deliver advertising messages to individual households via an internet-connected 'smart' TV, cable, satellite, or other set-top box" (Broussard, 2019), addressable TV is designed to personalize each viewer's experience to increase receptivity and engagement. With the total TV advertising spending in the UK increasing by 24 percent from 2020 to 2021, hitting a record level of £5.46 billion British pounds (Statista, 2021), marketers are increasingly expressing interest in personalised advertising. Delivering ads that directly address an audience of interest based on their household data not only enables companies to maximise the return on their investment, but also promises to improve value for consumers. With access to a

wide range of targeting segments, from socioeconomic to location to life stage data, addressable advertising allows advertisers to deliver TV ads tailored to different viewers watching the same content (Malthouse et al., 2018).

Although advertising message tailoring can have favourable outcomes for marketers (Chung et al., 2016), literature related to consumer responses to this strategy falls into two opposing camps. Some scholars claim that consumers find tailored advertising messages to be more relevant, appealing, and motivating (Tucker, 2014). Empirical studies have supported this perspective by demonstrating that personalisation in advertising can increase its usefulness (Bleier & Eisenbeiss, 2015), improve attitude towards the ad (Li & Liu, 2017), and lead to a more positive evaluation of the message (Maslowska et al., 2011). Other studies have demonstrated that high levels of personalisation have the potential to backfire if consumers feel like their freedom of choice is being compromised (White et al., 2008) or they feel like their privacy is being invaded (Rosenthal et al., 2019). Feeling like one's privacy is invaded can lead to a drop in buying behaviour (Bambauer-Sachse & Heinzle, 2018) and an increase in ad avoidance (Baek & Morimoto, 2012). Because addressable TV typically relies on basic demographic data, rather than more invasive information such as recent search history, we hypothesize it will produce an uplift in audience engagement.

The benefits of relevant messaging can be understood in terms of 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 suggest that cognitive processing is highly dependent on an individual's ability and motivation to process incoming information. The ELM suggests that several factors affect the ability to process information, such an individual's availability of cognitive resources, level of relevant knowledge, and need for cognition. The motivation to attend to a message also affects message processing. In particular, according to ELM, personally relevant information is more likely to lead to a central processing route, which means that information is processed more deeply and is more persuasive, and consequently allows the individual to form stronger attitudes towards it. The tailored information in addressable TV advertisements may be perceived as personally relevant and engage self-referential processing, which in turn would improve cognitive processing, learning and memory for the advertisements (Chua et al., 2011). According to LC4MP, 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. However, if the incoming message is relevant to the individual, then information processing will increase, memory encoding will improve, and the message has a greater likelihood of being more persuasive (Kranzler et al., 2019). Consistent with this claim, Campbell and Wright (2008) tested the influence of message relevance in the context of online advertising and found that personally relevant ads significantly improved participants' attitudes towards the mes-

sage. In contrast, when a message induced cognitive overload, Srivastava (2013) found that people were less able to encode the message. In other words, theoretical accounts converge to suggest that increasing personal relevance in TV advertising will increase the saliency of the message and stimulate motivational activation to attend to it, resulting in deeper processing.

The effectiveness of tailored vs. non-tailored messaging has been explored outside of advertising. For example, studies have found that tailoring health messages to personal values, preferences and characteristics increased the perceived relevance of the information and enhanced the motivation to attend to the message (Jensen et al., 2012; Kreuter & Wray, 2003). Some meta-analyses on the outcomes of tailored smoking cessation programmes demonstrated that intensive tailored health campaigns also led to greater learning and memory in participants (Hartmann-Boyce et al., 2014; Noar et al., 2008). Further, a neuroimaging study demonstrated that personalised nutritional messages are significantly more effective in changing dietary behaviour compared to one-size-fits-all messages (Casado-Aranda & Sanchez-Fernandez, 2022). The authors of the paper detected activation of brain regions linked to self-related processing (namely, dorsomedial prefrontal cortex, angular gyrus, and precuneus) as well as brain regions that play a key role in memory encoding (hippocampus and medial temporal lobe) during tailored nutritional messages compared to traditional messages. The role of self-relevance for effective health messaging is also supported by studies demonstrating stronger activity in the medial prefrontal cortex and precuneus for tailored compared to non-tailored anti-smoking campaigns (Chua et al., 2009). Taken together, these results may indicate that greater effectiveness of personalised messages stems from their greater psychological self-relevance and deeper processing engaged in the audience. As a result, we hypothesize that audience engagement will be greater with addressable TV advertisements relative to non-addressable ads, as indexed by explicit liking ratings, improved recall for the ads, and greater external focus.

2.4 Screen Size

TV programming is no longer limited to large screen viewings in living rooms. Instead, the same content can be consumed across many different devices and screens of different sizes. The ubiquity of handheld devices combined with improvements in network connectivity and speed means that on-the-go media consumption is growing in popularity and smartphones have become a key medium through which TV and TV advertisements are viewed. In general, larger screens are known to create a more emotional and intense experience (Kim, 1997). For example, Reeves and colleagues (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 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), big screens produced greater memory recall, greater physiological response, and subjects 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). These results indicate that larger screens facilitate information processing, whilst smaller screens may limit cognitive access to content.

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 and colleagues (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, we hypothesize that audience engagement will be greater with TV advertisements shown on larger screens vs. smaller screens, indexed by explicit liking ratings, improved recall for the ads, and greater external focus.

3. Method

3.1 Participants

A total of 78 people (39 F, 39 M, aged 18–65) volunteered for this experiment. They were recruited by the market research company DRG (Newcastle, UK) via a pre-screening process designed to identify individuals who fit exactly two of the four addressability categories: gender, family, cars, and mobiles. We selected these categories of products and services as they are commonly advertised on television and appeal to a

wide range of viewers. The first two were demographic categories, namely women and people with at least one child under the age of 13 living at home. The second two referred to an interest in cars or an intention to purchase either a new phone or new mobile contract within the next twelve months. 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 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 allows us 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 1

Participant Group Based on their Addressability Categories

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

Note. 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).

3.2 *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 will be 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 our 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 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 randomized 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.

3.3 Procedure

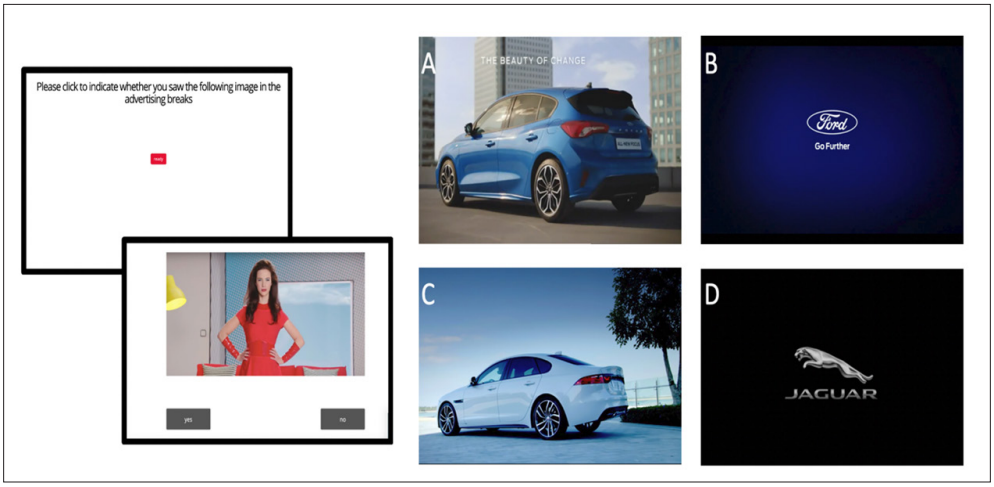
After reading information about the experiment, participants provided their consent to take part. They were fitted with an Empatica E4 wrist-worn device to record biometric signals including heart rate (HR) and electrodermal activity (EDA). The experiment began with participants watching a 4 minute 14 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 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) the 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. 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 1).

Figure 1

The Format of the Memory Test



Note. 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.

The second part of the experiment 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.

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.

3.4 Analysis

We 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). We 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 our models and express our results as probabilities of main effects being present (Makowski, 2018).

From 4000 samples we generated estimates of posterior distributions of the model parameter coefficients, which quantified the strength of evidence that each experimental condition influenced behaviour in a consistent way. Below we 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 we use the Maximum Probability of Effect (MPE). The MPE is the probability that the effect is positive or negative (depending on the median's direction). In other words, the MPE directly quantifies the likelihood that the manipulation condition had an effect on behaviour and physiology. We derived the MPE values 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. We used random effects for the participant, the advertisement and the show watched, and fixed effects for the addressability, screen size and advertisement category, specified as:

$$\text{Dependent variable} \sim \text{addressability} + \text{screen size} + \text{advertisement category} + \\ + (1 \mid \text{participant}) + (1 \mid \text{advertisement}) + (1 \mid \text{show watched})$$

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).

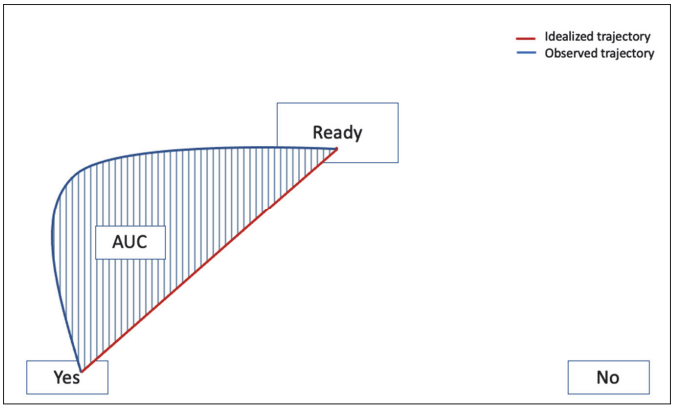
The sensors we used for collecting physiology data sometimes failed to record complete data, due to technical issues with the sensor, incorrect placement, the participant moving the wristband, and so on. After spotting and cleaning problematic recordings, we were left with 69 participants with complete heart rate data, but only 45 with complete electrodermal activity data, as it is much more sensitive to movement artifacts

and sensor failure. The electrodermal activity data above is not sufficient to draw any meaningful conclusions, 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-centered based on the baseline readings. That is, once we computed a mean heart rate value for a participant over an ad, we 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 us to focus on differences between addressability and screen-size conditions within each participants' data (Potter & Bolls, 2012).

To analyse the mouse-tracking, we used the *mousetrack* package (Coco & Duran, 2015) in R (version 3.4.3). In our analysis, we focused on a frequently used index *area under the curve* (AUC), which quantified the geometric area between the observed trajectory of the mouse cursor and a direct path. More direct mouse movements are reflected in a smaller AUC, and more indirect movements are reflected in an increased AUC (see Figure 2). For each trial, we quantified the reaction time (time from mouse cursor movement initiation to pressing of "yes/no" button) and the AUC for that movement.

Figure 2

An Example of Mouse-tracking in the Memory Test



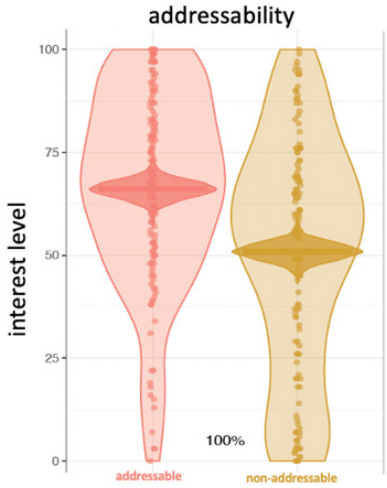
Note. After seeing an image on the screen and clicking the "Ready" box, participants saw the proposed response boxes. The area under the curve (AUC), shown as the hatched area and exaggerated in this diagram, is the area between the observed trajectory of the mouse cursor (blue curve) moving from the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

4. 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 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 3

Participants' Self-Rated Interest Level in Addressable and Non-Addressable Advertisements



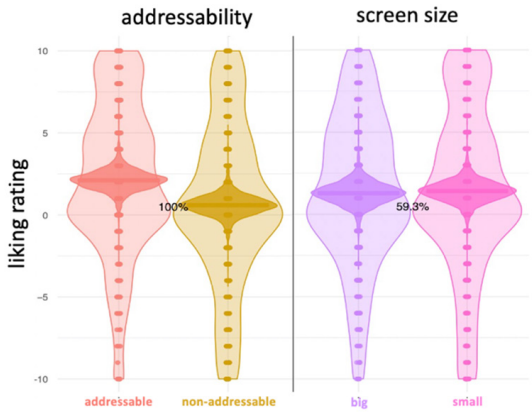
Note. If the addressability manipulation worked, then there should be a clear difference between the ratings for addressable and non-addressable ads. Indeed, there is strong evidence that participants were more interested in ads that were assigned to them as being relevant (shown in red on the left) 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%). Figure 4 presents the means and distributions for participants' self-report liking contrasting addressability conditions and screen size conditions.

Figure 4

Participants' Self-Rated Change in Level of Interest in the Seen Products or Services



Note. 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.

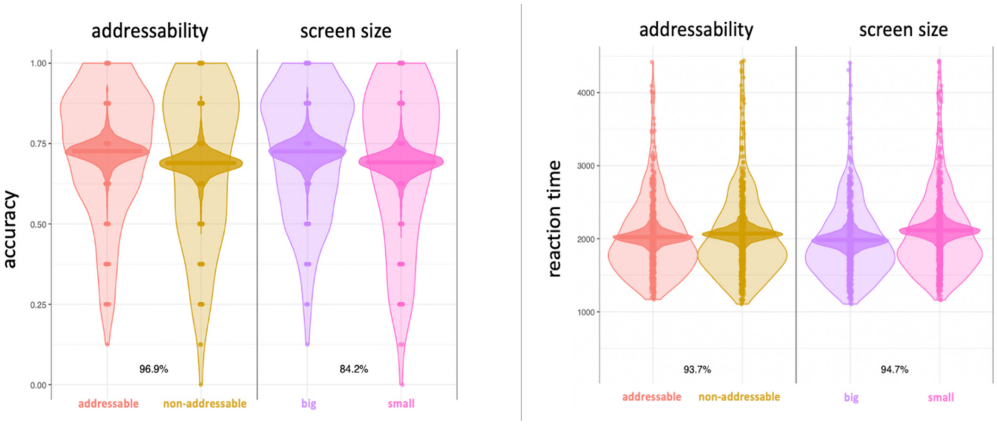
To measure conscious recall for the advertisements seen during the show, we examined participants' accuracy for images they had previously seen. There was strong evidence that responses on the memory test were more accurate for the addressable ads (73.1% accurate) than the non-addressable ads (69.2% accurate, MPE=96.9%, Figure 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 5b).

While accuracy indexes explicit recall for the ads, reaction times (RTs) can be used as an implicit measure of recollection, with faster responses indicating better recall. 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 5b), which means that subjects were significantly faster to recognize addressable ads than non-addressable ads. Similarly, response time evidence demonstrated strong evidence for lower reaction times for ads that had been previously 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 5

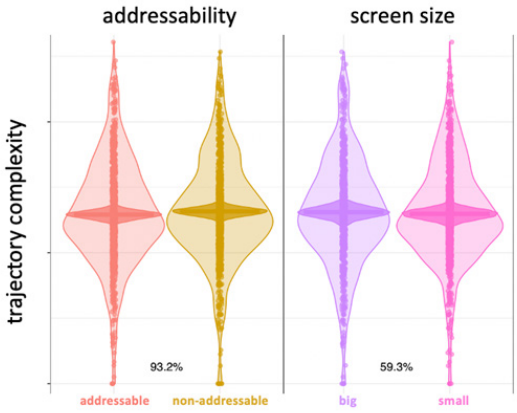
Participants' Accuracy and Reaction Time Scores on the Post-Experiment Memory Test



Note. 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.

Figure 6

Participants' Mouse Tracking Results



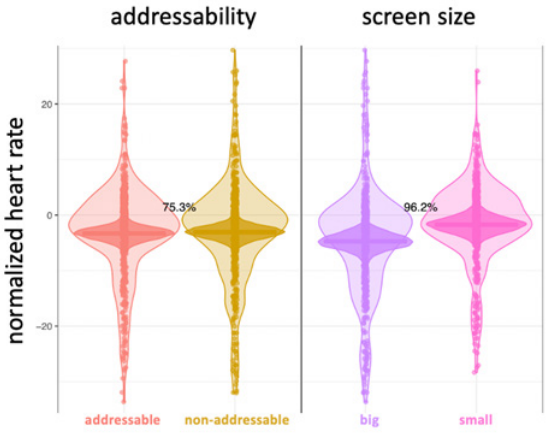
Note. Trajectory complexity is equivalent to the calculated AUC, with more uncertainty in a participant's response resulting in greater AUC and greater trajectory complexity.

As a second implicit measure of performance on the memory test, we used mouse tracking (Maldonado et al., 2019) to record the trajectory of participants' mouse movements. The difference between the measured mouse paths and a straight line to the response was considered an indicator of uncertainty with more complex trajectories indicating greater uncertainty. There was strong evidence that addressable ads produced more direct mouse trajectories (MPE=93.2%), however, there was no evidence for screen size having a meaningful effect on participants' mouse trajectories (MPE=59.3%, Figure 6). In other words, addressable ads were better remembered whether measured explicitly via accurate recall or implicitly as measured by RTs and mouse tracking.

Finally, we examined heart rate as an additional implicit physiological measure of engagement with the advertisements. For addressability, there was only weak evidence that participants' heart rates differed between addressable and non-addressable ads (MPE=75.3%, Figure 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. There was, however, strong evidence of an effect of screen size on heart rate (MPE=96.2%). Heart rates were lower by 2.7 bpm when individuals watched ads on a large screen than when watching on a handheld device, suggesting that participants were more externally focused when the screen was larger (Lacey & Lacey, 1980).

Figure 7

Participants' Mean-Centred Heart Rate



5. Discussion and Conclusion

In this study, we investigated the effects of addressability and screen size of television ads on audience engagement, an important measure of advertising effectiveness. We 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. Our study revealed that addressable TV advertisements

elicited greater ad recall and more ad liking compared to traditional, non-addressable, advertisements. Our findings also show that addressable advertisements elicited 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. We did not find any significant interactions between addressability and screen size, and therefore decided to focus on the two manipulations separately. We discuss the contributions that this study makes to the literature and marketing practitioners.

The current study sheds light on the effects of addressability and screen size upon consumer advertisement processing. There appear to be strong benefits to addressable advertising that include strong evidence that people both prefer and remember targeted advertisements more than those that are not relevant them. In addition, viewing advertisements on a larger sized screen appears to help increase motivation to attend to the message and improve retention for the content, relative to viewing on hand-held sized screens.

5.1 Theoretical Implications

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), our 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). Our 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 its content.

We also proposed that greater message addressability in TV advertisements may lead to greater externally focused attention in viewers, however, our heart rate findings did not fully support this hypothesis: addressability only resulted in a marginal increase in sustained attention. Typically, a reduction in heart rate is an indicator of increased allocation of cognitive resources to the message and in contrast, an increase in heart rate is a sign of resource allocation away from the message (Park & Bailey, 2018). The marginal heart rate deceleration that we observed in participants during addressable ads aligns with traditional communication theories, which argue that personally and motivationally relevant messages elicit greater resource allocation, which allows for their

gain and maintenance of attention and memory (Couwenberg et al., 2017). This agrees with findings from other research (Abercrombie et al., 2008) which show that heart rate deceleration in response to an image is associated with greater attention, deeper encoding and better subsequent recall for that image. Our findings also support ELM's (Petty & Cacioppo, 1986) premise that personally relevant messages lead to central route processing, which begins with the need for attention for the content, and then leads to the consumer thoroughly considering the advertisement's claims and comparing them to past experiences. Furthermore, by demonstrating greater memory encoding following heart-rate deceleration in response to addressable TV, the results are consistent with the LC4MP (Lang, 2000, 2006, 2017) claim that there is a limited pool of cognitive resources. From this perspective, the results of this study may be interpreted to indicate that due to enhanced availability of resources through motivational activation for more personally relevant ads, viewers engaged deeper processing to the point that it did not prevent the encoding of the message, but rather optimised it, as is often seen with tailored health messages (Casado-Aranda et al., 2022). Given that our findings suggest that the small effect of addressability on conscious attention accounts for a substantial effect on memory performance and explicit liking, future studies should investigate whether further processes mediate the effect of addressability on ad memory and attitude.

We 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 claimed that the greater sensory richness and realism brought on by large screen size may lead to split attention and cognitive overload (Lang, 2000), however, our 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 (Reeves et al., 1999; Lombard & Ditton, 1997), enabling easier cognitive access (Dunaway & Soroka, 2018), 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 and self-report; eye tracking and physiological measures show that people feel more engaged with stationary large screens (Szita & Rooney, 2021). Therefore, in a real-world setting, we would expect to find similar patterns to our 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. We 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 favoring larger displays, but only

for high resolution images, which signals that the difference may only become significant in the presence of increased image quality.

5.2 Practical Implications

Our research has important implications for practitioners in the media and advertising industry. We show that adding addressability to TV advertising leads to greater cognitive and emotional engagement in viewers, which may lead to more favorable behavioral outcomes, such as product purchase decision making. Industry professionals have highlighted a perception that TV advertising is getting expensive, however, our findings imply that it is possible to lower costs by narrowing down the target audience and not miss out on audience engagement, given the uplift that addressability offers. We also show that big screens should be getting significant consideration from agencies and brands, due to their superior impact on psychological processing of ads, despite the global increase in smartphone use and the temptation to migrate towards the digital and social media advertising space. Furthermore, we show that using implicit and explicit measures of audience engagement in response to TV advertisements may provide practitioners with more concrete insights on the mental states of consumers. Crucially, our results imply that the biometric measure reflecting externally focused attention could provide marketers with more guidance as to whether the advertisement will be attended to and remembered, and ultimately be effective. Overall, practitioners interested in increasing audience engagement and cost efficiencies would be wise to consider investing in addressable TV advertising. It is important to note that we did not investigate the effects of addressable advertising and screen size on behavioural outcomes, therefore we cannot directly establish whether the positive effects of the two advertising elements would lead to increased sales and profit.

5.3 Limitations and Possible Future Directions

We compared addressable and non-addressable advertisements based on only four categories of addressability, so we cannot rule out the possibility that the effects of addressability may not extend to other demographic or interest categories. It is worth noting that despite our manipulation check confirming that the manipulation of the variable was successful, the four categories were not equally effective. Specifically, of the four advertisement categories, the car and gender groups were more homogenous than the family and mobile phone groups. For example, the mobile category combined interest in a new mobile phone with interest in a new mobile network provider, and the family category contained a mix of products ranging from holidays to household items. Future studies may wish to test different ways to operationalise addressability to determine what best makes addressable ads relevant and what aspects are less effective.

A limitation of the measurement of heart rate is that participants are instructed not to move their hands freely to avoid movement of electrodes on the biometric device.

Such restriction in natural movement, paired with being in a laboratory environment, can make participants more aware of the experimental settings. That being said, we did take measures to ensure that the study was as ecologically valid as it could be. For instance, real advertisements for real brands were broadcasted throughout the TV show episode, and ad breaks were evenly distributed throughout the episode, just as the viewer would see them at home.

These limitations notwithstanding, to the best of our knowledge, our study may be the first to have measured psychophysiology to explore the effects of addressable vs. traditional TV advertising and large vs. small screens on viewer engagement. These results provide important insights for scholars interested in the theoretical implications of different elements of TV advertising, as well as for advertising practitioners seeking to enhance their TV advertising outcomes. We encourage replications across diverse samples of addressability categories to further generalise our findings. Future studies should also test whether placing an advertisement in an engaging or an unengaging TV programme context maximises the impact of the advertisement.

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