A Neuroscientific Method for Assessing Effectiveness of Digital vs. Print Ads

Using Biometric Techniques to Measure Cross-Media Ad Experience and Recall

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Marketers can choose among various media to convey advertising, ranging from printed advertising on paper to websites through the Internet and mobile through smartphones and tablets. Which medium is the most effective in terms of information memory or reading behavior is not clear, however. In this study, advertisements from an Italian newspaper were presented in three media formats: website (through the Internet with a desktop PC), paper, and a PDF version displayed on a tablet device. Responses to the same news and advertising were measured with eye tracker, electroencephalography (EEG) brain scanner, and memory test.

INTRODUCTION

Today people are reached by advertising messages through different media, as television and newspapers have been flanked by new devices, such as smartphones and tablets. These devices are now widespread and essential objects in everyday life, giving marketers new opportunities to place advertisements. It is not clear, however, which device is the most effective in conveying promotional information.

In addition to traditional techniques, such as memory recognition tasks, innovative psychological measurements are able to provide a broader evaluation of consumers' reactions to advertising. The study presented in this article compares readers' reactions to three different types of media evaluated by advertising memorization, visual attention, and cognitive response.

Three groups of participants read the same newspaper on three different media: paper, a website shown on a desktop PC, and a PDF version presented on a tablet. Participants' visual attention toward the advertisements in each medium was recorded by an eye-tracker system synchronized with an electroencephalography (EEG) brain scanner. Participants' advertising memorization was tested with recognition tasks performed after exposure to the advertisements. Results and conclusions are presented, and advertising effectiveness related to readers' behavior is discussed in a comparison of the three media formats.

Management Slant

- The PDF version of the newspaper on a tablet device yielded the highest memory performance, the greatest visual attention, and the highest electroencephalography (EEG) frustration index (defined as a "state of perceived irritation") while participants watched advertising messages.
- The website had the lowest performance in terms of visual attention and memorization.
- The study provides relevant insights for marketers related to the choice of medium and to benefits in the practical use of neuroscience methods.

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LITERATURE REVIEW

New Types of Media and New Challenges for Advertising

Advertising is crucial for the success of services and products (Ademola, 2009). It improves consumer awareness (Mattila, 1999), it persuades consumers to change their opinion or attitude to enhance their desire to purchase (Meyers-Levy and Malaviya, 1999), and it develops the competitive advantages of a brand (Till and Busler, 1998).

In addition to communication strategy (Baack, Wilson, and Till, 2008; Till and Baack, 2005), an important role in mediating advertising effectiveness is played by the medium chosen to convey the advertising message (Stafford, Stafford, and Day, 2002). Each medium has distinct features and thus elicits specific consumer behavior. Paper media, which make use of the physical entity, give the reader an indication of the size and format. A website is less tangible but allows readers to navigate through the contents and to select the section to which they want to direct their attention. A PDF emulates the paper medium in digital form.

Each medium facilitates different user behavior by level of engagement, level of attention, and psychological attitude toward advertising. Decades ago, Marshall McLuhan (1964) stated that the psychosocial effect of medium on the audience is higher than the message itself and that the medium affects advertisement effectiveness. It is thus important for a marketer to understand the relation between types of medium and advertising effects and how readers' behavior may change from one medium to another. Studies by previous researchers (Bezjian, Calder, and Iacobucci, 1998; Sundar, Narayan, Obregon, and Uppal, 1998) demonstrated that advertisements conveyed through paper formats are retrieved and recognized better than those conveyed over the Internet.

An explanation for this difference has been called "banner blindness," which refers to the tendency of users to avoid looking at banners when viewing websites (Benway and Lane, 1998). Banners and "skyscraper advertisements" (*i.e.*, vertical banners) compete with surrounding editorial contents in terms of visual attention (Drèze and Zufryden, 2000). In an eye-movement study on Internet search, researchers found that people were able to spot banner advertisements positioned in peripheral areas of visual scenes and intentionally avoid them (Drèze and Hussherr, 2003). Additionally, only 46.9 percent of the participants remembered seeing any banner advertisements during the test. A recognition task revealed that participants were not able to distinguish accurately advertisements that were presented during the experiments from ones that never had appeared.

One study showed that when the structure and design of websites remained the same, the duration of eye fixations on the banner decreased progressively for each page viewed (Lapa, 2007). This probably was due to human learning processes enabling participants to adapt quickly to visual stimuli and, in this case, to avoid advertising banners. Another study found that 63.3 percent of website banners were not fixated (Hervet, Guérard, Tremblay, and Chtourou, 2011), whereas still another demonstrated that on a printed medium, such as the Yellow Pages, the percentage of advertisements not viewed was only 10 percent (Lohse, 1997). Recent studies have shown similar results indicating that banners are viewed less when users are reading text on webpages (Simola, Kivikangas, Kuisma, and Krause, 2013). A review article supported the claim that advertising on the Internet is affected by advertisement avoidance in terms of visual behavior (Higgins, Leinenger, and Rayner, 2014).

There is limited published research on how people divide their visual attention when using a tablet and even less research about the effectiveness of advertising presented in this medium.

Although several studies have compared Internet and paper advertising, there is limited published research on how people divide their visual attention when using a tablet and even less research about the effectiveness of advertising presented in this medium. Some studies from marketing companies, however, have found that users of tablets have a more positive attitude toward advertisements, perhaps because they consider advertisements an acceptable part of the content when news is brought to them this way (*Orlando Sentinel*, 2012).

The current study deepens results from previous research (Bezjian *et al*., 1998; Sundar *et al*., 1998) adopting a neuromarketing approach to compare newspaper advertising effects in website, paper, and digital formats (on a tablet). In continuation of previous studies (Eveland and Dunwoody, 2001; Tewksbury and Althaus, 2000), the current authors embedded in the study a paper format of the very same newspaper, for comparison with the website version. The digital version was accessed by means of a desktop computer, and a PDF of the newspaper was shown on a tablet device. The authors included the tablet to respect ecological validity, given that 95 percent of Italians read the digital version of their newspaper on a tablet. The last 5 percent read the newspaper as a PDF on their PC.

Measuring People's Response to Advertising

Asking what participants think, feel, or usually do are well-proven methods for testing consumer behavior in psychology, but these methods also have drawbacks as a result of limited self-awareness (Pryor, Gibbons, Wicklund, Fazio, *et al*., 1977) or the social-desirability phenomenon (Arnold and Feldman, 1981). Participants tend to report what they think is the right answer or what is socially acceptable to say, which challenges the objectivity in measurements of reactions to affective content, such as advertising. Through neuromarketing tools, however, it is possible to capture the effects of an advertisement and the feelings that it provokes (Poels and Dewitte, 2006). Researchers further concluded that, in relation to advertisements, physiological measures have higher predictive power than self-reports (Poels and Dewitte, 2006).

In the last few decades, several studies have explored these neuroscientific applications in the fields of communication and consumer behavior (Khushaba, Wise, Kodagoda, Louviere, *et al*., 2013; Ohme, Reykowsa, Wiener, and Choromanska, 2009; Plassmann, Ramsøy, and Milosavljevic, 2012), and the field of research named "neuromarketing" has achieved growing interest (Lee, Broderick, and Chamberlain, 2006). Neuromarketing is a branch of marketing that uses neurological and biometric technologies to assess consumers' affective reactions (Lang, 1995; Larsen, Norris, and Cacioppo, 2003; Rainville, Bechara, Naqvi, and Damasio, 2006). Neuromarketing already has been applied to advertising messages (Missaglia, Oppo, Mauri, Ghiringhelli, *et al*., 2017), packaging (Liao, Corsi, Chrysochou, and Lockshin, 2015), and brands (Venkatraman, Clithero, Fitzsimons, and Huettel, 2012) as well as other stimuli and consumer experiences (Ciceri, Stasi, Nardone, Songa, *et al*., 2015; Mauri, Onoroati, and Russo, 2012; Russo, 2015).

The ability to record physiological reactions to different stimuli or media has opened a way to a wider understanding of consumer behavior. For this reason, this study measures the effects of advertising conveyed on different media not only in terms of using recognition tasks but also in terms of visual attention and cognitive response, through biometric techniques such as eye-tracking and EEG.

Memorizing Advertising and Its Relation to Visual Attention

The memory process represents a key factor in marketing because it is a critical part of how advertising influences consumer behavior (Mehta and Purvis, 2006). According to the scientific literature, consumers' brand evaluation and purchase decisions are affected by their remembering an advertising campaign, because people do not buy a product during or right after advertising exposure (Alba, Hutchinson, and Lynch, 1991; Nedungadi, Mitchell, and Berger, 1993). For this reason, memorization of advertising is a typical measure of effectiveness, with a number of empirical studies demonstrating its worthiness (Dubow, 1994; Lodish, Abraham, Kalmenson, Livelsberger, *et al*., 1995).

Memorization measures widely used in advertising research are recognition and recall tests, used in cued memory tasks (Friestad and Thorson, 1993; Kellaris, Cox, and Cox, 1993). Recognition is a memory technique involving asking consumers to choose which advertisements they have been exposed to, among a list of advertisements that have and have not been shown during a previous experimental test. Free-recall assessment, conversely, provides a trustworthy simulation to evaluate consumers' ability to remember an advertisement. It only relies on the participant's memory, however, without a list of stimuli (Bettman, 1979).

Recognition is a more effective measure of memorization than recall (Krugman, 1972), because the latter may mask the amount of actual memory (Zielske, 1982). The recognition score is the proportion or percentage of the recognized stimuli in relation to the whole number of advertisements. It has been used in a large number of studies about advertising memorization (Du Plessis, 1994; Furnham and Mainaud, 2011; Perfect and Askew, 1994; Simola *et al*., 2013). One study compared the percentage of recognized advertisements between a deliberate and an incidental advertising exposure in a color magazine (Perfect and Askew, 1994). Another study used a recognition task to demonstrate that congruency between advertisements and editorial texts improved memory for advertisements (Simola *et al*., 2013).

The relation between visual attention and cognitive processing, such as eye movements and memorizing, has been found for picture stimuli (Christianson, Loftus, Hoffman, and Loftus, 1991; Loftus, 1972), print advertisements (Krugman, Fox, Fletcher, Fisher, *et al*., 1994; Pieters, Warlop, and Wedel, 1999; Rosbergen, Pieters, and Wedel, 1997), and television commercials (Thorson and Zhao, 1997). One study labeled it the "eye–mind hypothesis" (Rayner, 1998), because the human visual system has been found to have a strong relation with higher-order cognitive processes (Rizzolatti, Riggio, and Sheliga, 1994; Russo, 1978) related to brand memory and decision making.

Measuring visual attention is essential to examining the effectiveness of advertisements because eye movements have a strong relation with higher-order cognitive processes (Rizzolatti *et al*., 1994; Russo, 1978). Visual attention is related to brand memory (Wedel and Pieters, 2000), consumers' attitudes (Rosbergen *et al*., 1997), and decision making (Pieters and Warlop, 1999; Chandon, 2002). Visual attention is conceptualized as "a brain operation producing a localized priority in information processing—an attentional 'window' or 'spotlight' that locally improves the speed and

The longer and deeper the visual attention to advertising is, the greater is the extent to which users actually can learn from it, recognize it, and recall it.

reduces the threshold for processing events" (Deubel and Schneider, 1993, p. 575).

In recent years, technological progress has made it possible to assess visual attention through eye tracking, a technology that can detect and analyze the visual-attention focus and its amount (Laubrock, Engbert, Rolfs, and Kliegl, 2007). A later study confirmed the usefulness of eye tracking, stating that it provides more accurate information than self-reports or memory scores (O'Connell, Walden, and Pohlmann, 2011).

In terms of memorization, several studies have demonstrated the relation between visual attention and brand memory (Chandon, 2002; Pieters and Warlop, 1999; Rosbergen *et al*., 1997; Wedel and Pieters, 2000). These studies have shown that an increase in eye fixations on an item increases the likelihood the individual will remember it. The longer and deeper the visual attention to advertising is, the greater is the extent to which users actually can learn from it, recognize it, and recall it (Mehta and Purvis, 2006). One study confirming the benefit of eye tracking stated that it provides more accurate information than self-reports or memory scores (O'Connell *et al*., 2011).

Brain Response to Advertising

Irritation by advertising is the factor considered in this research, because this emotional state is an important predictor of advertising effectiveness. It has been found to reduce short-range and particularly long-range effectiveness (Greyser, 1973) as well as persuasion (Aaker and Stayman, 1990; Duncan and Nelson, 1985). Some advertising practitioners say that irritation and effectiveness walk hand in hand.

Several groups have studied the effect of advertising in terms of

- irritation (Aaker and Bruzzone, 1985; Fennis and Bakker, 2001; Gallagher, Foster, and Parsons, 2001; Wells, Leavitt, and McConville, 1971),
- annoyance (McCoy *et al*., 2007; Nagar, 2009),
- disturbance (Reed, 1999),
- avoidance (Speck and Elliot, 1997), or
- skepticism (Obermiller and Spangenberg, 1998)

rather than engagement. One researcher found a modest but significant correlation between the number of participants who used the word "irritating" to describe the commercial and the overall level of brainwave activity (measured by EEG) while the participants viewed commercials (Rothschild, 1982).

Information-processing technology now allows advertisers to shift from traditional mass advertising to tailored messages personalized on the basis of subjective preferences, yet advertisements still are considered unwelcome and annoying. Consumers often use various advertisement-avoidance tools, such as online advertisement blockers, and when these tools are not available they simply avoid paying attention to the advertisement itself (Baek and Morimoto, 2012).

Accordingly, the authors of the current study included the irritation factor as an indicator of emotional involvement generated by viewing the same advertisements on the three media considered. Because irritation is the emotional state that typically characterizes advertising, especially nowadays with greater advertising pressure, the authors believe that it also can better connote and differentiate the emotional reaction to the advertising on the three media.

In recent years, researchers have attempted to investigate brain activity during the viewing of commercial advertisements (Barnett and Cerf, 2017; Dmochowski, Bezdek, Abelson, Johnson, *et al*., 2014; Langleben, Loughead, Ruparel, Hakun, *et al*., 2009; Vecchiato, Astolfi, De Vico Fallani, Cincotti, *et al*., 2010). This interest is justified by the possibility of identifying indirect variables of emotional and cognitive processing by recording variations in the activity of specific brain structures linked to human reactions (Vecchiato, Maglione, Cherubino, Wasikowska, *et al*., 2014).

A widely used method to detect brain activity is EEG. This technique measures the cortical activation of the participants by means of electrodes placed along the surface of the scalp. A high temporal resolution enables the EEG to detect brain activity associated with changing stimuli (Ohme *et al*., 2009; Vecchiato *et al*., 2014). The benefit in using EEG for testing television commercials was demonstrated by a study that provided a continuous record of arousal data directly related to a specific stimulus (Deitz, Royne, Peasley, Huang, *et al*., 2016).

METHOD

Experimental Technologies

Eye-Movement Recording. Eye movements were recorded with the video-oculographic (VOG) technique. VOG uses an image of the eye taken by a digital-video camera to compute gaze position. To make this data processing fast enough to be performed in real

Figure 1 SMI RED250 Video-Oculographic Recording Systems

Figure 2 SMI Video-Oculographic Recording Systems Eye-Tracking Glasses

Figure 3 Electroencephalography (EEG) Epoc Emotiv Headset

time, the device illuminates the eye with infrared light to create corneal reflexes. Being invisible to the participant, the infrared light does not create a distraction.

For the experiment described in this article, two eye-tracking recording devices were used:

- SMI RED250 (See Figure 1), a remote system (sampling frequency 250 Hz), and
- SMI eye-tracking glasses (sampling frequency 60 Hz), which are a wearable device (See Figure 2).

The researchers resampled data from the remote system at 60 Hz to compare them with data from the eye-tracking glasses. SMI technology and its software Be Gaze already have been used in several scientific papers (Cowen, Ball, and Delin, 2004; Humphrey and Underwood, 2009; Kessels and Ruiter, 2012; Simola *et al*., 2013).

EEG Recording. EEG activity was recorded by means of the Emotive EPOC headset (www.emotiv.com). This device (See Figure 3) is composed of 14 EEG channels located at the positions AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4, according to the International 10-20 system (Cacioppo, Tassinary, and Berntson, 2000). The Emotive EPOC headset samples at a frequency of 2,048 Hz, which then gets down-sampled to 128 Hz sampling frequency per channel.

The data are sent to a computer by Bluetooth through a proprietary USB dongle to communicate with the 2.4-GHz band. As with other proprietary algorithms, such as the one from Sands Research (Deitz *et al*., 2016), the reliability of the EPOC headset (Esfahani and Sundararajan, 2011) and its algorithm, Affective Suite, have been demonstrated in a number of recent publications (Goldberg, Sottilare, Brawner, and Holden, 2011; Gonzales-Sanchez, Chavez-Echeagaray, Atkinson, and Burleson, 2011; Grant and Schmidt, 2012; Khushaba *et al*., 2013; Kuber and Wright, 2013; Lievesley, Wozencroft, and Ewins, 2011; Ohme *et al*., 2009). All of the technologies were synchronized by means of the Observer XT from Noldus (www.noldus.com).

Experimental Protocol

A national Italian newspaper was used for the study, provided in three media: a website displayed on a laptop computer, a printed edition (paper), and a PDF file viewed on a tablet. Twenty-five real and static advertisements appeared in the three media, presented in each medium in the same order. The advertisements were identical in the three media and had the same size (in proportion to the page size).

For the study, the researchers created a mock newspaper for each medium that in all aspects was identical to the original version of the newspaper, to ensure a genuine comparison among the media. A total sample of 72 habitual newspaper readers (36 men) between 23 and 55 years old ($M = 38 \pm 9.15$ years) participated in the research study. The authors selected this target group because it is representative of Italian newspaper readers. They used a stratified sampling method that considered gender, age, and randomization as crucial.

All the participants were healthy, right-handed individuals with no personal or family history of mental illness. The authors controlled this variable in consideration of the hemispheric lateralization theory, although its validity has been criticized in the advertising field (Katz, 1983). Participants were divided into three subgroups of 24 participants to ensure an equal distribution of gender and age. Each group of participants only read the newspaper on one of the three media:

Table 1 Participant Distribution for Each Subgroup

	Age Range in Years	
Gender	**28–39**	**40–55**
Men	6	6
Women	6	6

- condition 1: website,
- condition 2: paper,
- condition 3: tablet.

(See Table 1 for the distribution of participants across gender and age range for each group.)

The room where the participants read the newspaper was quiet and brightly illuminated, with a comfortable lighting condition. The display luminance of the two technological devices was the same; it was set so that reading on the webpage and the tablet was perceived as comfortable.

Condition 1: Website. After the Epoc Emotiv EEG headset had been adjusted to the participant, it was synchronized with the system. The participant then was seated 60 cm away from the computer screen for the SMI-RED250 eye-movement recording system. Before the eye-movement recordings began, the researchers carried out a five-point calibration using SMI iViewX software. The monitor used to display the newspaper was a Dell 17.3 inch, set with the same screen brightness as the tablet.

Condition 2: Paper. After the EEG headset and SMI eye-tracking glasses were adjusted to the participant, he or she sat in front of a book holder with the traditional version of the newspaper (printed paper). The use of the book holder allowed the authors to control for the visual-angle display, because it was placed at the same distance from the seat where the participant was placed (60 cm). The researchers performed eye-tracking calibration by asking the participant to fixate on five points indicated by the experimenter on the paper surface.

Condition 3: Tablet. After the EEG headset had been adjusted to the participant, he or she sat in front of a book holder carrying the tablet. The tablet (9.7-inch screen) displayed the digital edition of the newspaper in PDF format. All the participants were placed at a distance of 50 cm from the seat and used the same tablet set with the same screen brightness as the monitor used to show the website. All participants wore SMI eye-tracking glasses. The researchers performed eye-tracking calibration by asking the participant to fixate on five points indicated by the experimenter on the tablet surface.

In all the three conditions the participants were asked to read the newspaper freely at their own pace. The only restriction was the impossibility of going back to read a news article. Participants only could move forward. The same 25 advertisements were exposed in the same order for each of the three media. Each experimental condition ended automatically when all 25 advertisements had been shown on the medium.

Distraction Task. After reading the newspapers on the different media, participants did a distraction task, which lasted about one hour, and then the memory recognition task.

Memory Recognition Task. A typical recognition task was carried out after participants had been exposed to the advertisements. The recognition task was presented on a computer screen. Each participant was exposed to 50 advertisements for six seconds each; half of these advertisements were distractors, and the other half were the same advertisements shown while participants were reading the newspaper. Participants rated their responses by clicking with the mouse on "yes" to indicate that they had seen the advertisement previously or "no" if they had not. Both response points appeared on the same PC screen.

Data Analysis

Eye-movement analysis was performed offline with Be Gaze software. On each advertisement, an area of interest (AOI) was defined, and software calculated several parameters for each AOI. In this study, the average gaze duration or average fixation time was analyzed from the first entry of the eyes into the AOI. This eye-movement measure represents the duration of every fixation on each advertising image, which is the total time spent viewing each advertisement.

Because vision effectively is suppressed during saccades, which are rapid movements of the eye between fixation points (Henderson and Hollingworth, 2003), they were excluded from the analysis. Eye movements lasting less than 40 milliseconds therefore were filtered and excluded from the analysis (Rayner, 1998). Fixations lasting less than 110 milliseconds or longer than 2,350 milliseconds were eliminated as outliers.

As a measure of visual attention on advertising, the authors therefore opted for fixation time, because its validity as an indicator of visual attention has been demonstrated empirically (Christianson *et al.*, 1991). Fixation time is a measure largely used in the research on attention and advertising memorization (Ares, Giménez, Bruzzone, Vidal, *et al*., 2013; Henderson and Hollingworth, 2003; Rosbergen *et al*., 1997).

In the analysis, the number of fixations was not considered as a visual-attention measure, because this index is limited to considering fixations with different durations in the same way (Tatler, Gilchrist, and Land, 2005). Adopting as a metric the number of fixations is not correct and may introduce errors, because this metric is not able to reflect the amount of attention objectively. A participant might have a high number of fixations, but of limited duration, for example, and not sufficient to allow a cognitive elaboration of visual information. Conversely, fixation time is a more robust and representative measure. The researchers also used this metric because it represents the duration during which information acquisition and processing for a particular advertising element can occur (Scott, Green, and Fairley, 2015).

EEG analysis was provided by the Emotiv Affective suite, a software package that reports real-time changes in subjective emotions experienced by the user. The Emotiv Affective suite offers five distinct affective detections:

- engagement (a reflection of the alertness and conscious direction of the attention toward task-relevant stimuli),
- long-term excitement and short-term excitement (which both describe an experience of awareness of positive physiological arousal),
- frustration (representative of an irritation state), and
- meditation (which indicates a type of relaxed state; Goldberg *et al*., 2011; Inventado, Legaspi, Bui, and Suarez, 2010; Koutepova, Liu, Lan, and Jeong, 2010).

The frustration affective index was used in this study. As described previously, it mostly is related to the typical state of perceived irritation caused by advertisements. It could be defined as "consumers' perceptions of the extent to which advertising is causing displeasure and momentary impatience" when they are reading a digital (McCoy, Everard, Polak, and Galletta, 2007) or traditional newspaper or seeing a television program when an advertisement appears (Aaker and Bruzzone, 1985). In this study, the EEG affective detection was registered continuously during the entire experiment. The researchers synchronized the eye tracker and EEG to isolate and therefore analyze specifically the EEG data during the observation of advertisements.

Detecting and removing artifacts in the EEG data due to muscle activity, eye blinks, and electrical noise is an important issue in EEG signal-processing analysis. The Epoc Emotiv hardware applies independent band-pass filters to remove the 50- and 60-Hz power components and other forms of preprocessing to reduce noise. The authors carefully inspected data about the EEG frustration index to detect artifacts or changes due to head movements or any other kind of signal noises.

Table 2 Median Fixation Times during Advertisement Visualization

Medium	Fixation Time (ms)
Web	553.26 ± 904.67
Paper	1,364.97 ± 1,379.96
Tablet	1,879.32 ± 1,173.74

The authors used a combination of independent component analysis (Hyvarinen, Karhunen, and Oja, 2001) and a semiautomated rejection coupled with visual inspection, using the EEGLAB software for artifact rejection. Outliers were removed with R software and Matlab. Only the EEG data recorded during the participants' eye fixations of static advertisings were considered for the analysis. After this preliminary EEG data-selecting and -cleaning phase, it was possible to assess cerebral response during advertisement visualization for each medium.

RESULTS

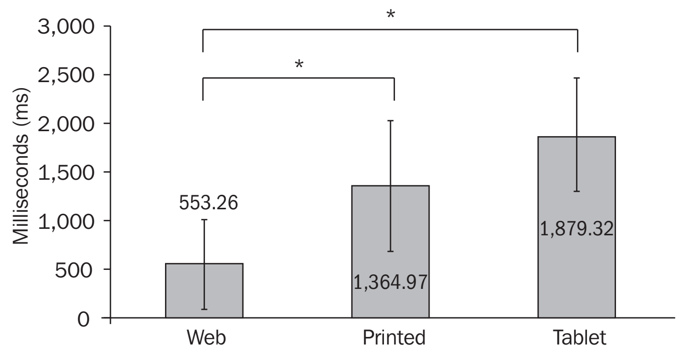
Eye-Tracking Results

The eye-tracking data did not follow a normal distribution (Shapiro–Wilk test, $p < .05$); thus, the authors performed nonparametric analyses. First, they assessed whether the number of pages read had an effect on readers' experience. They therefore compared the average fixation time on advertisements in the first pages with the average fixation time on advertisements in the last pages. Results revealed that there was not a significant difference (Mann–Whitney test, $p > .05$). The number of pages read or browsed did not affect participants' visual behavior.

When the authors analyzed the average fixation time spent on advertisements, the value was the lowest for the website medium compared with both the tablet and the paper media. The highest value was observed with the tablet medium (See Table 2). Statistical analysis showed that there was a significant difference in the fixation time on the advertisements among the three media (Kruskall–Wallis test, $p < .05$). A *post-hoc* Nemenyi test revealed that the difference was significant between web and paper and between web and tablet (See Figure 4).

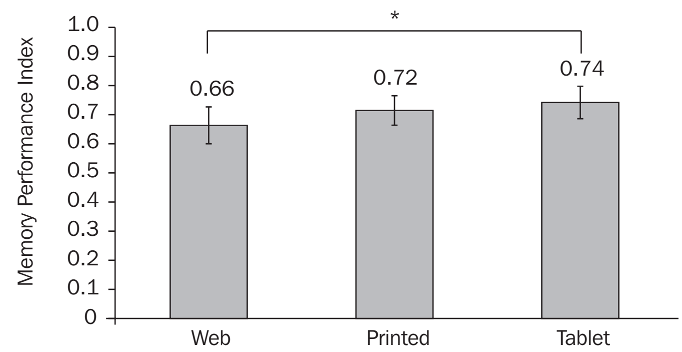
Memory Performance Results

The authors computed an index of memory performance that relied on the results of the recognition task. The index is the mean of two different indices:



Note: Differences between tablet and web and between paper and web were statistically significant (p < .05)

Figure 4 Mean Values for Fixation Time on Advertisements



Note: Differences between tablet and web were statistically significant.

Figure 5 Mean Values for Memory Performance Index

Table 3 Median Fixation Times during Advertisement Visualization

Medium	Memory Performance Index
Web	0.66 ± 0.133
Paper	0.72 ± 0.099
Tablet	0.74 ± 0.098

Table 4 Median EEG Frustration Index during Advertisement Visualization

Medium	EEG Index
Web	0.413 ± 0.144
Paper	0.577 ± 0.158
Tablet	0.599 ± 0.376

- the proportion of correct recognition (answer "yes" to a target ad) on the whole number of advertisements (*i.e.*, 25), and
- the proportion of "true negatives" (answer "no" to distractors) on the whole number of distractors (*i.e.*, 25).

The data were distributed normally, so the researchers used parametric tests to perform the analyses.

The participants who used the web medium had the lowest value in the memory performance index, whereas the highest value was achieved by participants who used the tablet medium (See Table 3). Analysis of variance revealed significant differences in memory performance among the three media, $F(1, 69) = 5.98$, $p < .05$. A *post-hoc* Tukey test revealed that the difference was significant between web and tablet (See Figure 5).

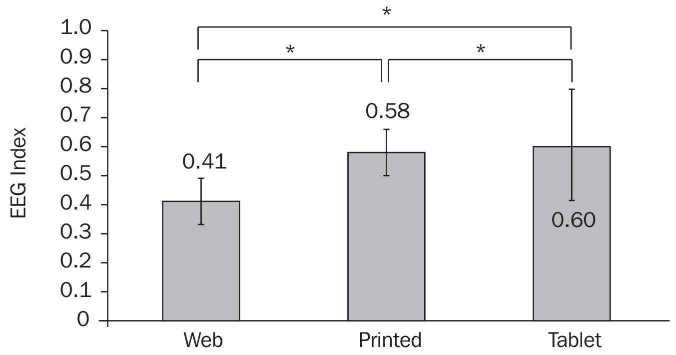
EEG RESULTS

The authors analyzed EEG data for each participant during each advertisement exposure. As first reported, they chose the frustration EEG index as a measure of participants' perceived irritation when looking at an advertisement. EEG frustration is more generally an index inversely related to the level of pleasure. An EEG frustration value closer to zero indicates a condition of perceived pleasantness, whereas a number closer to maximum value (1) reflects an unpleasantness situation.

The EEG data did not follow a normal distribution (Shapiro–Wilk test, $p < .05$), so the researchers performed nonparametric analyses. Even for this index, they assessed whether the number of pages read or browsed had an effect on readers' experience, adopting the same comparison as used for eye-tracking data. To do that, they compared the average EEG frustration index in the first pages with the average EEG frustration index in the last pages.

Results revealed that there was not a significant difference (Mann–Whitney test, $p > .05$). The number of pages read or browsed thus did not affect participants' response in terms of EEG frustration level. The median and standard deviation of this index during the visualization of each advertisement were computed (See Table 4).

As reported (See Table 4 and Figure 6), the EEG frustration index during visualization of the advertisements in the web medium was the lowest value, whereas during tablet advertising exposures the values were the highest, on average. In the paper condition, the value was closer to the tablet condition than to with the web condition. Statistical analysis revealed significant differences in the EEG frustration index among the three media (Kruskal–Wallis chi-square, $p < .01$). A *post-hoc* Nemenyi test revealed that the difference was significant between tablet and web, between paper and web, and between tablet and paper conditions during the advertising exposure (See Figure 6).



Note: Differences between each pair of media were statistically significant.

Figure 6 Median Values for the Electroencephalography (EEG) Frustration Index.

Table 5 Summary of Significant Differences among the Metrics Considered

Media	**Memory Performance Results**	**Eye-Tracking Results**	**EEG* Results**
Web vs. tablet	$p < .05$	$p < .01$	$p < .05$
Web vs. paper	*ns*	$p < .05$	$p < .01$
Tablet vs. paper	*ns*	*ns*	$p < .01$

* EEG = electroencephalography

DISCUSSION

Results showed a significant difference among the three media for all of the considered measures. The only medium that resulted in significant differences for all metrics (memory performance, eye-tracking data, and EEG frustration index) was the web compared with the tablet (See Table 5). The results for the web compared with the paper medium show two metrics with significant differences: eye-tracking data and the EEG frustration index. No significant difference emerged between print and web media in terms of memorization performance. As other researchers have shown (Gallagher *et al*., 2001), both media are equally effective in this metric. When the researchers compared the tablet and paper conditions, significant differences did not emerge, with the exception of the EEG frustration index data.

These findings confirm a well-defined and very typical behavior with advertising experienced on different media, as demonstrated in previous studies (Varan, Murphy, Hofacker, Robinson, *et al*., 2013). In particular, the authors found a similar behavior reaction to advertising conveyed by tablet and paper. The web, in contrast, was characterized by a typical and very different reaction to advertising stimuli. These differences related to advertising performance could be due to different reading behaviors that characterize each medium.

On the one hand, results from tablet and paper media were very similar. On the other, web conditions represent a medium characterized by a very different behavior, as reflected by the results reported here. Media experts have predicted that digital versions of newspaper read on a tablet or other mobile device will replace the printed paper (Anderson *et al*., 2012). Some nuances have to be taken into consideration, however. Reading-behavior data collected in this study indicate that reading on a tablet might be closer to reading a classical newspaper than is reading on a website.

With respect to visual-attention data, total fixation time was higher for tablet and paper media in comparison with the web medium. Participants spent less time watching advertisements, thus remembering fewer of the advertisements, when they were reading the newspaper on a website. This result is consistent with previous studies that explained this phenomenon as banner blindness. Whereas the structure of the website leads to a quick learning of the position of the advertising (Lapa, 2007), this is not the case for printed (Lohse, 1997) or tablet media.

Another explanation for this result could be related to readers' expectations of the appropriateness of advertising in the online medium. When readers are interactive in their use of an online medium and perceive the medium as a channel for news and information, they might consider it inappropriate for advertising (Sundar *et al*., 1998). Moreover, advertising on the Internet is perceived as irritating, and for this reason online readers avoid looking at the advertisements (Brackett and Carr, 2001).

As for visual attention, the same trend was found for the EEG data. A higher value in the EEG frustration index was related to increased activity of brain waves associated with consumers' perceptions of irritation and displeasure generated when they were watching advertising on tablet and paper. The lowest frustration index value was elicited with exposure to advertising on the Internet by means of a website.

In terms of behavioral responses, therefore, participants not only less likely would spend time (in terms of visual attention) on advertising stimuli when they were reading the newspaper on a website, but they also experienced the lowest EEG frustration. In terms of the recognition task, the memory performances also were the highest for participants viewing advertisements on tablet and paper media and lowest for participants viewing them on the website. These results once again support the banner-blindness hypothesis.

The poor performance of the web medium in terms of advertising memorization also may be supported by previous studies in mass communication that have examined differences in learning from the web compared with traditional print medium (Eveland and Dunwoody, 2001; Tewksbury and Althaus, 2000). Several

The unpleasant experience readers had when they saw advertisements on printed newspaper and tablet does not seem to have had a negative effect on advertisement memorization.

studies have found that consumer attitudes toward print advertising are, in general, more positive than their attitudes toward advertising on the web (Grussell, 2007; Ha and McCann, 2008).

Scientific research has found that advertising on printed newspaper is considered by readers to be as informative and useful as the editorial content itself. Readers perceive newspapers' advertising to be less annoying than advertising in other media (Elliott and Speck, 1998). This finding is confirmed in the current study with the eye-tracking data. On average, readers spent more time looking at the advertisements conveyed by paper and tablet, which thus denotes a minor annoyance effect of advertising in these media.

The same was not confirmed with the EEG frustration index, which was higher in the printed and tablet newspaper conditions than in the website condition, denoting more irritation. This could be explained by the minor amount of attention that readers, on average, spent on advertising conveyed by website, which might have elicited a consequently smaller amount of irritation and annoyance, as reflected in the EEG frustration index.

The unpleasant experience readers had when they saw advertisements on printed newspaper and tablet does not seem to have had a negative effect on advertisement memorization, which was higher in comparison with the same indicator for the website newspaper—a medium in which the EEG frustration amount was minor. As is already known, in advertising, a very unpleasant advertisement can be as effective as a very pleasant one (Greyser, 1973), because strong negative or positive emotions are more effective than those in between. In this study, negative emotions combined with a higher amount of attention on advertising contributed positively to advertising memorization.

Taken together, the results confirm the role of the medium as an important variable to take into consideration for evaluating the effectiveness of the communication between senders and receivers (McLuhan, 1964) and for assessing advertising. The combination of eye-tracking and EEG data has been shown to be methodologically feasible. It represents a potential means to gain new insights into the neurocognitive and behavioral bases of reading in general (Dimigen, Sommer, Hohlfeld, Jacobs, *et al.*, 2011) and, in particular for the current study, of advertising effectiveness during news reading.

Conclusions

The results show how evaluation of advertising effectiveness, in terms of memorization, visual attention, and cognitive processing, is influenced by media type. The banner-blindness hypothesis has received additional support from data presented and analyzed in this research and by means of neuromarketing techniques. On one hand, eye-tracking data show that people spent more time on advertising flyers when reading a newspaper on a tablet and on paper in comparison with website navigation. On the other hand, brain waves associated with a perceived unpleasantness showed greater activation when participants viewed advertisements while reading a newspaper on a tablet and on paper rather than on a website. This finding underlines the benefits of applying new techniques, such as eye tracking and EEG, in combination with pen-and-paper techniques, such as memory tasks. This multimethod approach to a marketing issue provides a deeper understanding of reader behavior and increases researchers' ability to describe consumers' psychological and behavioral response to advertising.

Other disciplines might take advantage of this multidimensional approach. This could enable them to go further and develop more complete and broader ways to measure consumer behavior by merging neuroscientific methods in the field of marketing. The approach allows researchers to explore and evaluate ways to improve scientific methods in the field of communications science.

The study gives marketers and academics a here-and-now picture of consumer reactions toward advertising on different media as they appear on the market today. The study offers the opportunity to compare three different media. Many other published studies with similar approaches considered only one medium at time (Ambler, Ioannides, and Rose, 2000; Daugherty, Hoffman, Kennedy, Nolan, *et al.*, 2015; Deitz *et al.*, 2016; Orzan, Zara, and Purcarea, 2012; Rothschild, Hyun, Reeves, Thorson, *et al.*, 1988; Varan *et al.*, 2013; Venkatraman, Dimoka, Pavlou, Khoi, *et al.*, 2015; Wawrzyniak and Wasikowska, 2016).

With respect to the study of advertising effectiveness in newspapers, to the authors' knowledge, no studies have been conducted that used the neuromarketing approach. In today's context, characterized by multichannel advertising, knowing the typical features of each newspaper medium is a strategic part of planning an effective media mix able to optimize consumer attention, engagement, and advertising memorization on newspapers.

This research demonstrates that marketers can measure attention and therefore understand the likelihood that the advertisements will be noticed. In addition, by measuring EEG activation, marketers are able to assess the subconscious effect of advertising on consumers, and, more important, they are able to have a more detailed view of each medium's typicality.

Limitations and Future Research

In addition to the significant results presented in this article, some critical points should be taken into account. First, marketers and professionals should take note of the priority of ecological validity over methodological issues. The researchers compared the results from different media with different experimental protocols that preserved the typical ways of using the media. This approach takes advantage of the natural and most common conditions of newspapers' exposure in real life in the lab experimental conditions. The use of different experimental protocols, however, leads to the possibility that external variables might affect the results, even though previous research has used the same experimental setup (Eveland and Dunwoody, 2001; Tewksbury and Althaus, 2000).

To decrease the effects of external variables as much as possible, the authors showed the same stimuli (advertising images) in the three media and in the same sequence. The authors are aware that some features of different devices could influence users' experience. Screen size can affect perceived usability and efficacy, because users are more efficient in seeking information if they interact with screens larger than 4.3 inches. This factor affects their perception of user experience (Raptis, Tselios, Kjelsdskov, and Skov, 2013). This experiment used a desktop PC and a tablet, which both had a screen larger than 4.3 inches, to minimize the effect of screen size.

The study had an explorative aim, and the main goal was to reach useful insights for marketers, comparing the effectiveness of three different solutions regardless of the specific reasons related to the features of the devices. On the basis of the results in this study, future research should deepen the understanding of the role of these specific features.

To assess differences in user experience due to different displays, it may be beneficial to compare separately the website shown on a tablet and on a PC screen and the PDF version shown on a tablet and on a PC screen, to overcome the effects of external variables. User traits also were considered as exogenous variables and excluded from this study.

It also would be useful to corroborate and generalize the study's findings for testing the long-term memorization of advertisements on different media. The authors expect that the memory will diminish over time (see Zielske, 1982). It would be interesting to observe the advertising performance over time that different media are able to promote. In this way, it could be possible to provide a metric to be used in media planning (Foucher, Le Blanc, Morgensztern, and Vallaud, 2006). Further research will consider these aspects to understand more in detail the typical memorization and experience behaviors that characterize each medium.

Certainly, this research contributes to the debate on the possibilities that the neuromarketing methodology offers a means to understand objectively behavioral aspects to which marketing has always paid attention, but with limited results. In this sense, passive physiological measures in general have the advantage of not disturbing cognitive processes and for this reason are suitable to analyze this phenomenon (Rothschild *et al*., 1988). Recent research has confirmed the validity of these neuromarketing methods in providing more direct and detailed information on important aspects of consumer response to marketing messages, giving additional insights that lead to better decision-making processes (Stipp, 2015). JAR

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