Unconscious Processing and Regional Brain Activation with Advertising Images: A Preliminary Study

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ABSTRACT

Preferences for purchasing goods and services may be shaped by many factors, including messages presenting logical, persuasive information or those employing images or text that may be perceived or processed outside of conscious awareness. The hypothesis that these two types of messages (“logical persuasion” [LP] vs “unconscious influence” [UI]) might affect brain function differently was tested using stimuli drawn from real-world print advertisements and quantitative EEG as a noninvasive measure of regional brain activity. Twenty-four healthy subjects viewed images while brain electrical activity was recorded. Activity in the theta range (4-8 Hz) was examined because prior work linked this frequency band with emotional processing. Data were analyzed using a block design to compare brain activity during rest, LP, and UI periods. Considering all subjects as a group, no statistical differences were found in brain function between stimulus categories. When subjects were stratified by gender, however, the UI and LP images exhibited statistically significant differences in impact on frontocentral and temporal regions. For both men and women, LP stimuli were associated with significant decreases in theta power (vs. resting state), while theta power either increased or showed a lesser decrease during UI periods; male and female subjects differed in the specific brain regions showing these changes. These findings suggest that advertising images can evoke different changes in regional brain activity in men and women, related to the use of LP and UI elements.

INTRODUCTION

Human behavior is impacted by multiple factors, some of which are within the conscious awareness of the individual; others may fall outside conscious awareness and are often termed “subliminal,” “preconscious,” or “unconscious” factors. A central tenet of commercial advertising is that an individual’s purchasing preferences can be affected so that one product or service is chosen over another. It is possible that this impact can take place within the context of an advertisement that presents logical, factual information that is rationally persuasive (“logical persuasion” or LP); alternatively, an advertisement might employ images or text that are perceived and/or processed outside of immediate awareness in order to shape behavior without reliance on rational evaluation (“unconscious influence” or UI). This latter category is hypothesized to include images that might manipulate the viewer by impacting autonomic arousal or emotional state, and could include elements that could be considered provocative in nature. As an illustration, an LP advertisement might show the product clearly and convey factual, descriptive data (“best mileage in its class,” “top rated”). In contrast, a UI advertisement might downplay text and instead incorporate elements into the image that could be considered to be sexually or thanatologically evocative by some viewers (e.g. breast- or phallic-shaped elements, or skull-and-bones-like patterns). Thoughtful reviews of this controversial area include those by Theus (1994), Merikle and Daneman (1999), Shapiro (1999), and Aylesworth et al., (1999), with most investigators finding some evidence indicating the presence of these elements in print advertisements. The impact of the presence or absence of these elements on brain function is unknown. We hypothesized that patterns of regional brain function might differ when subjects viewed logical persuasion vs unconscious influence images drawn from real-world print advertisements.

METHODS & SUBJECTS

Experimental Design

In order to examine patterns of regional brain function under conditions of viewing LP and UI images, quantitative EEG data were collected using an activation paradigm. The paradigm of viewing these images was included as a task in a larger set of activations and rest periods during EEG recording in a project studying brain function and structure in healthy aging, and was reviewed and approved by the UCLA Institutional Review Board. Informed consent was obtained from all subjects, in accordance with the Declaration of Helsinki.

Subjects

Data were collected from 24 healthy volunteers who were part of the project studying healthy aging. All were in good health at the time of enrollment, and had a normal neurological and psychiatric examination. Exclusion criteria included any active or past history of an Axis I psychiatric disorder; any poorly controlled medical illness that could affect brain function (e.g., untreated hypothyroidism); concurrent use of CNS-active medications that could interfere with EEG activity (e.g., benzodiazepines); current or past drug or alcohol abuse; or any history of head trauma, brain surgery, skull defect, stroke or transient ischemic attacks, or presence of stroke on previous MRI. Subjects were 11 females and 13 males. The mean age for all 24 subjects was 77.2 years (s.d. 10.6 yrs); males and females did not differ statistically on age, handedness, or years of education.

Advertising Image Activation

EEG data were selected to assess brain function in each of three conditions: (1) resting, awake state, with eyes closed, (2) viewing stimuli categorized as “logical persuasion” images and (3) viewing stimuli that were “unconscious influence” images. Twenty-four images were used as stimuli; all were advertisements that appeared in magazines, newspapers, and similar print media. Some example images are shown in Figure 1. The sample LP advertisements present (a) a table of facts and figures about cigarette products, (b) the details about how to “build a better toothbrush,” (c) information and the question “which makes more sense” concerning a curved vs straight tampon product, and (d) suggestions about sedentary dogs and their food. In contrast, sample UI advertisements show (e) water beading on a road surface with a shape suggesting the outline of a dead body, (f) an overlay image combining a woman standing with legs apart and a statue’s scepter positioned in her groin, (g) a woman leapfrogging over a fire hydrant erupting with a water spray as a man enthusiastically grins behind her, and (h) a “big dog” measuring the length of his sausage-shaped dog food at 7 units on the measuring tape (presumably inches in this American ad). Stimuli were presented using a block design:

6 LP 6 UI 6LP 6 UI

Each stimulus was presented via computer screen for 20 seconds (SuperLab; Cedrus Corp., San Pedro CA) at a viewing distance of 15-26 cm. Data recorded during the 12 LP stimuli presentations were averaged for each individual, as were the data for the 12 UI stimuli. Segments contaminated by excessive artifact (e.g., muscle-related EMG or eye-motion artifact) were excluded from analysis. The resting awake state was assessed at the start of the recording session, prior to any activations. Prior to presentation of the stimuli, subjects were instructed to look at and remember each image.

EEG Methods

Recordings were performed using standard procedures and equipment previously detailed (Cook et al., 2002), in a sound-attenuated room. In order to sustain the awake state, subjects were alerted by the technicians with prompts at the emergence of any sign of drowsiness. A Pz-referential montage was used to collect data from 35 scalp recording electrodes, placed with a custom electrode cap (ElectroCap, Eaton, OH) using the International 10-20 system (Figure 2). Signals were digitally recorded with the QND system (Neurodata, Inc., Pasadena, CA), using a passband of 0.3-70 Hz. This system allowed for offline reformatting of data after the recording to determine power values relative to a linked-ears reference. Data were analyzed at a sample rate of 256 samples/sec for each channel, using segments of data of 2-sec duration (512 points).

In order to guide our investigation of emotional processing with information from prior studies, and to avoid Type I statistical error from multiple comparisons, we restricted our analysis to activity in the theta band (4-8Hz). Activity in the theta band has been associated with emotional disturbances and with the effects of medication on mood (Knott and Lapierre 1987; Ulrich et al., 1988a; Knott et al., 1996; Cook et al., 1998, 2002, 2005; Anderer et al., 2000; Pizzagalli et al., 2001), and we believed that the processing of these advertising stimuli might overlap with the neural circuitry which processes affective information. Additionally, relative power in the theta band shows a positive correlation with regional cerebral blood flow (Cook et al., 1998) so increases or decreases in theta relative power can be interpreted in that context. As a further step to avoid Type I statistical errors, we looked for comparisons where more brain regions showed a difference than would be expected by chance; a comparison of 35 brain regions would be expected spuriously to yield 1.75 instances of a raw t-statistic at the p=0.05 level, so we did rejected any comparisons with fewer than two brain regions showing high t-score values.

Data Analysis

Analyses were performed using the SPSS statistical package (SPSS, Inc., Chicago, IL). Continuous variable data were analyzed with t-tests; categorical data were examined using the chi-square statistic.

To test for activation under the two conditions (LP, UI), EEG measures were examined both as raw values at the time of viewing the stimuli, and as changes from resting baseline values (LP - baseline, UI - baseline).

RESULTS

Overall Relative Theta Power

Considering data from all subjects in one group, significant differences were not detected in regional brain activity between LP and UI conditions, either in raw relative power values or in changes-from-rest.

Differences with Stratification by Gender

Male and female subjects did not differ in resting-state values of relative power. When subjects were stratified by gender, male and female subjects did exhibit different changes-from-rest in relative power during stimuli presentation. Male subjects differed significantly between LP and UI activation conditions at electrodes in the C4 (t_{12}=3.97 p=0.002), FP1 (t_{12}=2.55 p=0.03), FPZ (t_{12}=2.32 p=0.04), and PO1 (t_{12}=2.31 p=0.04) electrode positions. In contrast, female subjects exhibited significant differences between LP and UI activations at C3 (t_{10}=2.32 p=0.04), F4 (t_{10}=2.72 p=0.02), F7

(t_{10}=3.58 p=0.005), F8 (t_{10}=2.48 p=0.03), FC5 (t_{10}=3.02, p=0.01), FC6 (t_{10}=2.41 p=0.04), FP1 (t_{10}=2.62 p=0.03), FZ (t_{10}=2.39 p=0.04), T3 (t_{10}=2.32 p=0.04), and T4 (t_{10}=3.05 p=0.01) locations. Figure 3 shows changes from rest in relative power values for both LP and UI conditions, divided by gender; it also shows statistical maps indicating regions where t-test values exceed 2.18 (raw $p<0.05$). For all these brain regions, the changes from resting-state values leading to elevated t-test values were that LP stimuli were associated with a decrease in theta relative power, while UI stimuli led either to an increase in power or to a lesser decrease in power than the LP stimuli.

DISCUSSION

We had hypothesized that LP and UI images would elicit different patterns of brain activation, and found that these differences were detectable when gender was included in the model as a moderating variable (Kraemer et al., 2002). Differences between stimuli conditions were found in female subjects in a broad network of regions including frontocentral (FP1, F4, F7, F8, FC5, FC6, FZ, C3) and temporal (T3, T4) locations; for male subjects, stimuli conditions were different in a smaller network involving prefrontal, central, and parieto-occiptial regions (C4, FP1, FPZ, PO1). These two networks shared the left prefrontal region (FP1). In all these brain regions, the changes associated with viewing the stimuli were that LP stimuli were associated with decreases in power while UI were associated with either an increase in power or less of a decrease, in comparison with resting-state values. We believe this is the first study examining unconscious processing of advertising images and its relationship to regional brain activation patterns.

Our findings are consistent with other studies of information processing that may occur outside of awareness. Using EEG and magnetoencephalography, Hoshiyama and colleagues (2003) examined subconscious brain responses to facial and non-facial images, and detected activation around the fusiform gyrus ("fusiform facial area") for facial images even when the presentation was below the level of conscious awareness (16ms duration). Lehmann and colleagues (2004) reported a dissociation between overt and unconscious processing of facial recognition in the fusiform area.

In his review article, Pessoa (2005) noted that the processing of emotional information is prioritized by the brain but does not always require the emotional information to be the focus of conscious attention. Whalen and colleagues (1998) used "backward masking" in which fearful or happy faces were shown very briefly and then replaced with a "neutral mask face" for a period approximately five times longer; they observed a larger magnitude of brain response to the fearful faces than the happy faces, even though subjects did not report being aware of seeing any emotionally-expressive faces at all. Orozco and Ehlers (1998) described gender-related differences in the P450 event-related potential response to viewing emotionally-expressive faces: their female subjects were observed to generate longer latency and higher amplitude P450 potentials than male subjects to both happy and sad faces, suggesting that male and female subjects may processing facial information differently, and a longer- and higher-amplitude P450 waveform is consistent with activation of a more extensive network as we observed here. In work using backward masking of happy and sad faces with only female subjects, Killgore and Yurgelun-Todd (2004) found fMRI activation of the amygdala and anterior cingulate, suggesting that they are “important components of a network involved in detecting and discriminating affective information presented below the normal threshold of conscious visual perception.” Our subjects exhibited differences in prefrontal, frontal, central and temporal electrodes; these overlie structures that participate in limbic processing of emotional stimuli and the behaviors arising from that processing.

In the brain regions where UI and LP stimuli were associated with statistically different shifts in theta relative power, the directions of change can be summarized as follows: viewing LP images was consistently associated with decreases in theta activity, while viewing UI images was associated with an increase in theta activity or with less of a decrease than with LP stimuli. This suggests that viewing UI images leads to greater activation in circuits producing theta activity than viewing LP images. This relationship held for both male and female subjects, though with differences in which regions were activated in this way. We speculate that these increases in theta activity might reflect increased emotional processing (e.g., Aftanas et al., 2004, Kemp et al., 2005), but additional data would be needed to support this conjecture in the context of advertising images.

Several limitation of this study should be noted. One is whether the observed gender-related differences are tied to the particular stimuli in our battery or if this is a more general phenomenon. Future extensions could address this by employing a wider variety of stimuli drawn from sources not confined to real-world advertisements; this might allow evaluation of information presented outside of conscious awareness and with varying degrees of emotional charge. Another limitation is that our subjects were all older individuals. The emotional valence of some of the UI elements in the stimuli might be different in younger subjects, and future studies should address this by enrolling subjects across a wider range of ages. Our surface EEG data largely reflect the activity in cortical regions adjacent to the recording electrodes, and this limitation could be overcome in future work by employing methods that can directly assess the participation of brain regions less accessible to surface EEG (e.g., functional MRI to study fusiform, amygdala, and cingulate regions). Finally, our data do not allow us to differentiate between the “emotional” and “unconscious” aspects of the UI stimuli; indeed, advertisements of this UI variety blend the two, and disambiguation might be better addressed using images chosen or constructed to separate these elements. Despite these limitations, this study finds evidence for differences in how the brain processes advertising images, depending on whether the images appeal to rational, logical functions or to unconscious, emotionally-valenced functions, and that this processing may differ between male and female subjects.

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FIGURE CAPTIONS

Figure 1. Example Advertising Images. Samples of Logical Persuasion (LP) advertisements are shown (upper row, images a-d) along with Unconscious Influence (UI) ads (lower row, images e-h).

Figure 2. Electrode Placement. 35 electrodes were placed on the scalp using an electrode cap. Line segments indicate bipolar channel pairs that entered into the cordance calculation.

Figure 3. Changes in Activity for LP and UI conditions. For female (left column) and male (right column) subjects, changes from rest state in relative power are shown for the logical persuasion and unconscious influence conditions (top two rows). Yellow represents no change from rest, while orange and red shades indicate increases and green and blue shades indicate decreases when viewing LP or UI stimuli. Regions of statistical significance ($p<0.05$) are shown with maps of t-test values; regions with nonsignificant values are shown in white. Brains are shown from above, with electrode locations indicated by black marks.