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Confidentiality: {Public, Consortium}

Date and status: {Date: created date - Status: Version 1.0 is the first accepted version}

This work was supported by TEKES as part of the next Media programme of TIVIT (Finnish Strategic Centre for Science, Technology and Innovation in the field of ICT

Media experience elicited by print and tablet news:

A psychophysiological investigation

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Executive summary

This study focuses on the differences in media experience (MX) determined by type of device used in a news-reading setting. An experiment was conducted in which study participants read the Finland's leading national newspaper in two sessions of 15 minutes each, one on a tablet and the other on the traditional paper.

During the experiments, we obtained three categories of measurements: self-report (questionnaires and interview), physiological (electroencephalography - EEG, electrodermal activity - EDA, facial electromyography - fEMG, and heart rate), and behavioral (video recording). The data were collected after each reading session (digital and print) for (a) the whole reading experience, (b) each page browsed, and (c) each article read. In addition to the data collected during and *post* reading, a background questionnaire was answered online before the experiment in order to collect information about demographics, reading habits and personality of the participants. An interview was also conducted after the experiment to gather data about preferences and the reading experience.

The study is exploratory, because there are not many references that discuss the differences between the two media to be able to formulate hypotheses. A few related works show contradictory results, therefore studying the differences between digital and print newspapers in more detail is important. However, with respect to psychophysiological research there are well established correlates between physiological measurements and psychological constructs such as attention, emotion, and cognitive processes that are expected to be confirmed also in this study; in addition to those, there are a number of intuitive (but not yet proven) associations that we are intending to explore further (for example, between interestingness of a news and alpha power which is an index of approach motivation and attention, or between familiarity of news and different measures of facial electromyography that index positive and negative affect) .

In this paper, we limit the analysis to the data collected from questionnaires, EEG, EDA, and fEMG with regard to the whole media experience in each of the two reading sessions.

Abstract

In this study we compare the media experience elicited by digital and print news reading. The study was conducted as part of a larger project whose focus is on modeling and analysis of media experience. Media experience is a multidimensional and complex concept that can be represented and analyzed at three main levels: (1) meta-level that refers to the societal situation in which media products are used and developed; (2) macro-level that refers to the social interaction between people that is enabled by the use of media; and (3) micro-level that refers to the experience of individuals with media and to the characteristics of the media artifacts (Helle et al. 2011). The present study focuses on the micro-level and for measuring the individual experiences with media we have used self-report (questionnaire) and physiological measurements.

We have carried out a number of experiments in 2012 during February, March and April in a laboratory setting where the stimulus material was the Finland's leading national newspaper, Helsingin Sanomat. During the experiment the participants were reading the current issue of the newspaper in a natural way, in two browsing sessions, one on a digital tablet and the other on the traditional print medium. The main findings of the empirical study are that associations between physiological responses such as EEG activity, facial electromyography and EDA on the one hand and psychological constructs such as attention, arousal and valence on the other hand hold also when these measurements are recorded during a less structured task such as the free reading of a newspaper. Moreover, we found that selected self-report measures of media experience such as familiarity, interestingness, hierarchy, interactivity are associated with more objective measures that are recorded during physiological data collection. Last but not least, we observed that there are differences in physiological responses when reading from a digital versus a print medium.

1. Introduction

Media experience (MX) is a multidimensional construct that is ultimately intertwined also with societal situation, economy, and technology. It can be viewed at three main levels of detail: (1) meta-level that refers to the societal situation in which media products are used and developed; (2) macro-level that refers to the social interaction between people that is enabled by the use of media; and (3) micro-level that refers to the experience of individuals with media and to the characteristics of the media artifacts (Helle et al. 2011). As the term "Media Experience" implies, the concept refers fundamentally to *mental experience* including *appraisals* and *evaluations* of the media content and artefacts (e.g., perceived usefulness, understandability, and trustworthiness) and *feeling* states elicited by media (e.g., emotions, spatial presence, playfulness).

At the micro-level, MX is represented by a model with 16 dimensions that reflect different aspects of the experience of the user with a media product. These dimensions categorized into two classes: appraisal and emotional. However, some of the dimensions, such as playfulness, are more difficult to be placed into one of these two categories. Appraisal dimensions are the following: Usefulness, Interestingness Understandability, Trustworthiness, Familiarity, Unexpectedness, Brand experience, Price per value, Interactivity, Usability. The emotional dimensions are Aesthetics and presentational factors, Entertainingness, Playfulness, Spatial presence (in particular Attention allocation), Sensory perception and Emotions (pleasantness, arousal and dominance). A brief description of these dimensions is presented in the Appendix.

With respect to research methods, there are a number of different methodological approaches and measurement techniques (e.g., self-report, psychophysiological assessment, tracking of behavioral indicators of media experience, media ethnography) to assess the different components or dimensions of media experience. Different methodological approaches are optimal for assessing the different components of the media experience model. For example, media ethnography is particularly well suited for studying media practices, whereas continuous psychophysiological recordings are a strong method for acquiring information on the emotional aspects of media experience. An important research question is how the various methods employed in media experience research should be combined in order to get accurate and comprehensive information on media experience.

The present study investigates the MX of users interacting with digital and print newspaper for reading news. The aim of the study is to compare the media experience elicited by digital and print news reading. To this end, we have carried out a number of experiments in 2012 during February, March and April in a laboratory setting where the stimulus material was the Finland's leading national newspaper, Helsingin Sanomat. During the experiments the participants were reading the current issue of the newspaper in a natural way, in two browsing sessions, one on a digital tablet and the other on the traditional print medium. Different types of measurements were collected during the experiment, and in this study we analyze the

physiological and self-report data. In this paper, we try to answer the question: How MX differs between printed newspaper and digital news as assessed by psychophysiological measures and self-report? In addition, we are interested to assess the extent to which psychophysiological measures correlate with self-report measures of MX (convergent validity).

The motivation for this study is that understanding the differences between print and digital media in MX is of utmost importance (these differences are currently not fully understood). In addition, examining the convergent validity of different MX measures is important so that an integrated, broad view of MX can be attained.

The paper is structured as follows. Section 2 presents related work regarding physiological measurements and their correlates with emotional and appraisal dimensions of media experience. Section 3 describes the methods used for data collection and analysis. Section 4 presents the results of the empirical study. Section 5 concludes the paper. The Appendix presents the short definitions of the MX dimensions and the contents of the questionnaire we developed for measuring MX.

2. Related work

2.1. Psychophysiological measurements

Psychophysiology is a branch of psychology that studies the changes in the activity of the physiological systems caused by the psychological input (Turner 1994). The psychological input can be represented by different cognitive, emotional and behavioral phenomena. These are then studied as to their effects and relationships to physiological systems by observing/measuring, for example, heart rate, electrodermal activity and electroencephalographic activity. Providing that specialized equipment and experience are available, these types of psychophysiological measurements have been found as yielding useful information for assessing media experience in terms of attention and emotion of users.

Psychophysiological measures have some advantages over participants' self-reports of emotions (Ravaja, 2004a). Self-reports typically have to be collected after the experimental session in order not to interfere with it, which makes them prone to the confounding effects of language, memory and cognitive interpretations. Importantly, psychophysiological measures may also reveal subtle emotional responses that are not available to conscious awareness. A potential problem with psychophysiological measures is that they may be related also to other psychological constructs. For example, heart rate can explain changes in both attention and emotion, thus making this measurement difficult to interpret; whereas heart rate accelerates to emotional arousal, it is decelerated by attentional engagement.

2.1.1. Facial electromyography (EMG)

Facial EMG is a noninvasive method, where the facial muscle activation level is measured by attaching electrodes on specific facial locations, and which is used frequently as a psychophysiological index of positive and negative valences (Lang et al., 1993). There are three muscles whose responses are usually recorded using electromyography: zygomaticus major (lip corner raiser muscle; ZM), corrugator supercilii (brow furrower muscle; CS), and the outer region of the orbicularis oculi (cheek raiser muscle; OO).

2.1.2. Electroencephalography (EEG)

EEG is based on the recording of the electrical activity of the brain with electrodes placed in a special cap (up to 256 electrodes). Typically the EEG signal is analyzed either by 1) studying ERP's (event-related potentials), or by 2) studying oscillatory responses in different frequency bands. The ERP method would require many repetitions of some short duration (typically less than 1 second) stimulus. Thus, we chose to study oscillatory responses during the reading period. With this latter approach, one of the most important indices derived from EEG data is *brain prefrontal asymmetry* that has been used to index emotional valence and motivational direction. Accumulated research suggests that relatively greater left frontal cortical activation is associated with positive activation (PA) and approach motivation, whereas relatively greater

right frontal activation is associated with negative activation (NA) and withdrawal motivation. In addition, the so-called *alpha activity* has been found to correlate with attention, emotional arousal, interest and recall (Simons et al. 2003). Alpha wave power is defined as the amplitude of brainwaves in the 8-13 Hz frequency band.

2.1.3. Electrodermal activity (EDA)

EDA measurement is commonly known as skin conductance and it measures changes in the electrical conductance of the skin caused by the level of sweat in the eccrine sweat glands. In contemporary electrodermal research, EDA is usually measured with a constant voltage bridge. For skin conductance measurement, specific electrodes are placed on the palmar side of the second phalanx of the first and second fingers of the nonpreferred hand although other placements are also possible. EDA is frequently monitored to measure the activation of the sympathetic nervous system (Ravaja, 2004a). Consequently, EDA is an excellent index for the physiological component of arousal, and it has been shown to correlate with subjective ratings of arousal (Lang et al., 1993). Specific measures based on EDA can index the occurrence of involuntary attention (see Ravaja, 2004a).

2.2. Psychophysiological measurements in media research

2.2.1. Facial EMG

Facial EMG is frequently used to index *positive and negative valences* as well as *arousal* (Lang et al. 1993; Jäncke, 1994; Ravaja, 2004a). As shown earlier, there are typically three groups of muscles whose activity is recorded in order to measure different types of emotional responses to psychological stimuli: zygomaticus major (ZM), corrugator supercilii (CS) and orbicularis oculi (OO). Increased activities at the ZM and CS regions have been associated with *positive and negative valences*, respectively (Lang et al., 1993; Witvliet & Vrana, 1995). Activation of the outer region of OO region has been associated with *high-arousal positively-valenced emotions* (Jäncke, 1994; Ravaja, 2004a). Moreover, increased activity at OO is thought to be involved in the expression of *enjoyment smile and genuine pleasure* (Ekman et al., 1990) and also has been found to discriminate between *positive* and negative or neutral states in picture viewing (e.g., Jäncke 1994). Bradely and Lang (2000) have presented also evidence that the OO muscle has elevated activity for *arousing* versus neutral sounds.

In media research, some studies show similar evidence of the activity at CS and ZM when participants are presented with affective content of films (i.e., dynamic medium compared with still pictures) that supports the associations between facial EMG and negative and positive valence of stimuli, respectively (see Ravaja, 2004a for examples). Similarly, Bolls et al. (2001) show evidence of CS and ZM higher activity when exposed to negative and positive radio ads, respectively.

When studying the effect of more neutral messages as conveyed by financial video news messages on the affective dimensions of valence and arousal, Ravaja et al. (2004) found that corrugator activity was significantly higher during *a priori* negative, compared to positive, messages, but negative and positive messages were not differentiated by zygomatic activity. In addition, OO activity was higher during *a priori* positive messages and high-arousal messages as compared to negative messages and low-arousal messages, respectively. In that experiment the stimuli variation was represented by small reliable differences in the emotional tone of the messages.

A study by Hazlett and Hazlett (1999) compared facial EMG to self-report as a measure of emotional responses to television advertisements containing many emotional cues. They found that facial EMG measures discriminated emotional responses more effectively than self-report. In addition, the facial EMG was more strongly related to *recall* than self-report (although, this association was not convincingly established). Furthermore, peaks in facial EMG responses elicited during the commercial were temporally related to specific emotion-congruent events in the commercial. However, this study demonstrated that a commercial that has a high likability rating can elicit negative emotions (as measured by EMG) related to tension and drama. Therefore, it is not straightforward to conclude on the basis of EMG data which commercial to be selected for publication, because there is some evidence that a good advertisement may

elicit a strong overall emotional response, whether positive (indexed by zygomatic activity) or negative (indexed by corrugator activity). Thus relying only on EMG data may not be warranted in many situations; it is possible that a combination of facial EMG and cognitive response analysis resolves some of the problems (Ravaja, 2004a).

The aforementioned studies suggest that corrugator EMG activity can be used as a valid indicator of negative emotional responses in media studies, whereas zygomatic EMG activity should be interpreted with caution as an index of positive emotional responses, especially when the emotional messages are less extreme. As a further caveat, a slight increase in zygomatic activity (e.g., a facial grimace) may also be produced by very unpleasant stimuli (e.g., pictures of mutilated bodies) (Lang et al., 1993).

With regard to OO muscle activity, this is a potentially useful measure of positive emotional responses also during media messages, although OO activity may increase also during high-arousal stimuli (see also Witvliet & Vrana, 1995).

To summarize, the facial EMG measures are useful to index *pleasantness*, and *positive high-arousal emotions*. It is, however, also conceivable that facial EMG can be used to index other media experience dimensions involving emotional components, such as *playfulness* (through enjoyment and pleasantness)*, spatial presence* (when spatial presence is high, emotional content is likely to elicit more extreme positive or negative responses), *usability* (satisfaction elicited by good usability)*, usefulness* (useful media would be expected to elicit stronger positive affect compared to non-useful media), *interestingness* (more interesting content is expected to elicit stronger positive affect compared to uninteresting content), *understandability* (understandable content is expected to elicit more positive affect compared to non-understandable content), *trustworthiness* (media perceived as trustworthy would be expected to elicit more positive emotions compared to untrustworthy media), *brand experience* (good brand experience should be accompanied by positive affect), *perceived price/value* (low price/value should elicit positive affect), and *familiarity* (familiar products may elicit positive affect). The relationship of facial EMG measures with these other dimensions of media experience has, however, not been thoroughly examined and further studies are needed in this area to validate facial EMG as a measure of these dimensions.

2.2.2. EEG

EEG measures have been found in many studies to correlate with *positive affect* and *approach motivation*. When studying attention and motivation (approach/withdrawal), there are two widely used physiological measures: **frontal EEG asymmetry** and **alpha power**. The measurements of the left frontal cortical activation have been found to correlate with *positive activation* and *approach motivation*, while right frontal cortical activation associates with *negative activation* and *withdrawal motivation*. The alpha power EEG measure correlates inversely with *attention, emotional arousal, interest* and *recall* (Simons et al., 2003; Mulholland, 1978; Appel et al., 1979; Reeves et al., 1985).

Examples of studies that are based on EEG measures to investigate the response of users to different media stimuli are in the domain of television viewing (e.g., Simons et al. (2003) investigated the effect of image motion on users attention when compared to still images), and of TV commercials (e.g., Appel et al. (1979) and Reeves et al. (1985) investigated the relationships between recall and alpha power, while Ohme et al. (2010) applied frontal EEG asymmetry to investigate the effectiveness of TV ads in generating approach motivation).

Given the relationship of frontal EEG asymmetry with positive affect and approach motivation, it would be expected that frontal EEG asymmetry might be able to index the same media experience dimensions as suggested in the case of facial EMG (see above). The established relationship of the EEG alpha power with attention and interest suggests that alpha power can be used to index perceived unexpectedness and interestingness of media stimuli. However, as is the case for facial EMG, further studies are needed to validate EEG-based measures as measures of these other media experience dimensions.

2.2.3. EDA

Based on different conceptual definitions of *arousal*, EDA is an excellent operational description of it. Moreover, empirical studies using the picture-viewing paradigm have also shown that EDA is highly correlated with self-reported emotional arousal (e.g., Lang et al., 1993). Accordingly, arousing pictures of either valence result in increased EDA as compared to low-arousal pictures.

A number of studies have also suggested that EDA is associated with various theoretical constructs of processes such as *activation*, *attention*, and the *task significance* or *affective intensity* of a stimulus as experienced by a subject (Dawson et al., 2000). However, these theoretical constructs do not relate to EDA separately or directly, but in the context of other variables and processes. Therefore, because EDA measures can be associated with many psychological constructs, it is difficult to interpret them in empirical studies, and hence the experiments should be designed carefully. In this respect, to be able to infer the psychological process mediating the resultant electrodermal response, one has to control experimental conditions so that only a single process is varied at a time (e.g., emotional arousal as influenced by emotional tone of the messages). This ensures that the differences in EDA between the conditions are not due to message confounds, but to the specific factor under analysis.

Studies on media have showed increased arousal as indexed by EDA during exposure to television and radio messages with arousing content, television messages with a high rate of cuts and edits, and video messages presented on a large screen (see examples of studies in Ravaja, 2004a). Grabe et al. (2000) found that differences in education level are associated with differences in arousal as measured by EDA and in information encoding (as measured by a verbal recognition test) when people are exposed to messages containing negatively compelling images. Moreover, the same study showed that, in that experimental setting, self-report and psychophysiological measures provided different conclusions. A similar study was conducted by Grabe and Kamhawi (2006) who showed that there are gender differences in processing negative news in terms of skin conductance measures of arousal.

To summarize, EDA measures can be used to index *arousal* and *attention*, as well as *task significance* and *affective intensity*. Thus, EDA can potentially be used to index also other media experience dimensions involving arousal and attention, such as *usability* (poor usability elicits frustration accompanied by increased arousal), *entertainingness* (that are accompanied by relatively high positively-valenced arousal), *spatial presence* (when spatial presence is high, high-arousal content will elicit higher subjective and physiological arousal), *playfulness* (involves at least moderately high arousal), *interestingness* (interesting content elicits higher arousal), *understandability* (non-understandable content elicits frustration and arousal), *brand experience* (good brand experience would be expected to be accompanied by at least moderately high arousal), and *unexpectedness* (unexpectedness may elicit arousal). Also in the case of EDA, validation studies are needed to establish its relationship with some of the experience dimensions, although some of the suggested relationships are quite obvious (e.g., with usability, interestingness, understandability).

2.3. Self-reports

Self-reported data are collected when one wants to gather information about user's perception of a product or of the interaction with it, or to gather information about the emotional experience of the users such as what the users feel about the product. Self-reported data can be collected both during laboratory sessions of interacting with the product or during live interaction. There are many ways of collecting these kinds of information from users, but the most common techniques are rating scales (e.g., Likert scale, semantic differential scale), lists of attributes to choose or to rank, and open-ended questions.

In psychological studies, emotional dimensions (e.g., valence and arousal) are routinely measured via graphical or textual Likert scales. A common instrument for measuring the emotional response to an event is the self-assessment manikin (SAM). The SAM is a non-verbal pictorial assessment technique that was developed by Lang (1980; Hodes, Cook and Lang, 1985) to directly assess the pleasure (valence), arousal (activation), and dominance (degree of control) in reaction to an object or an event. This instrument has

been effectively used to measure emotional responses to various stimuli such as pictures, images, sounds, advertisements, and pain. In a commonly used measurement scheme (Lang, 1994), the valence scale consists of nine graphic depictions of human faces ranging from sad to happy expression, whereas arousal scale contains nine graphical characters varying from a calm state to a state of high visceral agitation. Positive and negative activation (PA and NA) are often measured as sum variables of self-rated items such as joyful, enthusiastic and peppy (high PA) or distressed, anxious and fearful (high NA) (e.g., Ravaja 2004b; Watson et al., 1999).

Table 1 summarizes the established and hypothesized correlates of physiological measurements with the feeling and appraisal dimensions. In Appendix, the questionnaire items used to measure the feeling and appraisal dimensions are presented.

Table 1. Correlates of the physiological measures with the feeling and appraisal dimensions of MX

Physiological measure			Established correlates		Hypothesized correlates
Type	Sub-type	Value	Dimension	Stimula	
fEMG	ZM	High	Positive valence	Pictures, movie, radio and tv ads, financial video messages (CS only)	• Playfulness (through enjoyment and pleasantness) • Spatial presence (through positive and negative responses) • Usability (positive affect, satisfaction) • Interactivity (positive /negative affect) • Aesthetics (positive affect) • Usefulness (positive affect) • Interestingness (positive affect) • Understandability (positive affect) • Trustworthiness (positive affect) • Brand experience (positive affect) • Perceived price/value (low price/value is associated would positive affect) • Familiarity (positive affect)
	CS	High	Negative valence		
	OO	High	High-arousal positive valence Genuine pleasure Enjoyment smile Positive valence	Sounds, financial video messages, pictures	
EEG	Alpha power	High	Attention Emotional arousal Interest Recall	Moving vs. still pictures TV ads	• Unexpectedness • Interestingness • All others as with fEMG
	Frontal asymmetry	Higher on the left	Positive activation and approach motivation	TV ads	
		Higher on the right	Negative activation and withdrawal motivation		
EDA	EDA	High	Emotional arousal Activation Attention Task significance Affective intensity	Pictures TV and radio messages Video messages on a large screen	• Usability (poor usability determines frustration and arousal) • Interactivity (attention, arousal) • Aesthetics (attention, arousal) • Entertainingness (high arousal positive valence) • Playfulness (high arousal) • Spatial presence (higher arousal) • Interestingness (higher arousal) • Understandability (higher frustration and arousal for non-understandable items) • Brand experience (high arousal) • Unexpectedness (high arousal)

3. Methods

For the data collection we set up an experiment where the stimulus material was the main newspaper in Finland, namely Helsingin Sanomat. An iPad tablet was utilized as the digital platform. The design of the experiment was within-subjects; each participant being exposed to two conditions: (1) participants freely browse a (fresh) print version of the newspaper 15 min, and (2) participants freely browse (fresh) digital news messages of the same newspaper for 15 min. The order of the conditions was counterbalanced.

3.1. Participants

Participants were recruited via email by sending invitation letters to student mailing lists. 33 people were selected from those who voluntarily expressed their wish to take part in the study. One participant was later removed from the data analysis because of unreliable data. The participants were instructed upon the experiment not to read the news in the morning of the test. All participants, but one, were students within age range 19-40 (22 women). Regarding the reading characteristics during the experiment, the iPad was seen first in 15 cases. The different issues of the newspaper were covered as follows: Monday (7 cases), Tuesday (5), Wednesday (3), Thursday (6), and Friday (10).

3.2. Data collection

During the experiment, we obtained three categories of measurements: self-report (questionnaires and interview), physiological, and behavioral (video recording). The data was collected after each reading session (digital and print) for (a) the whole reading experience, (b) each page browsed, and (c) each article read. In addition to the data collected post reading, a background questionnaire was answered online before the experiment in order to collect information about demographics, reading habits and personality of the participants. An interview was also conducted after the experiment to gather data about preferences and the reading experience.

Psychophysiological measures

The following psychophysiological measures were collected during the two reading sessions and during a rest period of 5 minutes. The rest period represents the baseline measurements during which the participants were instructed to look at a fixed point on the front-side wall.

- electroencephalography (EEG; frontal EEG asymmetry and alpha activity to index approach motivation and attention)
- electrodermal activity (EDA; to index emotional arousal)
- facial electromyography (EMG; to index positive and negative emotions)
    - zygomaticus major
    - corrugators supercilii
    - orbicularis oculi
- heart rate (HR; to index emotional arousal and attention)

Self-report measures

A set of self-report measures were obtained *before* the experiment (for details, see Background questionnaire in Appendix) which includes information about demographics, interest areas, reading habits and personality. After each reading session, self-report measures of MX were obtained (see the MX questionnaire in Appendix) for measuring emotions (e.g., pleasantness and arousal, specific emotional states) and different dimensions of MX which were defined in the project. Both questionnaires (background information and MX evaluation) were implemented in Webropol and administered online. In three (two - after removal of one participant data) cases, the participants had to make use of printed questionnaires due to technical problems with the Webropol system.

Interview

After the experiment, participants were also interviewed. The topics covered included experiences during reading print and digital news, advantages and disadvantages related to print and digital news (and perceived reasons).

Video recording

The reading behavior of the participants was video recorded to enable later scoring of their behavior.

3.3. Data analysis

In this paper, we limit the analysis to the data collected from questionnaires, EEG, EDA and fEMG with regard to the whole media experience in each of the two reading sessions. The self-reported data were aggregated at the level of dimension; the score of one dimension was calculated as the sum of the scores of the items that define the respective dimension, after all scales were standardized so that to represent with 1 the negative answers and with 5 the positive answers.

For the *self-reported data*, we performed at first *Paired samples t-test* analyses to compare the two devices used for reading. Table 2 shows the significant differences between iPad and Print, all differences favoring the Print newspaper (mean scores are greater for Print than for iPad; Table 3).

Table 2. Significant differences in self-reported data using Paired samples t-test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Beauty.iPad - Beauty.Print	-1,25000	2,28600	,40411	-2,07419	-,42581	-3,093	31	,004
AestheticsScale.iPad - AestheticsScale.Print	-4,28125	6,26941	1,10828	-6,54161	-2,02089	-3,863	31	,001
AE.iPad - AE.Print	-4,87500	11,67504	2,06387	-9,08430	-,66570	-2,362	31	,025
Interactivity.iPad - Interactivity.Print	-2,50000	6,61864	1,17002	-4,88628	-,11372	-2,137	31	,041
Arousal.iPad - Arousal.Print	-,68750	1,44663	,25573	-1,20907	-,16593	-2,688	31	,011

Table 3. Means of significant dimensions

Device	Beauty	Aesthetic Scale	Aesthetic dimension	Interactivity	Arousal
iPad	11,19	29,66	64,78	23,91	4,53
Print	12,44	33,94	69,66	26,41	5,22

For analyzing the *physiological responses*, we have employed *Linear Mixed Models (LMM)* approach. The physiological data were natural-logarithmically transformed before entering into the analysis.

The established and hypothesized relationships of physiological measures with media experience constructs presented in Table 1 and preliminary analyses of psychophysiological data using Paired samples t-test (the physiological measures were averaged over the whole reading time, 15 minutes) informed us about the sets of variables to use in the linear mixed model (LMM) analyses. In the LMM analyses, the data were aggregated at minute-level thus deriving a new variable Epoch with values in [1,15], which was used as a repeated measure.

All LMM models used Device as factor, and selected MX dimensions as covariates. The dependent variable was in each model one physiological measurement or construct (average value of all EEG measures, frontal asymmetry calculated at F4 and F3 sites, ZM, CS, and EDA, respectively; because of incomplete data – only 22 subjects, we did not use OO in the analysis). All the independent variables were entered as fixed effects, while the random effects were given by Intercept and Subject. The repeated measures were Device and Epoch. The Covariance type for the Repeated measures was set to Diagonal, and for the Random effects, Variance components. In all models, the baseline measurement for the dependent variable was used as a covariate fixed effect.

4. Results

4.1. EEG

4.1.1. Average EEG – alpha power

An index for engagement and attention was calculated as the *average* of all EEG measurements and observed on the Alpha frequency band (8-13 Hz or 8-12 Hz).

Differences between Print and digital

Using an LMM model (Figure 1) for comparing the brain activity of users browsing the Digital and Print newspaper, we found that iPad elicited greater attentional engagement (lower alpha power values) compared to a printed newspaper (see Table 4); this might indicate that iPad news were more interesting, but may also suggest that reading news from iPad involved more attentional resources, because the iPad use requires more actions from the user, i.e., with iPad each news message had to be opened for reading.

In addition to alpha power calculated as an average of all EEG electrodes, we calculated an average EEG for other frequency bands (theta low and high, beta low and high, and gamma low; Table 4). Typically, theta (4-6 Hz) increases during memory processes and alpha (8-12/13 Hz) decreases. However, there are some studies showing that this is true only for phasic responses, and for tonic responses it is *vice versa* (Klimesch, 1999). Beta high frequency (20-30 Hz) and gamma low (30-45 Hz) are higher for iPad, suggesting more attention and higher-level /associative processes when reading iPad. This goes in line with the results from the alpha power analysis (iPad is found to elicit more attentional responses, if we consider alpha to be inversely correlated with attention and cognitive demands).

Figure 1 Average EEG and Device

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MIXED Avg_EEG_ BY Device WITH Avg_EEG_Base
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device Avg_EEG_Base | SSTYPE(3)
  /METHOD=REML
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
  /EMMEANS=TABLES(Device) .
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Table 4. Differences in Average EEG due to Device; EEG measured on different frequency bands

No.	Band name	Range Hz	Sig. for Device	Mean iPad	Mean Print
1	Theta low	4-6Hz	0,002	1,474	1,511
2	Theta high	6-8Hz	0,046	1,085	1,104
3	Alpha low	8-10Hz	0,030	0,938	0,96
4	Alpha broad 1	8-12Hz	0,017	1,614	1,637
5	Alpha broad 2	8-13Hz	0,000	1,959	1,99
6	Alpha high	10-12Hz	0,028	0,872	0,894
7	Beta low	12-20Hz	0,022	1,821	1,838
8	Beta high	20-30Hz	0,000	1,614	1,574
9	Gamma low	30-45Hz	0,000	1,657	1,603

Having observed the difference between devices with respect to alpha power (digital reading elicits more attentional resources than Print reading), it is now interesting to investigate what MX dimensions are significantly correlated with the brain activity measured on alpha band or other frequency bands, so that the association with the Device variable remains significant, especially on the alpha band.

Associations between alpha power and low_arousal, Brand_experience and Familiarity dimensions

In a model where *Low Arousal* variables are introduced as *covariates*, as well as *Brand_experience* and *Familiarity* (Figure 2), we also found that most of the differences due to the Device hold as significant, except for two frequency bands (alpha high and beta low; Table 5). A significantly correlated variable with whole-head EEG activity on all frequency bands, except on alpha high, is low-arousal negative emotion (e.g., boredom; VL_AL in the table). Its coefficient estimate 0,023 on the alpha broad band (8-13Hz) (Table 6) confirms the fact that for low-arousal negative emotion during reading, the EEG alpha power values are high and therefore attentional engagement decreases. Low-arousal pleasant emotion (VH_AL) during reading does not have significant associations with the EEG activity in this model.

Figure 2 Average EEG, Device, Low-arousing reading, Brand_experience and Familiarity

```
MIXED Avg_EEG_ BY Device WITH Avg_EEG_Base ValenceL_ArousalL ValenceH_ArousalL Brand_experience Familiarity
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0,
ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device Avg_EEG_Base ValenceL_ArousalL ValenceH_ArousalL Brand_experience Familiarity | SSTYPE(3)
  /METHOD=REML
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
  /EMMEANS=TABLES(Device) .
```

Brand_experience and Familiarity appear to be significantly associated with the whole-head EEG activity on Theta low band (estimates are -0,024 and 0,030 respectively), and on beta high band (estimates are +0,03 and -0,01 respectively). Theta activity has been linked to decreased alertness and impaired information processing. Therefore, also higher Theta values indicate lower engagement, and a negative correlate (e.g., Brand_experience) indicates that readers' perception of higher quality of the newspaper is associated with higher engagement (the case of iPad). On the other hand, the positive estimate of Familiarity indicates that higher perceived Familiarity is associated with lower engagement (the case of Print). Regarding the

associations on the beta band, as seen earlier, higher values on beta high frequency (20-30 Hz) and gamma low (30-45 Hz) indicate more attention and associative processes; thus the estimates signs show that higher familiarity is correlated with lower attention and higher Brand_experience is related to higher attention and engagement.

Table 5. P-values for the associations between Average EEG and Device and Low- arousing reading, brand_experience and familiarity

No.	Band name	Range Hz	Intercept	Device	Avg_EEG_Base	VL_AL*	VH_AL*	Brand_experience	Familiarity
1	Theta low	4-6Hz	0,000	0,000	0,000	0,000	0,266	0,008	0,000
2	Theta high	6-8Hz	0,000	0,000	0,000	0,000	0,965	0,217	0,019
3	Alpha low	8-10Hz	0,000	0,003	0,000	0,048	0,945	0,541	0,068
4	Alpha broad 1	8-12Hz	0,000	0,030	0,000	0,043	0,678	0,255	0,700
5	Alpha broad 2	8-13Hz	0,000	0,001	0,000	0,002	0,410	0,337	0,476
6	Alpha high	10-12Hz	0,124	0,421	0,000	0,088	0,608	0,002	0,140
7	Beta low	12-20Hz	0,003	0,068	0,000	0,000	0,880	0,001	0,925
8	Beta high	20-30Hz	0,000	0,000	0,000	0,012	0,088	0,000	0,032
9	Gamma low	30-45Hz	0,000	0,000	0,015	0,017	0,621	0,001	0,076

*VL_AL : negative valence, low arousal; VH_AL: positive valence, low arousal

Table 6. Estimates for the Low_arousal negative_valence, Brand_experience and Familiarity

No.	Band name	Range Hz	VL_AL*	Brand_experience	Familiarity
1	Theta low	4-6Hz	+0,056	-0,024	+0,0300
2	Theta high	6-8Hz	+0,040	-0,009	+0,0100
3	Alpha low	8-10Hz	+0,017	-0,005	+0,0100
4	Alpha broad 1	8-12Hz	+0,016	+0,009	+0,0020
5	Alpha broad 2	8-13Hz	+0,023	+0,007	+0,0040
6	Alpha high	10-12Hz	+0,015	+0,025	-0,0090
7	Beta low	12-20Hz	+0,030	+0,019	-0,0004
8	Beta high	20-30Hz	+0,018	+0,031	-0,0110
9	Gamma low	30-45Hz	+0,024	+0,032	-0,1248

*VL_AL : negative valence, low arousal

Associations between alpha power and Interestingness, *Attention*, *Arousal* and *Understandability dimensions*

In a model where *Interestingness*, *Attention*, *Arousal* and *Understandability* are introduced as *covariate* fixed effects (Figure 3), we observe that the whole-head EEG activity on the alpha band (8-13Hz) is significantly correlated with all these variables (Table 7).

Figure 3 Average EEG alpha activity and Device and Interestingness, Arousal, Attention and Understandability

```
MIXED Avg_EEG_ BY Device WITH Interestingness Attention Arousal Understandability Avg_EEG_Base
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0,
ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device Interestingness Attention Arousal Understandability Avg_EEG_Base | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
  /EMMEANS=TABLES(Device) .
```

Table 7. Associations between Average EEG alpha activity and Device, Interestingness, Understandability, Attention, and Arousal

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	,943868	,170623	45,284	5,532	,000	,600274	1,287462
[Device=1]	-,062109	,009806	794,202	-6,334	,000	-,081358	-,042860
[Device=2]	0[b]	0					
Interestingness	,025926	,004452	802,703	5,823	,000	,017187	,034665
Attention	-,008311	,002870	802,968	-2,895	,004	-,013945	-,002677
Arousal	-,035712	,006840	813,542	-5,221	,000	-,049138	-,022286
Understandability	,031234	,011196	798,976	2,790	,005	,009256	,053211
Avg_EEG_Base	,410300	,070600	28,923	5,812	,000	,265890	,554710

a. Dependent Variable: Avg_EEG on alpha band.

b. This parameter is set to zero because it is redundant.

In this model (Table 7), the results show that Arousal and Attention are inversely correlated with alpha power, fact that confirms that more arousing and attentive reading is associated with less alpha EEG activity, and therefore is more engaging. Surprisingly, Interestingness and Understandability are positively correlated with whole-head EEG activity on the alpha band (more interesting and understandable reading is associated with higher EEG alpha activity), meaning that they are associated with lower engagement. The positive association with Understandability can be explained by the fact that the reading was not a demanding activity. The "unexpected" positive association with the Interestingness dimension is more difficult to interpret. This result may be due to the fact that the four self-report items used to measure Interestingness are not capturing exactly the user's engagement during the reading, but the user's overall impression. Thus, we studied the associations between each individual item that composed the Interestingness construct and observed that whole-head alpha EEG activity is negatively correlated with the last item ("The news I read were interesting") (Table 8). All other items (Interestingness 1: Publication attracted and invited to read; Interestingness 2: The issue of the newspaper was as interesting as the previous numbers; Interestingness 3: In the newspaper were interesting things; see Appendix) were positively correlated with Average EEG.

Table 8. Associations between individual Interestingness items and the whole-head alpha EEG activity (Avg_EEG)

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	1,057859	,158176	38,621	6,688	,000	,737819	1,377900
[Device=1]	-,014768	,008982	728,488	-1,644	,101	-,032401	,002865
[Device=2]	0[b]	0	.	.	.	.	.
Avg_EEG_Base	,405782	,068213	29,019	5,949	,000	,266276	,545289
Interestingness1	,041894	,008297	742,510	5,049	,000	,025606	,058182
Interestingness2	,024020	,009157	754,024	2,623	,009	,006044	,041996
Interestingness3	,026461	,011506	735,749	2,300	,022	,003871	,049050
Interestingness4	-,063563	,013490	741,624	-4,712	,000	-,090046	-,037081

a. Dependent Variable: Avg_EEG on alpha band.

b. This parameter is set to zero because it is redundant.

4.1.2. Frontal Asymmetry

Frontal asymmetry, usually calculated as the difference between the activity on F4 and F3 sites (LN(F4)-LN(F3)) on the alpha band, indicates positive activation and approach motivation (when higher on the left site, F3), or negative activation and withdrawal motivation (when higher on the right site, F4).

Differences between Print and digital

In a model created to observe if there are significant differences in the activity on these sites associated with the device used for reading (Figure 4), we found that these differences are more evident on the Theta low-band, Beta high-band and Alpha low-band activity. On Alpha broad band (8-12 or 8-13 Hz), the significance is 0,099 and 0,069 respectively (Table 9). The generally higher values of the frontal asymmetry on the alpha broad bands in the case of Print indicate a slightly higher approach motivation and positive activation for iPad use.

Figure 4 Frontal asymmetry and Device

```
MIXED Frontal_Assymetry BY Device WITH Frontal_Assymetry_Base
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0,
ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device Frontal_Assymetry_Base | SSTYPE(3)
  /METHOD=REML
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
/EMMEANS=TABLES(Device) .
```

Table 9. P-values for the differences in frontal asymmetry associated to Device

No.	Band name	Range Hz	Device	Mean iPad	Mean Print
1	*Theta low*	*4-6Hz*	*0,010*	0,060	0,029
2	Theta high	6-8Hz	0,284	0,002	0,014
3	*Alpha low*	*8-10Hz*	*0,051*	0,055	0,076
4	*Alpha broad 1*	*8-12Hz*	*0,099*	0,062	0,076
5	*Alpha broad 2*	*8-13Hz*	*0,069*	0,057	0,070
6	Alpha high	10-12Hz	0,172	0,067	0,081
7	Beta low	12-20Hz	0,125	0,111	0,125
8	*Beta high*	*20-30Hz*	*0,026*	0,068	0,097
9	Gamma low	30-45Hz	0,897	0,002	0,004

4.2. EDA

EDA being an indicator of activation, attention and task significance, we have compared its values when measured during iPad and Print reading.

Differences between Print and digital

When only Device was used in LMM analysis, we have found that Device alone is not significantly associated with EDA, therefore there are not found significant differences between EDA measured during Print and digital tablet reading.

Associations between EDA and Device, Interactivity and Dominance dimensions

Introducing the *Interactivity* and *Dominance* dimensions (Figure 5), we found that EDA correlates significantly with these variables and also with Device. (Figure 5, Table 10).

Figure 5 EDA and Device and Interactivity, Dominance and Trustworthiness

```
MIXED LN_EDA BY Device WITH LN_EDA_Base Interactivity Dominance
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0,
ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device LN_EDA_Base Interactivity Dominance | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
  /EMMEANS=TABLES(Device) .
```

Table 10. Associations between EDA and Device, Interactivity and Dominance

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	4,038871	,647659	36,659	6,236	,000	2,726178	5,351565
[Device=1]	,214339	,058346	860,811	3,674	,000	,099821	,328857
[Device=2]	0[b]	0	.	.	.	.	.
LN_EDA_Base	,411079	,101986	29,061	4,031	,000	,202513	,619645
Dominance	-,313664	,029358	886,075	-10,684	,000	-,371283	-,256044
Interactivity	,062591	,010912	887,567	5,736	,000	,041174	,084007

a. Dependent Variable: LN_EDA.

b. This parameter is set to zero because it is redundant.

EDA was higher during iPad reading (the mean EDA for iPad is 6,03 vs. on Print 5,8); it means that more arousal is observed during reading on the digital medium. Similarly, positive activation is related with higher scores on Interactivity. The relationship between Dominance and EDA is negative, meaning that lower perceived control is associated with more emotional arousal.

4.3. Facial EMG

Differences between Print and digital

When Device is introduced alone in LMM analysis to see the extent to which it influences the ZM and CS responses, we have not found significant differences between Print and digital.

4.3.1. ZM

Associations between ZM and Device, Arousal, Playfulness, Familiarity, Valence dimensions

In a model where *Arousal*, *Playfulness*, *Familiarity* and *High_arousal positive_emotion* (Valence H_ArousalH) are introduced as covariate fixed effects (Figure 6), we found that also ZM activity differs significantly with respect to Device (the Device variable significantly influences the score of ZM). Print reading elicits higher ZM activity (0,381 on digital vs. 0,457 on Print). ZM being an indicator of positive valence, it means that reading on Print elicits more/higher positive physiological responses. All self-reported variables are significantly related with the ZM activity, however Playfulness and Arousal show negative correlates (Table 11).

Figure 6 ZM and Device, Arousal, Playfulness, Familiarity, Valence

```
MIXED LN_ZM BY Device WITH Arousal Playfulness Familiarity LN_ZM_Base ValenceH_ArousalH
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0,
ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device Arousal Playfulness Familiarity LN_ZM_Base ValenceH_ArousalH | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
  /EMMEANS=TABLES(Device) .
```

Table 11. Associations between ZM and Device, Arousal, Playfulness, Familiarity, Valence

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	,464023	,089719	143,929	5,172	,000	,286686	,641359
[Device=1]	-,075746	,017650	822,137	-4,292	,000	-,110389	-,041103
[Device=2]	0[b]	0					
Arousal	-,068087	,011506	523,085	-5,918	,000	-,090691	-,045484
Playfulness	-,020902	,006014	793,418	-3,475	,001	-,032708	-,009096
Familiarity	,031089	,007219	798,234	4,306	,000	,016918	,045259
LN_ZM_Base	,472328	,139007	29,263	3,398	,002	,188139	,756517
ValenceH_ArousalH	,027104	,010619	743,856	2,552	,011	,006257	,047951

a. Dependent Variable: LN_ZM.

b. This parameter is set to zero because it is redundant.

4.3.2. CS

Associations between CS and Device, Hierarchy, Attention, and Arousal dimensions

On the CS site, the differences recorded between digital and Print reading are also significant when the model includes *Hierarchy*, *Attention* and *Arousal* as covariate fixed effects (Figure 7, Table 12). Hierarchy is a sub-dimension of Aesthetics and presentational factors and reflects the readers' rating of the structure of the content presentation. CS is an indicator of negative valence, and again the Print reading indicates less negative responses, i.e., the reading on the digital medium elicits more negative-valenced emotions than reading on Print (mean of CS on Print is 1,58 vs. on iPad 1,964). Moreover, higher arousal and attention are associated with more activity on CS sites. On the other hand, higher scores of Hierarchy that indicate well-perceived structuring of the information, are correlated with lower activity on CS site, so with less negative emotions. These results can be interpreted that reading on iPad is more challenging (because people are not very familiar with the digital medium and structuring of the newspaper contents), thus leading to more negative emotions than the Print version.

Figure 7 CS and Device and Hierarchy, Attention, Arousal

```
MIXED LN_CS BY Device WITH LN_CS_Base Hierarchy Attention Arousal
  /CRITERIA=CIN(95) MXITER(100) MXSTEP(10) SCORING(1) SINGULAR(0.000000000001)
HCONVERGE(0, ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Device LN_CS_Base Attention Hierarchy Arousal | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION
  /RANDOM=INTERCEPT | SUBJECT(Subject) COVTYPE(VC)
  /REPEATED=Device*Epoch | SUBJECT(Subject) COVTYPE(DIAG)
  /EMMEANS=TABLES(Device) .
```

Table 12. Associations between CS and Device, Hierarchy, Attention, Arousal

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	,457950	,240093	47,877	1,907	,062	-,024821	,940721
[Device=1]	,383059	,022151	785,795	17,293	,000	,339576	,426542
[Device=2]	0[b]	0					
LN_CS_Base	,477534	,114332	29,868	4,177	,000	,243992	,711075
Attention	,017635	,005935	799,606	2,971	,003	,005985	,029284
Hierarchy	-,038905	,011151	795,556	-3,489	,001	-,060794	-,017016
Arousal	,059576	,016158	776,704	3,687	,000	,027858	,091293

a. Dependent Variable: LN_CS.

b. This parameter is set to zero because it is redundant.

5. Conclusion

The main findings of the empirical study are that associations between physiological responses such as EEG activity, facial electromyography and EDA on the one hand and psychological constructs such as attention, arousal and valence on the other hand, can be observed also when these measurements are recorded during a less structured task such as free reading of a newspaper. Moreover, we found that selected self-report measures of media experience such as familiarity, interestingness, hierarchy, interactivity are associated with more objective measures that are recorded during physiological data collection. This answer the research questions of convergent validity of measurements. Last but not least, we observed that there are differences in physiological responses when reading from a digital versus a print medium. The results showed that the users reading on the digital medium are more engaged than when reading on Print, especially when the engagement is indicated by the average EEG alpha power. In addition, we found that reading the Print newspaper elicits more positive emotions as measured by the activity at zygomaticus major and less negative emotions as measured by the activity at corrugator supercilii. This apparent contradiction can be explained by the fact that during Print reading people are more relaxed and they enjoy the reading itself, while reading on the digital medium elicits more effort for managing the application and the selection of articles and pages, thus determining more cognitive activity and engagement.

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Appendix – The MX Questionnaire

The questionnaire divided by dimensions of MX

In the following, a short description of the dimensions of MX measured during the experiments is given. A more detailed description is in the Deliverable Report 1 & 2.

- *Aesthetics and presentational factors* (**AE**) This dimension refers to the quality of the visual outlook of the publication. It consists of four different sub-dimensions such as aesthetics (visual appearance perceived very quickly), abundance (richness of content), hierarchy (the structure of the content presentation), and navigation (the accessibility to the content using visual cues).
- *Usefulness* (**USE**) Usefulness refers to a quality of content, especially to its informational or social functions. Usefulness represents the subjective perception of how useful a media item is to the observer. This implies that the user has a goal, for example, (1) gaining information, (2) social interaction, or (3) mood regulation. The third goal is described separately, by the Entertainingness dimension.
- *Entertainingness* **(ENT)** An entertaining media product holds the attention of the user in an agreeable or pleasant way. It also amuses or diverts the consumers. Entertainment is an important function of media content, besides the informational and social functions. It is especially essential for media products that are intended to amuse or divert the users (e.g., games, entertaining TV programs, movies, etc.).
- *Usability* (**USA**) Usability refers traditionally to achieving a goal with effectiveness, efficiency, satisfaction, and safety in a specific context of use of a product, here a newspaper. The goals of the readers of a newspaper can be gaining information, social interaction and mood regulation or entertainment, but especially the gain of the information.
- *Unexpectedness* (**Un**) A dimension that is especially found in entertainment media, which refers to the availability of new, unexpected items that would keep the user/reader interested and amused, while providing feelings of pleasantness.
- *Playfulness* (**P**) According to the report, playfulness is especially found in entertaining media, and is associated with feelings of spontaneity, joy, dynamicity, and sociality. As it is a powerful motivator of behavior, it should be found correlated with positive arousal. Moreover, playfulness when referring to media corresponds to the flow dimension which can be seen as a continuous experience of using the newspaper, starting from lighter activities such as browsing, to more attention-consuming activities like reading or solving a puzzle. Thus, the questionnaire could include also questions asking whether the articles were stimulating the reader to read them till the end.
- *Trustworthiness* (**T**) Trustworthiness or credibility refers to the perceived truth value of the used media. It refers to individual news or the source of the news.
- *Interestingness* (**INT**) It reflects the personal significance of the media items. Interesting items attract attention, are remembered better, are more entertaining, and are more persuasive.
- *Spatial presence (Attention allocation)* (**A**) The quality of capturing and keeping the attention.
- *Brand experience* (**B**) Brand experience is expected to contribute to the overall emotional responses to the media product, here the newspaper. It is conceptualized as “sensations, feelings, cognitions, and behavioral responses evoked by the brand-related stimuli that are part of the brand’s design, identify, packaging, communications, and environments”.
- *Familiarity* (**F**) It refers to how familiar (thoroughly known, well-acquainted) a person is with the specific media channel /provider/ product. It is likely to increase perceived trustworthiness, understandability and brand perception.
- *Price/Value* (**PV**) Perceived value. Price in terms of money that readers are willing to pay.
- *Emotions* (**E**) Emotions are a powerful force influencing the behavior of readers. There are two main sub-dimensions that describe the human emotions: valence or pleasantness and arousal or activation. Valence ranges from negative to positive, and arousal from low to high. A certain media product/element can therefore determine four main types of emotions: positive valence low arousal (relaxation, satisfaction),

positive valence high arousal (enthusiasm), negative valence low arousal (depression, boredom), and finally negative valence high arousal (anxiety, frustration, tension). These emotions in turn will affect the reader's attention, interest and reading behavior.

- *Interactivity* (**Ia**) There are many conceptualizations of the Interactivity dimension, both when referring to traditional systems and to media products. In the Media research, Interactivity can be considered as the set of perceived and accessible choice alternatives that allow a user to actually interact with the product, i.e., decide the next step in using the product (examples of choice alternatives in media products: pages, buttons, menu items, and other user interface components; links to news sections; the way the reader can navigate through the magazine, the way to access the content of an article). The interaction can be explained as follows: A person always first has at least a rudimentary understanding of the environment before the emotional stimulus is triggered that leads to observable behavior. From a research perspective this means that concrete behavior, such as clicking of a link in an online newspaper, can be assumed as a reflection of a person's interest. From a product design perspective interactivity thus offers a design space to guide users through a media product by the careful arrangement and layout of content elements such as labels, headlines, pictures, or graphics.
- *Understandability* (**U**) It is a prerequisite for usefulness and interestingness. Non-understandable media items are expected to elicit frustration or negative affect.
- *Sensory perception* (**SP**) This dimension defines the properties of the media products that are perceived through our senses, such as colorfulness of pictures, gloss or roughness of the paper. They affect the media experience, because they can strengthen or weaken the mental impressions that are desirable to a media product.

Abbreviations in the questionnaire (tables):

AE: Aesthetics and presentational factors	A: Spatial presence (Attention allocation)
USE: Usefulness	B: Brand experience
ENT: Entertainingness	F: Familiarity
USA: Usability	PV: Price/Value
Un: Unexpectedness	Ia: Interactivity
P: Playfulness	U: Understandability
T: Trustworthiness	E: Emotions
INT: Interestingness	SP: Sensory perception

Newspaper-level evaluation[1]

All questions are measured on a 5-point scale:

1. Täysin eri mieltä
2. Jokseenkin eri mieltä
3. Ei osaa sanoa
4. Jokseenkin samaa mieltä
5. Täysin samaa mieltä

AESTETICS AND PRESENTATIONAL FACTORS		Dimensions (main dimension in the first column)				
Beauty (visual appearance perceived very quickly)						
1. Lehden ulkoasu oli hyvä.	The layout was good.	AE				
2. Lehti oli värikäs.	The newspaper was colorful.	AE	SP			
3. Julkaisun värit vaikuttivat luonnollisilta	The colors of the newspaper looked natural.	AE	SP			
Abundance (The richness and variation of the options offered on a page)						
4. Julkaisu oli liian täynnä kaikkea.	The publication was too full of everything.	AE				
5. Lehti oli runsas, oli paljon valinnanvaraa.	The newspaper was rich and had a lot of choices.	AE	Ia			
Hierarchy (journalistic and visual order of the content by different levels of importance)						
6. Lehden sisältö oli hyvin jäsennelty.	The contents of the newspaper were well structured.	AE	Ia			
7. Tärkeimmät artikkelit nousivat hyvin esille.	The main articles are well presented.	AE				
Navigation (Visual aids for user orientation in the content)						
8. Minulle tuli paikoin tunne että olin eksyksissä.	Sometimes I had the feeling that I was lost.	AE	USA	Ia		
9. Lehden ulkoasu oli sekava ja monimutkainen.	The newspaper was confusing and complex.	AE				
Aesthetic scale for websites from Lavie and Tractinsky (2004)						
10. Lehden ulkoasu oli siisti.	The newspaper layout was neat.	AE				
11. Lehden ulkoasu oli selkeä.	The newspaper layout was clear.	AE				
12. Lehden ulkoasu oli miellyttävä.	The newspaper layout was pleasant.	AE				
13. Lehden ulkoasu oli kaunis.	The newspaper layout was aesthetic.	AE				
14. Lehden ulkoasu oli tasapainoinen.	The newspaper layout was balanced, symmetrical, proportionate.	AE				
15. Lehti oli ulkoasultaan omaperäinen	The newspaper layout was original.	AE				
16. Lehden ulkoasu oli tyylikäs	The newspaper layout was stylish.	AE				
17. Lehden ulkoasu oli kiehtova	The newspaper layout was fascinating.	AE				
18. Lehden ulkoasu oli luova	The newspaper layout was creative.	AE				

[1] The English translation and groupings of the questions are for interpretation only. The questionnaire was administered in Finnish and the questions were randomized.

USEFULNESS		Dimensions (main dimension in the first column)				
19. Lehdessä oli minulle arvokasta tietoa.	The newspaper contains valuable information for me.	USE				
20. Tämä lehti oli minulle hyödyllinen.	This newspaper was useful to me.	USE				
21. Lehden lukeminen oli hukkaan heitettyä aikaa.	Reading the newspaper was a waste of time.	USE				
22. Lukemani uutiset olivat merkityksellisiä omalta kannaltani.	The news I read were relevant to me.	USE				

ENTERTAININGNESS		Dimensions (main dimension in the first column)				
23. Lehden lukeminen oli viihdyttävää.	Reading the newspaper was entertaining.	ENT	P	E	USE	
24. Lehti oli aika tylsän oloinen.	The newspaper was quite dull.	ENT	P	E	USE	
25. Lehti oli hyvää ajanvietettä.	The newspaper was a good pastime.	ENT	P	E	USE	

USABILITY		Dimensions (main dimension in the first column)				
26. Tästä julkaisusta löysi vaivatta etsimänsä.	It is easy to find in this publication what I am looking for.	USA	Ia			
27. Lehden artikkelit olivat helppolukuisia.	The articles in the newspaper were easy to read.	USA				
28. Lehteä oli helppo käsitellä lukiessa.	The newspaper was easy to handle while reading.	USA				
29. Julkaisua oli hankala ja vaikea käyttää.	The publication was awkward and difficult to use.	USA				
30. Julkaisun heijastukset tai kiiltely häiritsi lukemista.	The reflections or shine of the publication disturbed the reading.	SP	USA			
31. Lehti/laite tuntui liian painavalta käsissä.	The newspaper/terminal felt too heavy in hands.	SP	USA			
32. Pystyin käyttämään julkaisua haluamallani tavalla.	I was able to use the publication in the way I wanted.	USA				
33. Teksti oli liian pientä tai vaikeasti luettavissa.	The text was too small or difficult to read.	USA				
34. Rivien pituus oli sopiva tekstissä.	The length of the row was suitable in the text.	USA				

UNEXPEDECTNESS		Dimensions (main dimension in the first column)				
35. Lehti tarjosi yllätyksiä.	The newspaper offered surprises.	Un				
36. Julkaisu oli juuri sellainen kuin odotinkin.	The publication was exactly as I expected.	Un				
37. Lehti toisti yhtä ja samaa.	The newspaper repeated one and the same thing.	Un				

PLAYFULNESS		Dimensions (main dimension in the first column)				
38. Lehti oli hauska ja iloinen.	The newspaper was nice and fun.	P				
39. Lehdessä oli myös leikillistä otetta.	In the newspaper was also a playing attitude.	P				
40. Lehdessä oli kekseliäisyyttä.	In the newspaper were ingenuities.	P				

TRUSTWORTHINESS		Dimensions (main dimension in the first column)				
41. Tämän julkaisun sisältö vaikutti luotettavalta.	The contents of this publication seemed reliable.	T				
42. Tämä lehti oli ammattilaisten tekemä.	This newspaper was made by professionals.	T				

INTERESTINGNESS		Dimensions (main dimension in the first column)				
43. Julkaisu houkutteli ja kutsui lukemaan.	Publication attracted and invited to read.	INT				
44. Tämä numero oli yhtä mielenkiintoinen kuin lehden aiemmatkin numerot.	This issue of the newspaper was as interesting as was the previous numbers.	INT				
45. Lehdessä oli mielenkiintoista asiaa.	In the newspaper were interesting things.	INT				
46. Lukemani uutiset olivat kiinnostavia.	The news I read were interesting.	INT				

SPATIAL PRESENCE (ATTENTION ALLOCATION)		Dimensions (main dimension in the first column)				
47. Lukukokemus oli mukaansatempaava.	The reading experience was compelling.	A	INT			
48. Kohdistin koko huomioni lehteen.	I devoted my whole attention to the newspaper.	A	INT			
49. Keskityin lehteen.	I concentrated on the newspaper.	A	INT			
50. Lehti vangitsi kaikki aistini.	The newspaper captured my senses.	A	INT			
51. Uppouduin lehteen täydellisesti.	I immersed myself completely into the newspaper.	A	INT			

BRAND		Dimensions (main dimension in the first column)				
52. Lehti oli korkeatasoinen.	The newspaper was of high quality.	B				
53. Arvostin lehteä.	I appreciated the newspaper.	B				
54. Tällä julkaisulla oli oma vahva persoonallisuus.	This publication had its own strong personality.	B				

FAMILIARITY		Dimensions (main dimension in the first column)				
55. Tämä julkaisu oli tutun oloinen.	This publication was familiar.	F				
56. Koin lehden minulle läheiseksi.	I found the newspaper close to me.	F				

PRICE /VALUE		Dimensions (main dimension in the first column)				
57. Lehti oli hintansa väärti.	The newspaper price was worth.	PV				
58. Lehti oli sisältöönsä nähden kallis.	The newspaper was expensive compared to its contents.	PV				

EMOTIONS		Dimensions (main dimension in the first column)	
59. Lukiessani lehteä tunsin oloni miellyttäväksi [SAM]	As I read the news I felt pleasant.	E: valence	
60. Lukiessani lehteä tunsin oloni kiihtyneeksi [SAM]	As I read the news I felt aroused.	E: arousal	
61. Lukiessani lehteä tunsin oloni turhautuneeksi.	As I read the news I felt frustrated.	E: negative valence, high arousal	
62. Lukiessani lehteä tunsin oloni stressaantuneeksi.	As I read the news I felt a bit anxious.	E: negative valence, high arousal	
63. Lukiessani lehteä tunsin oloni jännittyneeksi.	As I read the news I felt tense.	E: negative valence, high arousal	
64. Lukiessani lehteä tunsin oloni tylsistyneeksi.	As I read the news I felt a bit bored.	E: negative valence, low arousal	
65. Lukiessani lehteä tunsin oloni alakuloiseksi.	As I read the news I felt depressed.	E: negative valence, low arousal	
66. Lukiessani lehteä tunsin oloni innostuneeksi.	As I read the news I felt enthusiastic.	E: positive valence, high arousal	
67. Lukiessani lehteä tunsin oloni riemukkaaksi.	As I read the news I felt joyful or happy.	E: positive valence, high arousal.	
68. Lukiessani lehteä tunsin oloni rentoutuneeksi.	As I read the news I felt completely relaxed.	E: positive valence, low arousal.	
69. Lukiessani lehteä tunsin oloni tyytyväiseksi.	As I read the news I felt satisfied.	E: positive valence, low arousal	

[SAM] = Self-Assessment Manikin

INTERACTIVITY		Dimensions (main dimension in the first column)				
70. Julkaisua oli helppo selailla.	The publication was easy to browse.	Ia				
71. Oli vaikea löytää hyödyllistä tietoa, koska kaikkea oli liikaa.	I felt I did not get much useful information simply because it had too much information.	Ia				
72. Hallitsin tilanteen etenemistä lukiessani lehteä.	I was in control over the pace when reading/using Helsingin Sanomat.	Ia				
73. Lukiessani lehteä pystyin hyppimään nopeasti sivulta toiselle.	While I was reading Helsingin Sanomat, I could quickly jump from one page to another.	Ia				
74. Jutut aukesivat luettavaksi pitkällä viiveellä.	I could obtain information in Helsingin Sanomat with considerable delay only.	Ia				
75. Lehden jutuista olisi tarvittaessa helppo antaa palautetta.	It would be easy to provide feedback on newspaper's articles if necessary.	Ia				
76. Jos haluaisin, lehden toimittajiin olisi helppo saada yhteyttä.	If I would like, it would be easy to get in touch with the newspaper's journalists.	Ia				

UNDERSTANDABILITY		Dimensions (main dimension in the first column)				
77. Lukemani uutiset olivat helposti ymmärrettäviä.	The news I read were easy to understand.	U				

OVERALL Media Experience		
78. Lukukokemus oli kokonaisuutena hyvä.	The reading experience was overall good.	

Background information

1. Ikä: …. vuotta

2. Sukupuoli
Mies
Nainen

3. Koulutustasosi (valitse korkein suorittamasi tutkinto):
Peruskoulu
Ammattikoulu
Lukio
Ammattikorkeakoulu
Alempi korkeakoulututkinto
Ylempi korkeakoulututkinto
Lisensiaatti
Tohtori

4. Oletkö tällä hetkellä opiskelija?
Kyllä
En

5. Kuinka paljon aikaisempaa kokemusta sinulla on kosketusnäytöllisten digitaalisten lukulaitteiden käyttämisestä (iPad tai vastaava)? *
Ei ollenkaan
Hyvin vähän
Vähän
Paljon
Hyvin paljon

6. Kuinka kauan olet ollut HS:n tilaaja nyt:
En ole täällä hetkellä HS:n tilaaja
6 kk
1 vuosi
2 vuotta
3 vuotta
4 vuotta
5 vuotta
enemmän kuin 5 vuotta

7. Kuinka kiinnostavina pidät seuraavia Helsingin Sanomien osioita? *

	ei ollenkaan kiinnostava	ei kovin kiinnostava	hieman kiinnostava	kiinnostava	erittäin kiinnostava
Pääkirjoitukset					
Kotimaa					
Kaupunki					
Talous					
Ulkomaat					
Kulttuuri					
Urheilu					
Mielipide					
Ihmiset *					

8. Kuinka kiinnostavina pidät seuraavia Helsingin Sanomien osioita? *

	ei ollenkaan kiinnostava	ei kovin kiinnostava	hieman kiinnostava	kiinnostava	erittäin kiinnostava
Sää					
Elämä					
Tiede					
Kuluttaja					
Ruoka					
Matka					
Työpaikat					
Markkinapaikat					
Sarjakuvat					
Radio ja Televisio					
Sunnuntai					
Koti					
Mainokset *					

9. Tulisin hyvin toimeen ilman HS:a
Täysin eri mieltä
Jokseenkin eri mieltä
Ei eri eikä samaa mieltä
Jokseenkin samaa mieltä
Täysin samaa mieltä

10. Syvennyn lukemiini lehtiuutisiin yleensä huolella.
Täysin eri mieltä
Jokseenkin eri mieltä
Ei eri eikä samaa mieltä
Jokseenkin samaa mieltä
Täysin samaa mieltä

11. Tapani lukea lehti on enemmän systemaattinen kuin selaileva.
Täysin eri mieltä
Jokseenkin eri mieltä
Ei eri eikä samaa mieltä
Jokseenkin samaa mieltä
Täysin samaa mieltä

12. Ole hyvä ja arvioi seuraavien toteamusten kohdalla mahdollisimman rehellisesti, miten hyvin kukin toteamus kuvaa Sinua.

	täysin eri mieltä	osittain eri mieltä	osittain samaa mieltä	täysin samaa mieltä
8. Teen usein asioita vain sen vuoksi, että ne voivat olla hauskoja.	○	○	○	○
19. Minusta olisi jännittävää voittaa jokin kilpailu.	○	○	○	○
10. Olen melko huolissani tai järkyttynyt, mikäli luulen tai tiedän jonkun olevan vihainen minulle.	○	○	○	○
2. Olen valmis näkemään paljon vaivaa saadakseni sen mitä haluan.	○	○	○	○
1. Vaikka minulle olisi tapahtumassa jotakin ikävää, tunnen itseni vain harvoin pelokkaaksi tai hermostuneeksi.	○	○	○	○
6. Saamani kritiikki tai moitteet pahoittavat mieltäni aika tavalla.	○	○	○	○
5. Kun saan jotakin mitä haluan, tunnen itseni innostuneeksi ja energiseksi.	○	○	○	○
18. Pelkään hyvin harvoja asioita verrattuna ystäviini.	○	○	○	○
3. Kun jokin asia sujuu minulta hyvin, jatkan erittäin mielelläni sen tekemistä.	○	○	○	○
11. Kun näen mahdollisuuden johonkin mistä pidän, tulen heti kiihtyneeksi.	○	○	○	○
14. Kun minulle tapahtuu jotakin hyvää, se vaikuttaa minuun voimakkaasti.	○	○	○	○
16. Janoan jännitystä ja uusia kokemuksia.	○	○	○	○
13. Jos ajattelen, että jotakin epämiellyttävää tulee tapahtumaan, tulen tavallisesti varsin hermostuneeksi.	○	○	○	○
20. Olen huolissani siitä, että saatan tehdä virheitä.	○	○	○	○
7. Halutessani jotakin teen yleensä kaikkeni saadakseni sen.	○	○	○	○
12. Toimin usein hetken mielijohteesta.	○	○	○	○
15. Tunnen itseni huolestuneeksi, kun koen suoriutuneeni huonosti jossakin tärkeässä asiassa.	○	○	○	○
17. Kun tavoittelen jotakin, niin mikään ei pidättele minua.	○	○	○	○
9. Jos huomaan tilaisuuden saada jotakin mitä haluan, toimin välittömästi saadakseni sen.	○	○	○	○
4. Olen aina halukas kokeilemaan jotakin uutta, mikäli uskon sen olevan hauskaa.	○	○	○	○