Using EEG to examine the role of attention, emotion, working memory, and imagination in narrative-transportation.

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Purpose This paper presents a study using encephalography (EEG) to investigate consumer responses to narrative videos in energy efficiency social marketing. The purpose is to assess the role of attention, working memory, emotion, and imagination in narrative transportation, and how these stages of narrative transportation are ordered temporally.

Design/methodology/approach Consumers took part in an EEG experiment during which they were shown four different narrative videos to identify brain response during specific video segments.

Findings The study found that during the opening segment of the videos, attention, working memory, and emotion were high before attenuating with some introspection at the end of this segment. During the story segment of the videos attention, working memory, and emotion were also high, with attention decreasing later on but working memory, emotion, and imagination being evident. Consumer responses to each of the four videos differed.

Practical implications The study suggests that narratives can be a useful approach in energy efficiency social marketing. Specifically, marketers should attempt to gain focused attention *and* invoke emotional responses, working memory, and imagination to help consumers become narratively transported. The fit between story object and story-receiver should also be considered when creating consumer narratives.

Social implications Policy makers, and organisations who wish to promote pro-social behaviours such as using energy efficiently, or eating healthily should consider using narratives.

Originality/value This research contributes to theory by identifying brain response relating to attention, working memory, emotion, and imagination during specific stages of narrative transportation. The study considers the role of attention, emotion, working memory, and imagination during reception of stories with different objects, and how these may relate to consumers' narrative transportation.

Keywords Narrative transportation, EEG, attention, working memory, emotion, imagination, social marketing, energy efficiency

Paper type Research paper

Introduction

Storytelling is a powerful approach for influencing consumers and has attracted increasing attention from marketing researchers in recent years (Grayson, 1997; Thompson *et al*., 1998; Kozinets, 2008; van Laer *et al*., 2014). Social marketing and transformative consumer research scholars have also explored whether narratives can be used to promote pro-social behaviours and social change in consumers (Stead *et al*., 2013; Bublitz *et al.,* 2016). Promoting energy efficiency in consumers is one area to which social marketing is applied (McKenzie-Mohr, 2011; Sheau-Ting *et al*., 2013). Energy efficiency is an important topic given contemporary discourses relating to climate change, rising energy prices, fuel poverty, and energy security (Yergin, 2006; Simshauser *et al.,* 2011; Department of Energy and

Climate Change, 2012). Domestic energy consumption is consistently linked with climate change variables, including changes to atmospheric conditions, topography, damage to water systems, and threat to living organisms (Akhmat *et al.,* 2014). Promoting domestic energy efficiency is viewed as a key pillar of policy to tackle climate change. The United Nations Environment Programme reports that improvements in energy efficiency could be responsible for up to one-fifth of the cuts countries are required to make to meet the Intergovernmental Panel on Climate Change (IPCC)'s carbon budget and could prevent 22 to 24 gigatonnes of carbon dioxide emissions between 2015 and 2030 (United Nations Environment Programme, 2014).

Existing energy research largely focuses on interpreting consumer narratives from qualitative research about their existing energy use practices (see Cupples *et al.,* 2007; Day and Hitchings, 2011; Waitt *et al.,* 2016). As such, there is a paucity of knowledge about the use of narratives to encourage people to *change* their energy use behaviours and become more energy efficient. Narrative transportation theory provides an entry point from which to consider how narratives can be used to promote energy efficiency. According to the literature on narrative transportation, consumers who are drawn into a story will empathise with story characters and events and are consequently transported into the narrative world (Slater and Rouner, 2002; Green and Brock, 2002). Research shows that greater narrative transportation can lead to positive attitudinal and behavioural outcomes (McFerran *et al*., 2010; van Laer *et al*., 2014).

Narratologists suggest that narrative transportation entails attentional focus, working memory, emotional response, and imagination (Green and Brock, 2002; Green *et al.,* 2008; Busselle and Bilandzic, 2008). Yet, there is little existing knowledge on what the stages of narrative transportation are - for example what happens at the start of a story compared to during the story (Hamby *et al*., 2017), and what specific sub-processes (e.g., attention, working memory, emotion, or imagination) may occur at different moments during the experience of narrative transportation. Furthermore, there is a gap in our understanding of how consumers respond to different story objects in narrative transportation. Extant research focuses on the fit between story object and story plot (Russell, 2002; van den Hende and Schoormans, 2012), rather than the fit between story object and story-receiver.

As Appel and Malečkar (2012, p. 26) observe, "what is still lacking … are answers to the question of how transportation affects persuasion". Current understanding of narrative transportation is largely based on the use of traditional survey and task-based experiments (Green and Brock, 2002; Escalas, 2007) or qualitative interpretive research (Gerrig, 1993; Phillips and McQuarrie, 2010). These methodologies limit scholars' possibilities of finding an answer to Appel and Malečkar's question, as they rely on consumers' self-reporting of knowledge, attitudes, and behaviours - with associated issues of bias (Bryman, 2012). Narrative researchers acknowledge that many of the constructs related to reflection and interpretation in narrative persuasion occur outside of an individual's awareness, making it difficult to measure them using self-report methods (Moyer-Gusé, 2008). We know that people do not always tell us, or even know, exactly what they are thinking or doing (Neeley and Cronley, 2004).

Neuroscientific approaches may be able to help "complete the picture" as they provide insights into consumer information processing and decision-making in addition to traditional research methods, such as questionnaires and interviews (Falk *et al*., 2012; Agarwal and Dutta, 2015). Over 90% of the information that consumers are exposed to is processed subconsciously in the human brain (Zurawacki, 2010). Therefore, cognitive neuroscience methods, such as encephalography (EEG), enable us to study how marketing physiologically affects the brain (Lee *et al*., 2007).

This paper presents a study using EEG to investigate consumer responses to narrative videos in energy efficiency social marketing. Decision-making behaviours are generally associated with activation of frontal brain systems, and EEG techniques allow monitoring of these. This research thus contributes to understanding how and why stories influence consumers, in the context of using social marketing to promote energy efficient behaviours. More specifically, the study contributes to the narrative transportation literature by using EEG to (1) assess the role of attention, working memory, emotion, and imagination in narrative transportation, (2) understand more about the temporal development of narrative transportation, and (3) uncover the importance of fit between story object and story-receiver. To achieve this, we used two EEG techniques: Global Field Power (GFP) analysis and LORETA analysis. GFP analysis (Lehmann and Skrandies 1980; Vecchiato *et al*., 2010, 2011) allows researchers to investigate dynamic changes in cognitive processes in real time by measuring the changes in frontal alpha and theta (Aftanas and Golocheikine, 2001). More specifically, GFP is an approach that permits tracking of real time changes in measures of attention, working memory, and emotion during the screening of a video (Vecchiato et al 2010, 2011, 2013; Kong et al 2013). LORETA analysis (Pascual-Marqui, 2002) allows the identification of brain region activation. LORETA analysis identifies what specific Brodmann areas of the brain are engaged during a specific time point during the screening of a video based on beta EEG changes (Cook *et al*., 2011).

The remainder of this article is structured as follows. First, we chart current understanding of the role of attention, working memory, emotion, and imagination in consumer and neuroscientific marketing research and discuss how they relate to narrative transportation. We also consider how fit between story object and story-receiver may influence narrative transportation. Second, we present our research hypotheses. Third, we present the research methods and results. Finally, we derive theoretical and practical implications from this research, and make suggestions for future research.

Theoretical Framework

Cognitive neuroscience is an interdisciplinary domain that draws on ideas from psychology and neuroscience. It relies on theories and research methods from cognitive science, physiological psychology, cognitive psychology, and neuropsychology, aligned with computational modelling techniques. Cognitive neuroscience involves studying neural activities in the brain that influence cognition and mental processing. As such, it can offer insights into attention, working memory, emotion, and imagination by examining neural activity in the brain. Cognitive neuroscience has attracted increasing attention in marketing research over the last fifteen years, with the emergence of "neuromarketing," which Lee *et al.,* (2007, p. 200) define as "the application of neuroscientific methods to analyse and understand human behaviour in relation to markets and marketing exchanges". Several neuromarketing studies have examined consumers' brain response to marketing stimuli as well as the role of attention, working memory, emotion, and imagination (e.g. Ambler *et al.,* 2000; McClure *et al.,* 2004; Kenning *et al.,* 2007; Treleaven-Hassard *et al.,* 2010; Pozharliev *et al.,* 2015). This is particularly relevant for understanding narrative persuasion as the extant literature posits that these processes may play important roles in narrative transportation (Green and Brock, 2002; Green *et al.,* 2008; van Laer *et al.,* 2014).

Attention

Building on the work of Berlyne (1960), we define "attention" as the story-receiver's degree of focused concentration on the story, as measured in GFP analysis through measuring alpha wave activity in the brain by frontal electrodes 7.5Hz-12.5Hz (Klimesch, 1999; Vecchiato *et* *al*., 2010; Kong *et al*., 2013; Liang *et al*., 2017). Brodmann areas 10 and 11 are associated with attention, and this can be identified in EEG by performing LORETA analysis. Greater attention to marketing stimuli is linked to positive attitudinal and behavioural outcomes in consumers (Pieters and Warlop, 1999). This is especially important in energy efficiency social marketing, as consumers must first pay attention to marketing stimuli concerning energy conservation before these stimuli can influence consumers' actual energy use (Sheau-Ting, Mohammed, and Weng-Wai, 2013). In neuroscience, changes in frontal brain activity indicate attention (Vecchiato *et al.,* 2010, 2011, 2012, 2013). Studies have identified several factors that may influence consumer attention to marketing stimuli, including relevance (Treleaven-Hassard *et al.,* 2010), placement of stimuli (Chandon *et al.,* 2009), visual perception (Facebook, 2015), use of powerful well-known brands (Young, 2002; McClure *et al.,* 2004), and social context (Pozharliev *et al.,* 2015).

Gerrig's (1993) foundational work on narrative transportation proposes that attention is also a relevant consumer attribute that affects narrative transportation. As subsequent work confirms (Polichak and Gerrig, 2002), when consumers are motivated to pay attention to a story, they experience greater transportation as a result. However, consumers' attention can be perturbed and therefore reduced. As a result, Green and Brock (2000) find that distraction causes lower levels of narrative transportation.

Working memory

Working memory is the part of short-term memory concerned with immediate conscious perceptual and linguistic processing (Diamond, 2013). This cognitive system is responsible for the transient holding, processing, manipulation, and interpretation of information. Working memory can be measured in EEG using GFP by measuring theta wave activity in the brain by frontal electrodes 3.5Hz-7.5Hz (Klimesch, 1999; Vecchiato *et al*., 2010, 2011, 2013). Brodmann areas 10, 11, 21, 22 and 42 are associated with working memory, and this can be identified in EEG by performing LORETA analysis. In consumer behaviour, working memory is important as it is linked with reasoning and guiding decision-making and behaviour (Tellis and Ambler, 2008; Diamond, 2013). However, working memory has limited capacity.

Neuroscience suggests furthermore that working memory requires sustained attention (Sauseng *et al.,* 2010). This creates a challenge for marketers to ensure that consumers not only are attracted and then pay sustained attention to marketing information but also process the information in their working memory before transferring it to long-term memory so it can influence behaviour (Solomon, 2014).

In the context of storytelling, Weick (1995) observes that consumers are not merely readers of stories but also active interpreters and that consuming a story is an act of reading as well as *authoring* through which the story is processed. We propose that working memory is the activity that is required to attribute meaning to and develop an interpretation of a story. In short, consumers interpret stories in accordance with their working memory capacity (Rumpf *et al.,* 2015), in addition to other influences such as story salience (van Laer *et al.,* 2014), brand familiarity (Esch *et al.,* 2012), story placement (Breuer and Rump, 2012), and level of exposure (Breuer and Rump, 2012). This definition of narrative interpretation overtly acknowledges the active role of the consumer. As Deighton (1992) explains, the consumer's agency may ultimately convert the consumer's processing into a memorable experience. Thus, consumers frequently interpret stories to appropriate cultural meanings (McCracken, 1986), affirm their individual and/or social identity (Holt, 1995), and inform their consumption experience (Bahl and Milne, 2010).

Emotion

Emotions are complex and multidimensional feelings that reflect consumers' relationship to their social and physical surroundings and their interpretations of these relationships (Achar *et al.,* 2016). An emotion refers to any brief conscious experience that intense mental activity and an elevated level of pleasure or displeasure characterises (Cabanac, 2002). Emotions involve different components including subjective experience, cognitive processes, expressive behaviour, instrumental behaviour, and psychophysiological changes (for example, rapid heartbeat and breathing, sweating, and muscle tension). In GFP analysis, emotion is indicated when alpha (frontal electrodes 7.5Hz-12.5Hz) and theta (frontal electrodes 3.5Hz-7.5Hz) brain wave activity are simultaneously and significantly high compared to baseline resting state (Sauseng *et al*., 2005; 2008). Furthermore, Brodmann area 11 (right prefrontal) is associated with emotion, which can be identified in EEG by performing LORETA analysis (Harmon-Jones *et al*., 2010).

Emotion and consumer behaviour outcomes are strongly linked (Sheth *et al.,* 1991). For instance, McClure *et al.,* (2004) show that positive emotions towards an advertised brand have a far greater influence on customer loyalty than brand attributes. In the context of energy efficiency social marketing, Brosch, Patel and Sander, (2014) identify that emotions, such as pride, or fear of loss of control or comfort, are important influences on energy-related decisions and behaviours.

Neuroscience even suggests that emotions are an important ingredient of almost any consumption decision (Damasio, 1994). Neuroscientific research can identify the brain's strong positive and negative emotional responses associated with various stimuli (Schmidt and Trainor, 2001; Harmon-Jones *et al*., 2010). For example, fMRI studies show that consumers primarily use emotions related to personal feelings and experiences when evaluating brands rather than information related to brand attributes, features, and facts, thereby suggesting that well-known brands tend to elicit more positive emotional responses from consumers (McClure *et al.,* 2004; Esch *et al.,* 2012). Other factors influencing positive consumer emotions according to neuroscience include aesthetics (Kumar and Garg, 2010), memorable advertisements (Bakalash and Riemer, 2013), attractiveness of people or content in marketing (Häusel, 2014), message framing (Fiestas *et al.,* 2015), and whether products are luxury or basic items (Pozharliev *et al.,* 2015).

In the context of storytelling, reception of stories can evoke a specific form of emotion: empathy. Empathy is one of the main components of narrative transportation (Slater and Rouner, 2002). Empathy implies that consumers try to understand the experience of a story character, that is, to feel the world in the same way. Thus, emotional empathy explains the state of detachment from the world of origin that is narrative transportation.

Imagination

Imagination is a creative ability to form images, ideas, and sensations in the mind that helps make knowledge applicable for problem-solving, integrate experience, and learning (Egan, 1992). Imagination can be measured in EEG by LORETA through right parietal beta (frontal electrodes 3.5Hz-7.5Hz) brain wave activity (Pfurtscheller *et al*., 2003; Berends *et al*., 2013). Brodmann areas 6, 10, 11, 21 and 22 are generally associated with imagination processes, which can be identified in EEG by performing LORETA analysis. Since the early 1980s, marketing researchers have explored imagination in consumer behaviour and acknowledge the role of consumer fantasy and imagery in the decision-making process (Hirschman, 1982; Hirschman and Holbrook, 1982; Sherry, 1990). For instance, Sherry (1990) suggests that the use of imagination is necessary in the consumption process as it helps consumers imagine themselves using a product. There is increasing agreement that the imagination plays a key role in the consumption experience (Peñaloza, 2001; Sherry and Schouten, 2002) - leading Sherry *et al.,* (2001, p. 504) to describe marketers as “imagineers” who need to create experiences that fire the imaginations of consumers. Still, “little is known about the process and underlying mechanisms of how consumers actually manifest the imaginary during consumption” (Martin, 2004, p136).

In neuroscience, Berends *et al.* (2013) point towards answers. Their use of EEG can identify brain responses that are associated with imagination processes relating to observation and movement, through which the actions of others are perceived and a process of imagining a movement of one’s own body part without moving it occurs.

In the context of storytelling, images are often expressed. Their imagination then transports consumers (Green and Brock, 2002). In their imagination, consumers generate vivid, mental images of the story plot, such that they feel as though they are experiencing the events themselves.

Fit between story object and story-receiver

Fit between story object and story-receiver refers to the degree to which a story-receiver has prior knowledge about or personal experience with the story object (Green, 2004). In considering the different combinations of story object and story-receiver, there can either be a match or a mismatch between story object and story-receiver. Matches can take the form of better story object placements, where mentioned or shown objects that contribute to the personal narrative interpretation of the story-receiver are indeed greatly fitting, or worse story object placements, where mentioned or shown objects that should serve a key role in the personal narrative interpretation of the story-receiver are indeed badly fitting. This conceptualisation suggests a turn to the literature on fit to understand the role of attention, working memory, emotion, and imagination associated with each type of fit between story object and story-receiver.

Minimal fit seems crucial for narrative transportation to occur because the interpretation of a story requires the ability to process and understand the information contained in the story plot. As such, story-receivers should perceive a certain degree of fit to fully appreciate the story. The more fit people perceive, the greater narrative transportation they may experience, whether because of their intrinsic interest or because they find it easier to imagine the story plot from the story's focal object (Slater *et al*., 2006). This positive effect of fit on story processing and narrative transportation may be why people choose their preferred story repeatedly. Although research has considered the effect that the fit between story object and story plot may have on narrative transportation (Russell, 2002; van den Hende and Schoormans, 2012) there has been less focus on fit between story object and story-receiver. As an exception, Morgan *et al*. (2009) reveal that people who have consented to donate their organs when they die experience greater narrative transportation into stories about organs than non-donors, even after they self-selected a show from among their own favourites. Green (2004) presents a story of a man visiting a college fraternity; in that experiment, participants' knowledge of the objects related to Greek life in US colleges led to greater narrative transportation.

The fit between story object and story-receiver can be investigated in EEG research by comparing differences in GFP and LORETA measurements for attention, working memory, emotion, and imagination between four different narrative videos. Elevated levels of attention, working memory, emotion, and imagination during a narrative video would suggest a strong fit between story object and story-receiver.

Hypotheses Development

EEG permits us to identify which brain regions of a consumer, including those associated with attention, working memory, emotion, and imagination are engaged during the consumption of a story (using LORETA analysis), and at specific time points during the story (using GFP analysis). In cognitive neuroscience, there are two recognised approaches for tracking real-time changes in measurement of attention and working memory during the screening of a video: Steady State Topography (SST) analysis (see Silberstein *et al*., 1990) and GFP analysis (Lehmann and Skrandies, 1980; Vecchiato *et al*., 2010). However, SST is a commercially owned and restricted technique, so in this study GFP was used. GFP allows real-time monitoring of attention and memory changes associated with frontal systems. However, GFP suffers from limited localisation ability. Using LORETA in the same study remedies this by providing good indictors of regional brain activation associated with the same events. Existing research has identified that using a combination of GFP and LORETA offers a useful approach for studying consumer responses to advertising narratives (Vecchiato *et al*., 2013).

In the present study, our EEG analysis focused on two specific segments: (1) the start of each narrative video when the topic of the story becomes apparent, and (2) the story segment of each video. This is because there is little understanding about what the stages of narrative transportation are and whether different processes take place at the start of a story, compared to the later stages of the story (Hamby *et al*., 2017). Furthermore, there is a lack of understanding about exactly how attention, working memory, emotion, and imagination may be engaged during the experience of narrative transportation (Appel and Malečkar, 2012). Nevertheless, the previously reviewed research collectively provides sufficient evidence for us to suggest that attention, working memory, emotion, and imagination in the brain are important in the process of narrative transportation.

More specifically, our literature review suggests that high attention to a story throughout is important to help facilitate narrative transportation. Next, our literature review suggests that greater working memory throughout the story is also important to help facilitate narrative transportation. The literature review also suggests that high attention and working memory are simultaneously required to create an emotional response to a story during narrative transportation. Furthermore, our literature review suggests that great imagination is important to facilitate a process during which an individual links losing track of reality in a physiological sense with responses to the narrative world. That is, imagination is crucial for consumers to process the narrative. Finally, our literature review suggests that the fit between story object and story-receiver will impact upon narrative transportation leading to different consumer responses to different narratives. Thus, we hypothesise:

H1: Whereas opening and narrative video segments both attract great (a) attention, (b) working memory, and (c) emotion, only narrative video segments attract great imagination.

H2: As the fit between story object and story-receiver increases, so does the story-receiver's (a) attention, (b) working memory, (c) emotion, and (d) imagination.

Method

Subjects and design. The EEG study involved recording consumer brain responses to four narrative videos about energy efficiency targeted at older consumers aged 60 years and over in New South Wales, Australia. The programme was aimed at these consumers since existing research suggests that domestic energy use is an important concern for older consumers (Waitt *et al*., 2016). The study formed part of a larger multi-disciplinary community energy efficiency social marketing programme. The four narrative videos related to important energy use practices involving fridges, lighting, laundry, and star ratings of domestic appliances. Each narrative video follows a similar format with the same brand name of the community energy efficiency programme topic presented first, followed by the object of the video (e.g., fridges), and a definition of energy efficiency. A story segment with characters talking about and acting out practices relating to energy efficiency (e.g., using fridges or doing the laundry) follows this opening segment, and then the video closes with a presentation of facts about energy efficiency related to the preceding story. The Fridge narrative video segments ran for a total of 22 seconds, the Laundry video ran for 21 seconds, the Lighting video for 16 seconds, and the Star Ratings video ran for 16 seconds. The creation of the narrative videos drew on narrative transportation theory (van Laer *et al*., 2014) by featuring identifiable characters (including real older people from the community), presenting an imaginable plot (energy use practices were acted out), and creating a sense of verisimilitude (the acted-out practices were everyday and thus believable and lifelike).

A sample of 16 consumers participated in the experiment (50% women). This sample size is comparable to other EEG studies in marketing (Vecchiato *et al*., 2010; Daugherty *et al*., 2016). The average age of the participants was 68.7 years (SD = 4.4 years). A purposive sample was used with participants sampled from a consumer database that a university research centre maintains. All project participants provided informed written consent and the relevant university ethics committee provided ethical approval for the study.

Procedure. All participants received the following instructions: the aim of this study is to test consumer responses to videos that aim to promote energy efficiency in the home among people aged 60+. “The study will involve you being shown a selection of videos about using energy efficiently in the home. Whilst you are viewing these materials we will conduct EEG recordings. During the EEG recording you will have the electrical activity of your brain recorded (EEG) using an electrode cap”.

During the EEG recording participants were asked to watch the four different narrative videos that were shown on a computer monitor using timed presentation software that was synchronised with continuous EEG recordings. Videos were screened randomly with a counterbalanced order of presentation. A 10-second gap was provided between each narrative video to allow the participant to prepare for the next video. The total duration of the video screening was 20 minutes. Each participant was provided with a $60 gift voucher in recompense for their time. EEG was also recorded during baseline tasks with eyes open and eyes closed for comparative purposes.

EEG data were recorded from participants seated comfortably in an electrically shielded laboratory at a set distance from a video monitor. The EEG recording methodology employed was like previous studies (Vecchiato *et al*., 2010, 2013; Lawrence *et al*., 2014). EEG data were recorded using the SynAmps2 RT EEG amplifier system (NeuroScan Inc) and then analysed using Scan 4.5^{TM} (NeuroScan, Inc) and Brain Vision Analyser 2.0 (Brain Products GmbH) software. Participants wore a 64-electrode Quik cap (NeuroScan, Inc), with left and right mastoids and forehead ground reference electrodes. Amplification was set at 100k with bandwidth filters set between .15Hz and 200Hz and recorded at 512 Hz.

Analysis. As we identified earlier, The EEG analysis focused on two segments: (1) the start of each video when the object of the story becomes apparent and (2) the story segment of each video. Once eye movement and blink artefacts were removed from the EEG data, the time series data associated with the start and story segments from the videos were analysed for all 16 participants and then group-averaged. EEG power spectra were calculated for theta and alpha (for time series Global Field Power). The beta bands (17.5-31 Hz) were selected for subsequent LORETA analyses because of previous literature reporting correlations with regional cerebral perfusion and cerebral activation (Cook *et al*., 2011; Vecchiato *et al*., 2013).

To compare segments from each narrative video, the EEG source localisation algorithm LORETA was used (Pascual-Marqui, 2002), enabling the identification of activated brain regions (Fuchs *et al*., 2002; Jurcak *et al*., 2007). The used analysis protocol was based on previously reported studies that examined advertisements (Treleaven-Hassard *et al*., 2010; Cook *et al*., 2011). These segments of EEG (beta) were then processed using the LORETA technique (Pascual-Marqui *et al*., 2002; Cook *et al*., 2011). Regions of activity and regions of interest (ROIs) were identified with the 3D coordinates (Talairach Coordinates Brain Atlas Technique) associated with functional brain region mapping known as Brodmann areas. Each Brodmann area is associated with a specific functional activity, such as attention, working memory, emotion, or imagination (Bankman, 2000; Brodmann, 2006).

Time locked decision-making events (activation tasks) have been useful in highlighting brain networks and regions of brain activity associated with those tasks and the various cognitive processes (Cook *et al*., 2011). The sources of beta activity were determined with LORETA. Activity between active viewing states and non-task segments were compared to determine the levels of significance (Cook *et al*., 2011). Statistical analyses were performed with SPSS (SPSS Inc. Chicago) and Brain Vision Analyser 2 (Brain Products GmbH). For all events normality of distribution and homogeneity of variance were calculated for absolute power for beta activity time series. Greenhouse-Geyser corrections for violations of compound symmetry assumption were performed with additional Bonferroni correction to control for type 1 error. Continuous or time series data were analysed with t-tests and t-level thresholds were computed that correspond to a threshold of statistical significance ($p < .01$). Only these data were used for further LORETA localisation of activity (Zar, 1984).

Even though the beta LORETA is a good indicator of activity during many seconds, it is not able to address changes consistent with second-for-second changes in attention, emotion, and memorisation. Global Field Power analysis using frontal theta and alpha can measure these processes. If for any event during the viewing of the video, the z-scores for alpha GFP and theta GFP are significantly greater, this indicates greater levels of attention and memory. It also suggests that there is a stronger emotional response (Vecchiato *et al.,* 2011). Furthermore, the theta GFP and alpha GFP index were combined following Kong *et al.* (2013) to calculate their Impression Index that is designed to measure the effect of marketing stimuli.

To better quantify the attentional and memory processes associated with specific events during each narrative video about energy efficiency, we then conducted GFP analysis. The EEG trace (time series) for each narrative video was filtered to isolate the theta (3.5-7.5Hz) and alpha (8-12.5 Hz). These spectral components were then used to calculate the GFP for each segment and converted into z-scores to extract indexes of attention and memorisation (Kong *et al.,* 2013; Vecchiato *et al.,* 2011; 2012). All frontal electrodes according to the 10/20 International system were used to calculate the GFP: Fp1, Fp2, F1, F2, F3, F4, FPz, Fz, F5, F6, F7, F8, FC3, FC4, FT7, FT8.

According to Vecchiato *et al.,* (2012), if both theta and alpha z-scores are significant for an event, the stimulus elicits greater emotional response; and the event makes an impression. Black arrows on each of the GFP figures indicate these (Vecchiato *et al.,* 2010; Kong *et al*., 2013). However, it is possible to have higher memorisation scores but lower attention scores for an event. This may be associated with recognition and previous experiences, and reflect some introspection process (Vecchaito *et al.,* 2010, 2012; Kong *et al.,* 2013).

To identify the significance of these events, an ANOVA of the z-scores was performed for all events for all participants comparing active viewing with a rest condition. The variance of the spectral data during active viewing was compared to the spectral noise of the rest baseline segment (Vecchiato *et al*., 2010). For the time series data, z-scores greater than 2 were associated with a significance threshold of $p < .01$ (Zar, 1984), being Bonferroni-corrected z-scores. Once significant events were identified, the associated beta LORETA could be calculated for that event, identifying brain regions (by Brodmann areas) that were the main sources of beta activity for the recorded cortical EEG. This approach is comparable to other neuroimaging assumptions using fMRI localisation techniques (Cook *et al*., 2011).

Results

Segment 1 – Start of the videos

Figure 1 shows the GFP time series and LORETA maps for attention, working memory, emotion, and imagination for key events during segment 1 - start of the narrative videos - averaged across all participants and narrative videos. Table 1 shows the theta and alpha z-scores from the GFP analysis, and the Brodmann areas associated with beta activity from the LORETA analysis during segment 1, both averaged for all participants across the four narrative videos and individually for each of the four narrative videos. To analyse the group average, it is necessary to ensure like-for-like events are averaged. Therefore, to maintain the level of significance and reduce variability across the average data, only segments with identical events and relative timing were analysed to completion. This also reduced any artefact or event contamination that could have confused the interpretation of the final analyses.

In Figure 1a, the GFP z-score indices for attention and working memory are illustrated for the start segment. Emotion is high for all the major events as the narrative videos commence: (1) Appearance of community energy efficiency programme brand name; (2) Identification of video story object (e.g. fridges, laundry etc.); (3) Definition of energy efficiency fade-in; (4) Definition of energy efficiency on-screen; (5) Definition fade-out and story segment start. Events 1 and 2 seem to elicit the greatest emotional response (i.e., combined increase in theta and alpha GFP associated with emotional response. Note how attention drops over the 12 seconds. At event 3, attention drops (i.e., withdrawing), but memory processing is high suggestive of some introspective process.

INSERT FIGURE 1 HERE

INSERT TABLE 1 HERE

Figure 1b shows the LORETA maps for each of the five events associated with the start segment of each narrative video. Beta activity suggests that attention-associated Brodmann areas 10 and 11 are engaged. For event 2, the narrative video title is identified (Brodmann areas 10, 11, and 22) suggesting regions associated with working memory are active. This is also supported by the GFP theta data. For events 3 and 5 this activity continues as facts are presented. According to the LORETA analysis, during segment 1 beta activity associated with imagination which is suggested by right parietal and left frontal activity (Brodmann areas 10 and 22) was not identified.

It is possible to compare the participant responses across the four narrative videos during the start segment by examining the size of a response to a stimulus event, by considering whether attention and/or memory are maintained throughout the segment, and by looking at the number of events during the start segment where z-scores are above 2 and are therefore significant (Vecchiato *et al.*, 2010). During the start segment, we find that the Star Ratings narrative video gained the most attention, followed by the Lighting video, then the Fridges video, with the Laundry video attracting the least attention. The Fridges narrative video invoked the most working memory, followed by the Lighting video, then the Laundry video, with the Star Ratings video attracting the least working memory. By examining the z-scores for both attention and memorisation, the Star Ratings narrative video invoked the greatest emotional response, followed by the Lighting video, and then the Fridges video, with the Laundry video invoking the lowest level of emotional response. By examining the LORETA analysis for the start segment of each video, we find that imagination, as indicated by beta activity showing Brodmann areas 10 and 22 being active, is evident during the start segment for the Fridge video, but not for the other three videos.

Segment 2 – The story

We then conducted GFP and LORETA analysis to investigate consumer responses to the second video segment: the story. Figure 3 shows the GFP time series and LORETA maps for attention, working memory, emotion, and imagination that are illustrated for specific events during the story: (1) opening scene; (2) story characters appear; (3) narration starts; (4) energy efficiency facts are presented; (5) narration ends. These were averaged across all participants and narrative videos. Table 2 shows the theta and alpha z-scores from the GFP analysis as well as the beta activity associated with the Brodmann areas from the LORETA analysis during segment 2, both averaged for all participants across the four narrative videos and individually for each of the four narrative videos.

INSERT FIGURE 3 HERE

INSERT TABLE 2 HERE

In Figure 3a, the GFP shows that attention and working memory are high at the start of the story segment. Emotion where both alpha (attention) and theta (working memory) are high and occurring at the same moment (black arrow) occurs at events 2 and 3. This suggests a strong emotional response at the start of the story segment. Note some peaks are high for working memory but low for attention (events 1, 3, and 4). Event 4 elicits a lower emotional response, with event 5 suggesting some working memory processing associated with the story subtext. In the LORETA map shown in Figure 3b the beta activity indicates frontal activity at brain region Brodmann area 10 being significant for events 1-4, indicating attention. By event 5, response from the brain region associated with imagination (Brodmann area 22) is high however. This coincides with great working memory according to the GFP results and provides support to Hypothesis 1.

As with during the start segment, we can compare responses across the four narrative videos during the story segment. To compare the narrative videos during the story segment we considered whether attention and/or memory was maintained throughout the segment, and looked at the number of events during the story segment where z-scores were above 2 and were therefore significant. The Fridges narrative video invoked the greatest level of attention, followed by the Laundry video, the Star Ratings video, and the Lighting video, respectively.

The Fridges video invoked the greatest level of working memory, followed by the Lighting video, the Star Ratings video, and the Laundry video, respectively. By examining the z-scores, we find that the Fridges narrative video invoked the greatest level of emotional response, followed by the Star Ratings video, the Lighting video, and the Laundry video, respectively. We can also considered differences in imagination related response across the four narrative videos during the story segment by looking at the beta activity from the LORETA analysis. Here, the Fridges video evoked the most imagination, followed by the Laundry video, the Lighting video, and the Star Ratings video, respectively. Remember that the fit between the story object and the story-receivers differed solely because of the story object, since the story object differed from one video to the next but the story-receivers were constantly the same. Hence, these results provide support for Hypothesis 2: fit was greatest between the fridge and the story-receivers in this study.

Discussion

This paper contributes to the narrative transportation literature by using EEG to assess the role of attention, working memory, emotion, and imagination in narrative transportation, and to understand more about the temporal stages of narrative transportation, as well as the role of fit between story object and story-receiver. The findings from this study suggest some important theoretical and practical implications, and avenues for future research.

Theoretical implications

Overall, the study identifies significant levels of response to the four narrative videos. This finding reinforces earlier researchers' conclusions that storytelling can be an effective way to engage attention (Polichak and Gerrig, 2002), working memory (Petrican *et al.,* 2008), emotion (Slater and Rouner, 2002), and imagination (Green and Brock, 2002) in consumers. With respect to Hypothesis 1: during the start segment of the four narrative videos we find that attention, working memory, and emotion are significant, but no imagination occurs at this stage. Averaged across the four narrative videos there was high attention, working memory, and emotion during the very beginning of the start segment, with attention dropping over time but working memory being engaged again later. The latter may suggest some introspection and reflection is occurring (Berends *et al*., 2013; Vecchiato *et al*., 2013), which could be due to older consumers reminiscing and reflecting on their domestic energy consumption practices (Day and Hitchings, 2011; Waitt *et al.,* 2016). However, it may also suggest that once the object of a story becomes apparent, a reflective process related to the narrative takes place. In any case, the study demonstrates that narrative videos elicit reflection during the narrative transportation experience itself already. As such, the current research extends Bortolussi and Dixon (2015) and Hamby *et al*., (2017) who claim that narrative transportation and reflection are separate processes.

During the story segment, we find that on average across the four narrative videos participants were highly engaged in the stories with attention, working memory, and emotion high from the outset. Attention and working memory then tapered off. Working memory increased again, suggesting that participants were processing and interpreting the information. Working memory high but attention low is likely to have led to much introspection towards the end of the segment. Working memory and imagination also occurred later during the story segment - which speaks to a vicarious walk in a story character's shoes that narrative transportation researchers identify (van Laer *et al*., 2013). Overall, this process suggests that narrative transportation is not the "convergent process" that Green and Brock (2000, p. 701) make it out to be. We posit that attention, working memory, and emotional response to a story are important precursors to imagination and that this signifies that transported consumers both process and reflect upon the narrative during their narrative transportation experience. We also suggest that narrative transportation may vary in intensity. Narrative transportation seems to require imagination and at least one additional sub-process: attention, working memory, or emotion. However, the intensity of narrative transportation varies with the number of activated sub-processes.

In response to Hypothesis 2: the findings also suggested some crucial differences in participant response across the four narrative videos. During the start segment, we found a significant emotional response for the Fridges narrative video when the object of the story became apparent. We did not find this response for the other videos. During the story segment, the Fridges video attracted the most attention and working memory as well as the greatest level of emotional response and imagination. In short, narrative transportation into the Fridges video was significantly higher than in the other videos. Since we used a within-subject design, this finding suggests that some story objects attract attention, engage working memory, evoke emotions, and stimulate imagination more than others. It is reasonable to expect this greater effect to be the result of a greater fit between the story object and the story-receivers. Prior research already suggests that fridges evoke significant affective responses in consumers because they contain food (which evoke emotions in turn), are used several times each day, form an important part of making home, and are often family heirlooms with a history (Waitt and Phillips, 2016).

The Star Ratings video attracted significant attention at the start of the story segment but then tailed off. Star Ratings are quite an abstract and technical topic that may have disengaged participants (Murray and Mills, 2011). Not surprisingly, we did not find that the story segment of the Star Rating video sparked the imagination. Though less than the Fridge video, the Lighting video did spark some imagination. However, attention was low. Except for working memory, the sub-processes at work during reception of the story segment of the Laundry video were also less intense than during the Fridge video. It seems that unlike a fridge, the laundry is mostly mundane, dull, and functional (Beckwith, 1992).

The differences in attention, working memory, emotion, and imagination between the four videos' story segments suggests that there may be some important differences in consumer response to stories that are the result of their fit with the story object. Our findings here hint at a gap in the extant marketing literature on narrative persuasion. Its focus on the fit between story object and story plot (Russell, 2002; van den Hende and Schoormans, 2012) without always paying attention to the fit between story object and the consumer of the story, may have created this gap. However, a story object is not an independent artefact. Our findings suggest that the story object may invoke different responses in different consumers. It seems that to increase narrative transportation, a tangible object that consumers keep in their possession should not only play the role of a character or prop but consumers should also have a strong connection to it.

Practical implications

There are several practical implications that can be drawn from the present study. First, the study can help inform marketers on how to sequence and tell marketing stories more persuasively (Hamby *et al*., 2017). Our findings suggest that gaining attention, evoking working memory, and evoking emotion may act as important precursors to imagination of the narrative and reflection upon the story. To achieve greater narrative transportation it may be necessary for marketers to do more than attract focused attention from consumers therefore. Marketers should also attempt to stimulate working memory, emotion, and imagination with their stories. In our energy efficiency narrative videos this was achieved by using real community members as relatable story characters, creating an imaginable plot by re-telling energy stories told to us by community members, and verisimilitude by featuring real people's homes and community locations in the videos. Second, the study findings suggest that the use of narrative in pro-social marketing - a phenomenon less common than in commercial marketing - to address topics such as energy efficiency should be strongly considered. Energy efficiency programmes targeted at specific groups such as older low income, or families could use energy narratives among these groups to encourage people to reflect on their practices (Waitt *et al*., 2016). Third, the study finds differences in response to the four narrative videos which suggests that the fit between story object and story-receiver is important. Therefore, marketers should consider whether there is a strong fit between story object and specific consumer groups before pursuing a narrative approach. For example, for an abstract and technical topic such as Star Ratings, narrative may not be so effective.

Limitations and future research

One limitation of this study is the relatively small sample of 16 older consumers. Although similar in sample size to other EEG studies (Vecchiato *et al.,* 2010), future research with a larger sample size and with a broader range of consumers would aid generalisability. Future research with a larger sample size could also consider demographic effects on consumer responses to narrative videos. A further limitation relates to identifying short and long-term memory processes with current EEG techniques. We can only use reverse inference here, based on the findings from previous literature. Even though the LORETA data and GFP could suggest long term memory, we may have been measuring other working memory processes too (Klimesch, 1999; Sauseng *et al*., 2005). However, Sauseng *et al*. (2005) suggest frontal parietal changes are associated with working memory, consistent with our findings. Furthermore, this study only focused on stories about energy efficiency, and studies that consider attention, working memory, emotion, and imagination underlying different marketing stories are clearly needed. It should also be acknowledged that this study exclusively used EEG; we do not measure actual consumer behaviour and the insights from EEG research are not definitive. For example, although GFP and LORETA analysis might suggest that working memory is engaged when consumers view narrative videos, this does not mean that the story has been processed in memory beyond a doubt; it merely suggests this may be the case (Vecchiato *et al*., 2013). However, prior research has identified GFP and LORETA as a useful approach for informing the placement of narratives in advertising by assessing whether the narrative successfully influences consumers or needs to be placed elsewhere in a video (Vecchiato *et al*., 2013). Future research that combines EEG with consumer behaviour outcomes can solve this debate and further add to our understanding of narrative transportation. Finally, our findings suggest that the fit between the story object and the story-receiver may be a vital component of the narrative transportation process but further research is required to unpack and better understand this idea.

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Start Segment of Video	Event No.	Event	GFP Theta z-score Memorisation Index	GFP Alpha z-score Attention Index	Beta LORETA BA (*p*<0.01)
All videos	1	Brand	9.7**	11.6**	21,22
	2	Topic	6.2*	7.2*	10,11,22
	3	Definitions	12.6**	1.7	10,11
	4	Definitions	4.1*	5.5*	22
	5	End of Intro	5.6*	4.3*	10,11
Fridge	1	Brand	7.4*	0.9	21
	2	Topic	8.5*	2.3*	10,11
	3	Definitions	10**	1.96	-
	4	Definitions	8.2*	0.85	-
	5	End of Intro	5.3*	0.81	-
Laundry	1	Brand	2.1 *	1.1	-
	2	Topic	10.1**	0.48	21,22
	3	Definitions	3.9*	1.1	-
	4	Definitions	4.5*	3.4*	10,11
	5	End of Intro	3.3*	2.2*	-
Lighting	1	Brand	7.6*	0.35	21,22
	2	Topic	9.3**	0.1	-
	3	Definitions	6.5*	6.8*	10,11
	4	Definitions	0.8	0.1	-
	5	End of Intro	0.8	0.6	-
Star	1	Brand	0.8	1.7	-
	2	Topic	0.4	3.8*	-
	3	Definitions	10.2*	8.2*	10,11
	4	Definitions	1.1	6.7*	10,11
	5	End of Intro	0.1	0.2	-

Table 1: Summary of EEG changes associated with specific events during the **Start Segment** Significant z-scores for theta and alpha changes and beta LORETA. A grand average for all videos is also included. Note the associated active cortical source for beta activity is also listed. Note for * (*p*<0.01) and **(p<0.001). Note brain regions designated by Brodmann areas BA10, BA11- frontal decision-making regions (anterior and orbital frontal cortex), BA21, BA22- auditory and language association regions (middle and superior temporal gyrus).

Narration Segment of Video	Event No.	Event	GFP Theta z-score Memorisation Index	GFP Alpha z-score Attention Index	Beta Loreta BA (p<0.01)
All video	1	Scene Begins	2.9*	0.9	10
	2	Characters in situ	6.8*	6.2*	10
	3	Narration starts	4.9*	3.8*	10
	4	Facts	1.8	2.4*	10
	5	Narration ends	2.6*	0.2	21,22,18
Fridge	1	Scene Begins	2.9*	1.7	
	2	Characters in situ	6.7*	7.9*	10
	3	Narration starts	5.0*	5.1*	10
	4	Facts	1.7	3.2*	10,21,22
	5	Narration ends	2.4*	0.2	
Laundry	1	Scene Begins	0.6	1.9	
	2	Characters in situ	0.1	0.4	21,22
	3	Narration starts	0.1	0.2	
	4	Facts	0.1	0.15	
	5	Narration ends	0.4	3.85*	22
Lighting	1	Scene Begins	4.1*	3*	22,32
	2	Characters in situ	0.1	0.5	
	3	Narration starts	1.5	0.7	
	4	Facts	0.2	0.9	
	5	Narration ends	2.0*	0.7	22
Star	1	Scene Begins	0.2	1	
	2	Characters in situ	1.3	1.6	22
	3	Narration starts	0.2	1.3	
	4	Facts	1.2	0.4	
	5	Narration ends	2.1*	1.2	42

Table 2: Summary of EEG changes associated with specific events during the **Narration Segment;** significant z-scores for theta and alpha, and Beta LORETA. A grand average for all videos is also included. Note the associated active cortical source for beta activity is also listed. Note for *

(p<0.01) and **(p<0.001). Note brain regions designated by Brodmann areas BA10, BA11- frontal decision-making regions (anterior and orbital frontal cortex), BA21, BA22- auditory and language association regions (middle and superior temporal gyrus), BA6 – premotor cortex, BA42-Primary auditory cortex, BA18-visual cortex.

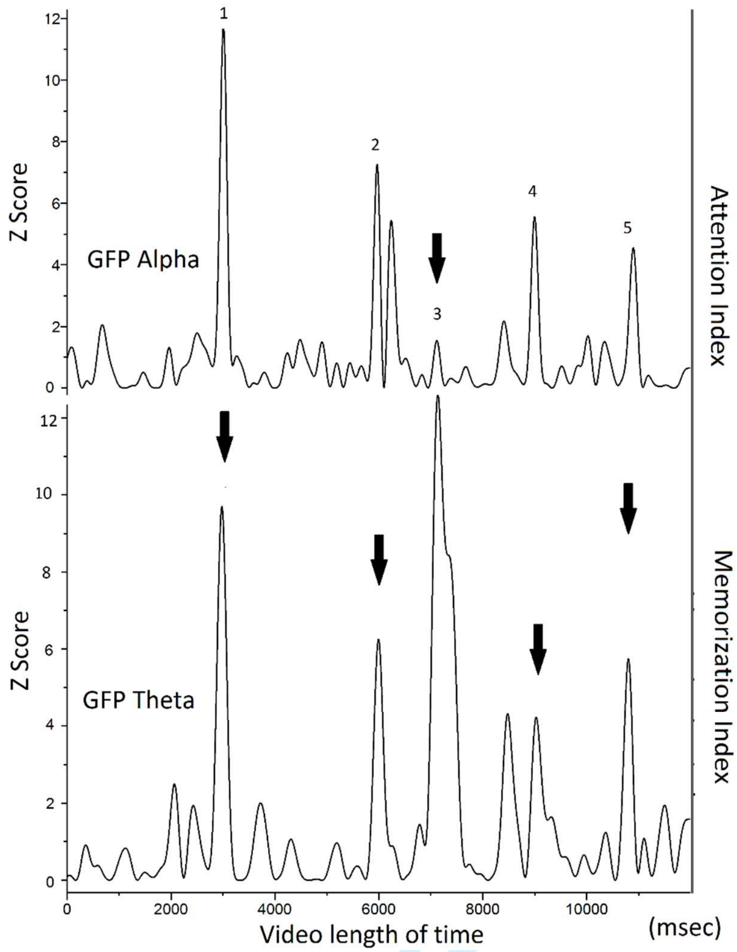

Figure 1a: The GFP time series for the **Start Segment**; the z-score obtained by Global Field Power calculations of frontal electrodes in the theta (lower trace) and alpha (higher trace) normalised group average (n=16). This is an average of the first 12 seconds of ***all videos*** for all participants. Five events have been selected where both theta (memorization) and alpha (attention) are high and occurring at the same moment, these combined are associated with emotion (black arrows). Note some peaks are high for attention but low for memory at specific times and the converse is also the case. Note z-scores >2 are associated with a significant threshold of $p<0.01$. *NB Events (1-5);* 1: Community energy efficiency programme brand name appears; 2: Identification of video topic (e.g. fridges, laundry etc.); 3: Definition of energy efficiency fades ins; 4: Definition of energy efficiency on screen; 5: Definition fades out and the narrative segment starts.

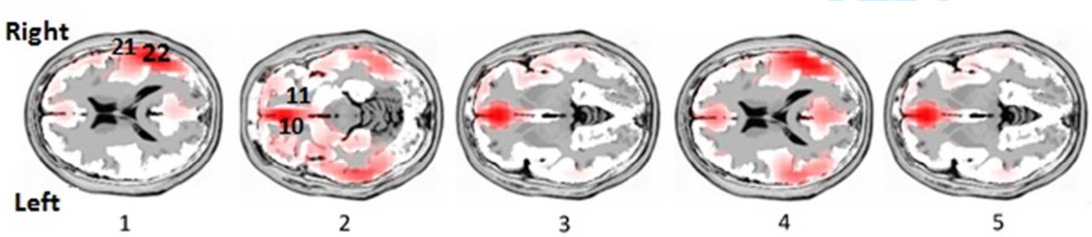

Figure 1b: The LORETA maps (for Beta activity) for each of the 5 events. *NB Events (1-5);* 1: Community energy efficiency programme brand name appears; 2: Identification of video topic (e.g. fridges, laundry etc.); 3: Definition of energy efficiency fades ins; 4: Definition of energy efficiency on screen; 5: Definition fades out and the narrative segment starts. Each panel illustrates a superior view of brain regions with for beta activity as identified with LORETA (p<0.01). Brodmann areas are illustrated; BA10,11,21, 22.

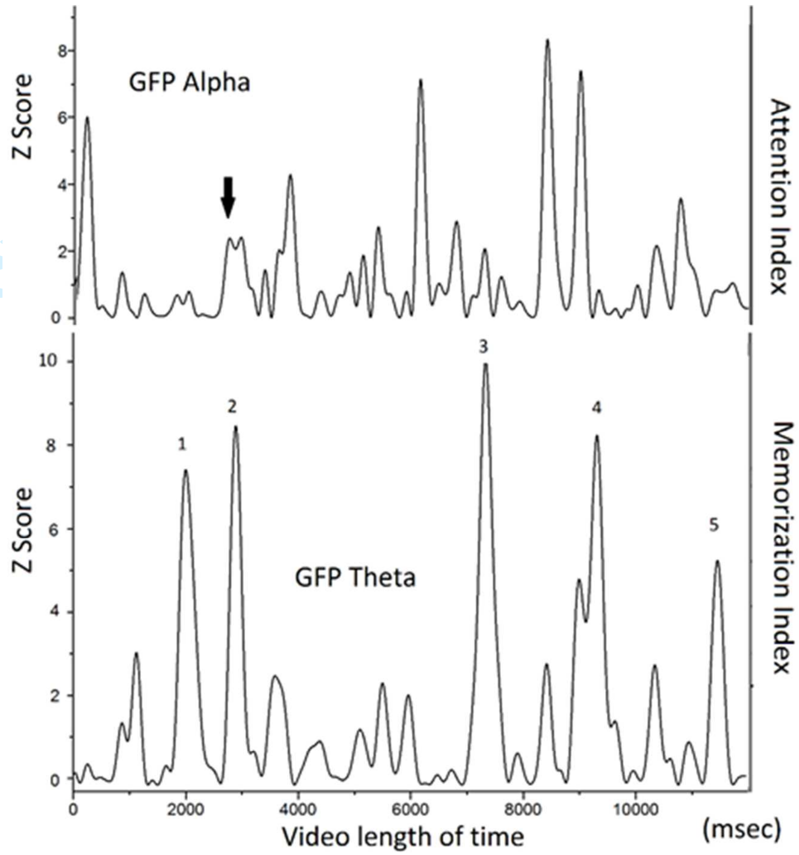

Figure 2: The GFP time series for the **Start Segment**; the z-score obtained by Global Field Power calculations of frontal electrodes in the theta (lower trace) and alpha (higher trace) normalised group average (n=16) for the "**Fridge**" video introduction. This is an average of the first 12 seconds of this video for all participants. Five events have been selected from the video. The black arrows represent when both theta (memorization) and alpha (attention) are high simultaneously, these combined are associated with emotion. Note some peaks are high for memory but low for attention at specific times and the converse is also the case. Note z-scores >2 are associated with a significant threshold of $p<0.01$. *NB Events (1-5);* 1: Community energy efficiency programme brand name appears; 2: Identification of video topic (fridges); 3: Older woman on couch, 4: Older couple come into shot, 5: Narrative segment starts.

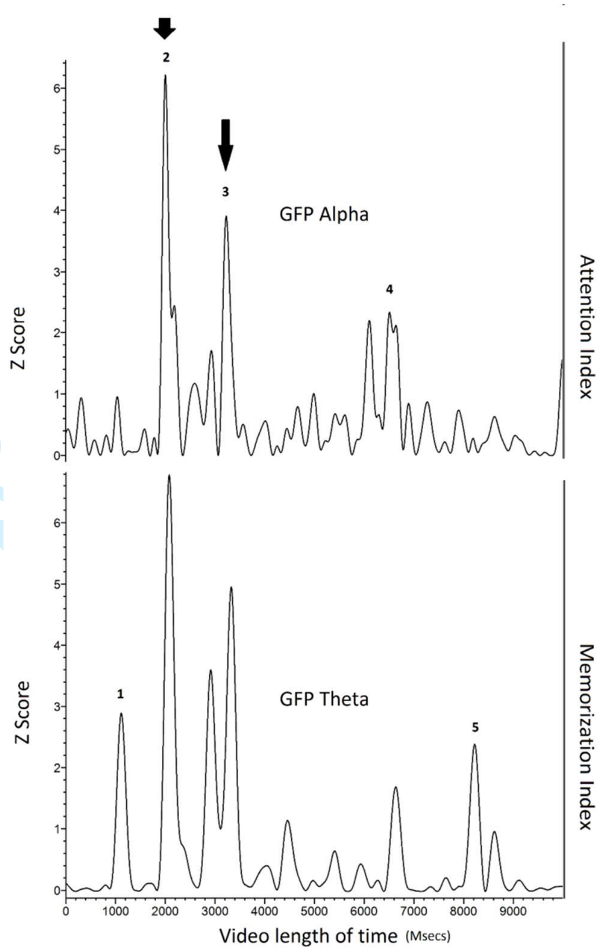

Figure 3a: The GFP time series for the **Story Segment;** the z-score obtained by GFP calculations of frontal electrodes in the theta (lower trace) and alpha (higher trace) normalised group average (n=16). This is an average of the first 10 seconds of ***all videos*** for all participants, for the Story segment. Note z-scores >2 are associated with a significance of $p<0.01$. Black arrows indicate when both theta and alpha z-scores are high, indicating emotion. NB Events (1-5); 1: Scene begins, 2-Actors in situ, 3-Narration Starts, 4- Facts presented, 5- Narration ends.

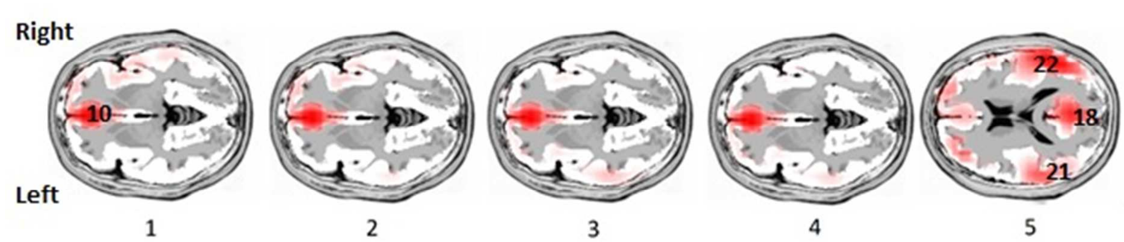

Figure 3b: The LORETA maps (for Beta activity) for each of the five events associated with attention and memory changes according to the GFP z-score for the first ten seconds of the **Story Segment**. This is an average of the first 10 seconds of ***all videos*** for all participants, for the Story segment. Each panel illustrates a superior view of brain regions with for beta activity as identified with LORETA ($p<0.01$). NB Events (1-5); 1: Scene begins, 2-Actors in situ, 3-Narration Starts, 4- Facts presented, 5- Narration end. Brrodmann areas are illustrated; BA10, 21, 22, 18.

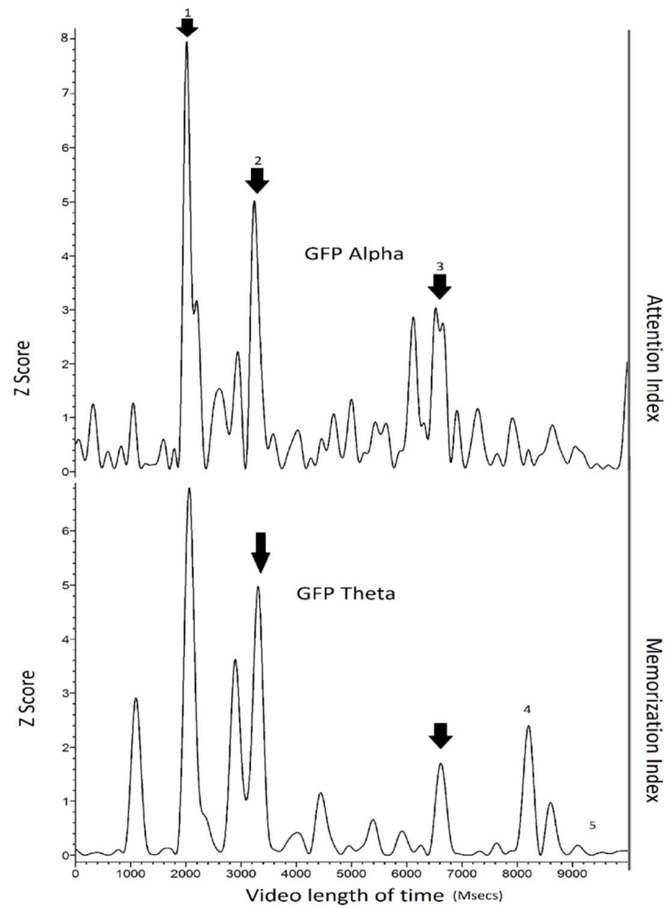

Figure 4: The GFP time series for the **Story Segment;** the z-score obtained by GFP calculations of frontal electrodes in the theta (lower trace) and alpha (higher trace) normalised group average (n=16). This is an average of the first 10 seconds of the **Story Segment** of the video entitled **"Fridge"**. Note z-scores >2 are associated with a significant threshold of $p<0.01$. NB Events (1-5); 1: Scene begins, 2-Actors in situ, 3-Narration Starts, 4- Facts presented, 5- Narration end.

Appendix: EEG analysis for neuromarketing applications - studying brain changes associated with cognition while observing narrative videos

Justification for techniques used.

Principally, the EEG techniques we have selected to examine specific cognitions are those which can track the video's events second for second and therefore take advantage of the temporal resolution of the EEG. One technique which can do this is the Global Field Power analysis (GFP) which has already been published extensively to track attention and memory processes while watching advertising videos, to compare cultural differences with advertisements, and to track consumer responses to narratives in advertising (Vechchiato *et al.,* 2010; 2011). However we also applied another technique LORETA (Pasqual-Marqui, 1999) which can indicate which sources or brain regions or regions of interest (ROIs) contributed to the decision making when attention or memorization was highest. Combining these techniques takes advantage of the temporal resolution and source localization techniques for EEG. We are also using specific frequencies such as looking at theta, alpha, and beta activity which are associated with memory, attention, emotion, and other cognitive processes.

In essence, there are only two techniques available in EEG which can track and time lock continuously to the events of a video. One technique is the GFP (Lehmann and Skrandies 1980; Vecchiato *et al.,* 2010, 2011) and the other is the Steady State Topography (Silberstein *et al.,* 1990). The GFP can monitor alpha desynchronization and theta increases in the same timeframe as a video; tracking cortical brain changes with events being observed by a participant. The relationship between changes in alpha and theta frequency band measures and cognition is well documented and replicated (Summerfield and Mangels, 2005; Klimesch, 1999). The Klimesch review is one of the better reviews of this EEG approach with respect to alpha, theta, and cognition.

Generally there are EEG markers associated with attention, working memory, and emotion (Vechiatto, 2011 review), however imagination is based on literature associated with imagined movement (Pfurtscheller *et al.,* 2003), and creative thinking (Banerjee *et al.,* 20170; which suggests strong associations with fronto-parietal (theta and alpha) consistent with the GFP technique. Also reflective imagination and associated alpha changes has been shown to reflect strong fronto-parietal and fronto-temporal connectivity. This has also been demonstrated in the cognitive processes associated with visual attention (Liang *et al.,* 2017).

The applications of EEG techniques (changes in alpha, theta and beta activity) to studying cognition are well documented. Cognition involves a number of processes such as *attention* or engagement (Klimesch, 1999; Vecchiato *et al.,* 2010; Kong *et al.,* 2013, Liang *et al.,* 2017), *emotion* or attachment (Klimesch, 1999; Vecchiato *et al.,* 2010), *working memory* – memory cognition involving phonological and visuospatial processes (Sauseng *et al.,* 2005; 2008; Vecchiato *et al.,* 2010) and *imagination* – mental imagery, creative problem solving (Berends *et al.,* 2013; Pfurtscheller *et al.,* 2003). Each associated with specific variations in the EEG.

We do use temporal resolution advantage with the GFP analysis but supplement with spatial tomography associated with specific key times during the temporal sequence of each advert. However, previous literature(Cook *et al.,* 2011) have demonstrated that LORETA can give good spatial indicators of sources with Beta activity comparable to fMRI BOLD changes statistics. We may use this as an estimation but we uniquely use the time during a specific advert and use reverse inference to speculate why a region is active; however, it does support the fronto-parietal association with decision making (Klimesch, 1999; Hagemann, 2004). Also, LORETA does take into account volume conduction effects and is one of the better source localization tools.

The GFP graphs demonstrate the dynamics of EEG reflecting changes in cognitive processes; especially in frontal brain areas. This temporal graph demonstrates at what times maximum attention/engagement and memory processes are taking place. This is a useful way to help visualize the dynamics of this process during the course of the video, and is increasingly used in neuromarketing studies (see Vecchiato *et al.,* 2010).

The EEG analysis

The following figure (see Figure 1) summarizes the combination of techniques used to remove artefact, statistical analysis, the GFP and LORETA analyses for producing the GFP time series for alpha and theta, and location of beta activity during the significant moments associated with the narrative videos.

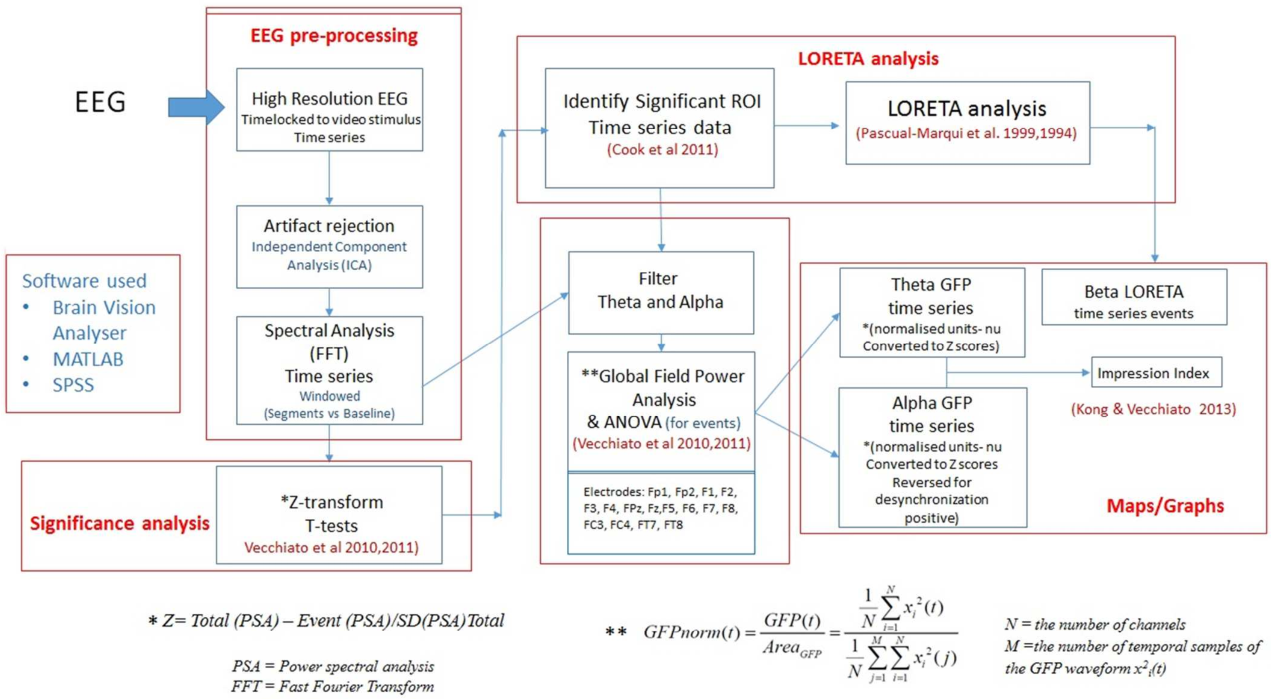

Figure 1: EEG analysis for artefact rejection, EEG analysis, significance analysis, GFP and LORETA during the video segments. The analyses utilised various software platforms; Brain Vision Analyser, MATLAB and SPSS.

The sequence of analysis begins with removing artefact such as eye movement and eye blink. This is done with the artefact rejection transform in *Brain Vision Analyser*, however the independent components analysis (ICA) can help identify and isolate these many forms of artefact too. All EEG recordings were grouped into three categories for further analysis; the EEG associated with viewing the narrative videos, break between the narrative videos, and the eyes open rest period. All EEG recordings (participant at rest, watching narrative videos, during the 10 second break between narrative videos) were band passed filtered (low pass =1.5Hz; high pass 35 Hz). These EEG segments were grouped together and averaged for all 16 participants. The EEG associated with the narrative videos were further segmented into “Start” and “Story” and averaged. Data were then converted and exported so as to do statistical and z-score calculations associated with the segmented data sets in Matlab and SPSS.

A number of events during the narrative video segments were identified (time) and used to estimate the z-score for all EEG time series (windowed). These data were then used in the LORETA analysis to investigate the sources of beta activity (ROIs) during specific events. The significance of each regions of interest (ROI) were then calculated from the time series z-scores. The Talairach Coordinates Brain Atlas Technique was applied to identify Brodmann areas (BA). The LORETA analysis routine in Brain Vision Analyser produces images where the Brodmann areas can be highlighted (see Figure 2).

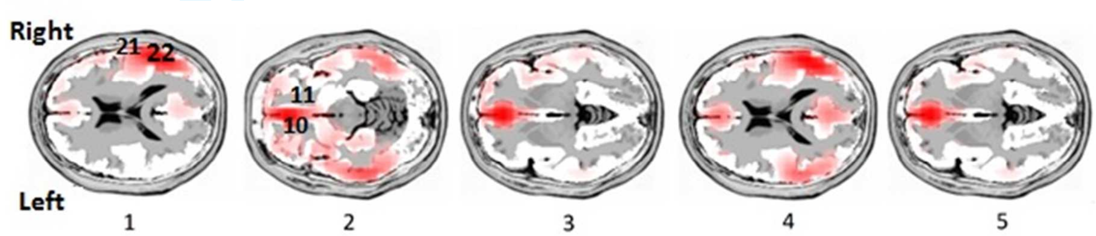

Figure 2: LORETA maps associated with 5 events during the narrative video. Brodmann areas 21, 22, 10, and 11 are predominately "active" during these events.

Corresponding additional alpha and theta analyses were also performed using reference free Global Field Power (GFP) analysis (Lehmann and Skrandes, 1980; Vecchiato *et al.,* 2010). This produces the GFP time series for specific segments of interest tracking events during the narrative videos. The GFP analyses focused on frontal brain regions by using time series data recorded from the following electrode sites; Fp1, Fp2, F1, F2, F3, F4, FPz, Fz, F5, F6, F7, F8, FC3, FC4, FT7, FT8, because we were predominantly interested in higher executive functions such as decision making that are associated with engaging with and interpreting stories. From these analyses, separate time series GFP data for theta and alpha were produced. These are then converted into z-scores time series (see Figure 3 as an example). Each trace illustrates the fluctuations in attention (alpha) and memory processes (theta), (Vecchiato *et al.,* 2010; Summerfield andMangels, 2005; Werkle-Bergner *et al.,* 2006) and if both alpha and theta are correspondingly high, then emotion at that moment of the video is also high (Kong and Vecchiato, 2013).

To identify the significance of these events, an ANOVA of the z-scores is performed for all events for all participants comparing active viewing with a rest condition. The variance of the spectral data during active viewing is compared to the spectral noise of the rest baseline segment (Vecchiato *et al.,* 2010). For the time series data, the z-scores greater than 2 are associated with a significant threshold of $p<0.01$ (Zar, 1984) and are Bonferroni corrected z-scores. Once significant events are identified, the associated beta LORETA can be calculated for that event, identifying brain regions (by Brodmann areas) which are the main sources of beta activity for the recorded cortical EEG; comparable to other neuroimaging assumptions; fMRI localisation techniques (Cook *et al.,* 2011).

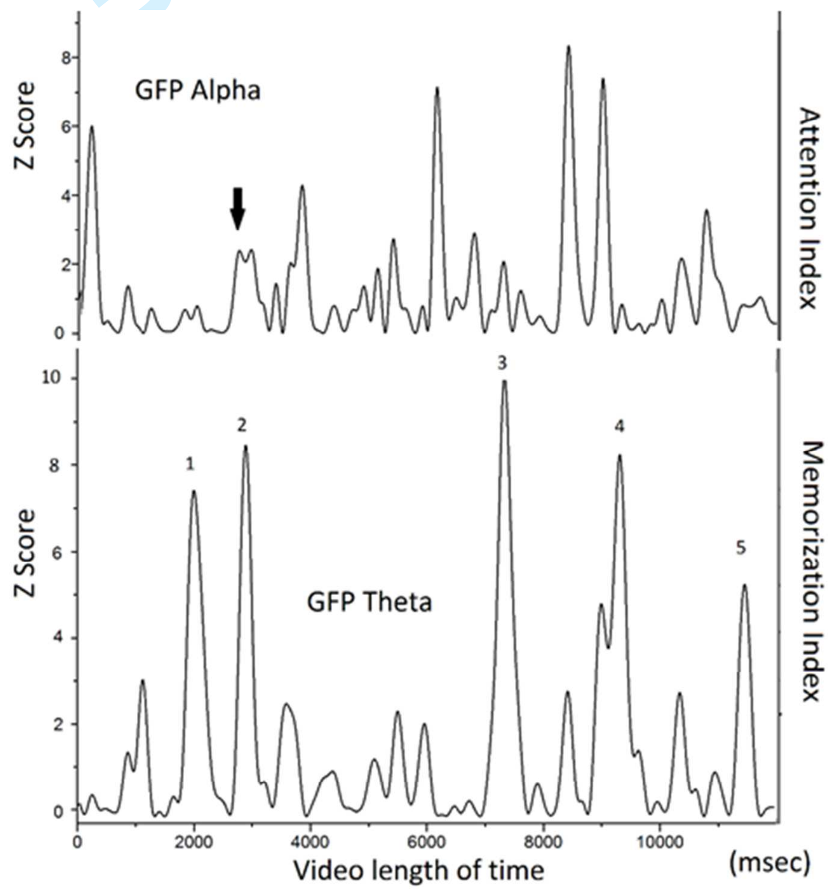

Figure 3: Time series EEG data associated with theta (top trace) and alpha (bottom trace) for a 12sec segment from a narrative video.

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