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Research Report

Cognitive processing of visual images in migraine populations in between headache attacks

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ABSTRACT

Background and objective: People with migraine headache have altered interictal visual sensory-level processing in between headache attacks. Here we examined the extent to which these migraine abnormalities may extend into higher visual processing such as implicit evaluative analysis of visual images in between migraine events.

Methods: Specifically, we asked two groups of participants—migraineurs ($N=29$) and non-migraine controls ($N=29$)—to view a set of unfamiliar commercial logos in the context of a target identification task as the brain electrical responses to these objects were recorded via event-related potentials (ERPs). Following this task, participants individually identified those logos that they most liked or disliked. We applied a between-groups comparison of how ERP responses to logos varied as a function of hedonic evaluation.

Results: Our results suggest migraineurs have abnormal implicit evaluative processing of visual stimuli. Specifically, migraineurs lacked a bias for disliked logos found in control subjects, as measured via a late positive potential (LPP) ERP component.

Conclusions: These results suggest post-sensory consequences of migraine in between headache events, specifically abnormal cognitive evaluative processing with a lack of normal categorical hedonic evaluation.

1. Background

Migraine is a headache disorder characterized by moderate to severe throbbing pain, with sensitivity or intolerance to light and sound during the headache, and is often accompanied by nausea and vomiting (Headache Classification Subcommittee of the International Headache Society, 2004). For a sufferer, what it is to be a migraineur often goes well beyond the headache itself. A migraineur may feel that he/she is impacted in daily activities, even when not suffering from an attack, during what is called the interictal period. Migraine has been considered to be a form of sensory processing disturbance, with evidence building to support the idea that migraineurs have abnormal responses to normal interictal sensory events (Goadsby, 2007). For example, migraineurs show reduced sensory habituation to repetitive visual stimulation as measured via visual evoked potentials. Specifically, the amplitude of the visual evoked components in response

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to checkerboard reversals normally decrease over time, but migraineurs show no such evidence of this sensory habituation (Coppola et al., 2009; Siniatchkin et al., 2003). Less characterized is the post-sensory impact of migraine, with recent evidence suggesting that migraineurs have subtle interictal cognitive abnormalities aligning with attentional deficits (Demarquay et al., 2011; Mickleborough et al., 2011a, 2011b). Collectively, these findings indicate that migraineurs show a hypersensitivity to both sensory and attentional visual processing of visual events. Given the altered interictal visual sensory and cognitive functioning in migraineurs, the objective of this study was to examine the extent to which migraine may extend into higher visual processing such as evaluative analysis of visual images.

Specifically, we wanted to advance our understanding of potential post-sensory anomalies in how migraineurs implicitly process visual images, and in particular, the natural and automatic process of evaluating images at a hedonic level. Our methodological approach was based on a recent ERP study in normal populations examining implicit aesthetic evaluative analysis of common everyday visual images, and in this case, commercial branding logos (Handy et al., 2010). To do this, we measured migraineurs and non-migraine controls responses using event-related potentials (ERPs) as they viewed a serial stream of unfamiliar visual objects (232 distinct, different logos) in the context of a target identification task. In each trial block, each of these 232 logos was presented once. After completing 10 trial blocks, participants were then asked to identify the 15 logos they liked most and which 15 they disliked most. Importantly, they were not explicitly asked to think about or evaluate the logos in any way prior to this point of the study.

Using this paradigm, we wanted to examine whether migraineurs might show altered implicit hedonic analysis of visual images. In particular, making a like or dislike judgment of visual images is such a normal part of human behavior that it can be generated without conscious intent (Dijksterhuis and Aarts, 2003; Chen and Bargh, 1999). Moreover, even emotionally neutral images such as logos are implicitly evaluated at a hedonic level, and specifically manifest a bias for disliked logos, akin to emotional negativity biases (Handy et al., 2010; Dijksterhuis and Aarts, 2003). The ERP components measured for assessing implicit hedonic processing were the frontal/central N2 and the frontal/central LPP. The N2 and LPP components were chosen because they have been found to be sensitive to implicit hedonic analyses in previous studies (Handy et al., 2010). Specifically, previous research suggests LPP amplitudes reflect the depth of evaluative analyses (Cacioppo et al., 1996; Crites et al., 1995; Cuthbert et al., 2000), such as increased evaluative categorization (Cacioppo et al., 1996; Crites et al., 1995) as well as activation of motivational and affective systems (Cuthbert et al., 2000). The LPP is also noted for being modulated by directing attention to emotional stimuli (Dunning and Hajcak, 2009). Using the N2 and LPP components, we asked whether migraineurs might show an altered pattern of implicit evaluative analysis at the hedonic level, and in particular we hypothesized that migraineurs might show anomalies in their responses to liked logos, disliked logos, or both, as compared to controls.

2. Results

The N2 and LPP components were chosen because they have been found to be sensitive to implicit hedonic analyses in previous studies (Handy et al., 2010). Because of the waveform variability between migraineurs and controls, the components were captured in a series of 50 ms windows from 225–575 ms designed to capture the peak of the two components in each group, comprising electrodes F3, FZ, F4, C3, CZ, and C4. Statistical interrogation included a repeated measures ANOVA with group (control vs. migraine) as a between-subjects factor and preference (like vs. dislike vs. all non-target logos), electrode location, and time window (50 ms windows from 225–575 ms) as within-subjects factors. Separate ANOVAs within each group were planned to follow-up any significant interactions including group and preference. Grand-averaged ERP waveforms for *Liked*, *Disliked*, and *All* logos are shown in Fig. 1 as a function of headache classification and scalp location and in Table 1 as a function of group, preference and time window.

2.1. *Frontal/central N2 & LPP*

As can be seen in Fig. 1, it appeared that the post-sensory preference effects differed between groups across time windows, and this was confirmed statistically. We found a main effect of preference ($F(2,56)=14.92$; $p<0.001$), qualified by a group by window by preference interaction ($F(2,56)=1.94$; $p<0.05$). Planned ANOVAs within each group revealed that controls had a main effect of preference ($F(1,28)=8.55$; $p<0.001$), and an interaction of preference and time window ($F(1,28)=2.74$; $p<0.01$). Specifically, within the control group the mean amplitude of the *disliked* logos was less positive than the mean amplitude of *all* logos in all but the first time window (from 275–575 ms; all $Fs(1,28)>12.50$; $ps<0.01$) and *disliked* logos was less positive in magnitude than the mean amplitude of *liked* logos in the two last windows (from 475–575 ms; all $Fs(1,28)=4.43$; $ps<0.05$), while the mean amplitude of *liked* logos was less positive in magnitude than the mean amplitude of *all* logos only in two time windows (from 325–425 ms; all $Fs(1,28)=4.59$; $ps<0.05$). These results reflect hedonic preference differences specifically in the LPP (275–575) components, but not in the N2 component (225–275). In contrast, migraineurs showed no such effect of preference ($F(1,28)=3.03$; $p=0.06$) or for preference by time window ($F(1,28)=1.81$; $p=0.05$). To be sure these null effects were not a result of greater variability in the migraineur ERPs, we compared the average variance of the two groups and found that they do not differ significantly ($t(56)=1.244$, $p=0.218$).

2.2. *Control analyses*

2.2.1. *Lateral occipital P1 peak*

Because migraineurs are known to show altered sensory responses, including the P1 ERP component (Mickleborough et al., 2011b), we added a control analysis of the lateral occipital P1, which is known to index the sensory-evoked excitability of extrastriate visual cortex (Heinze et al., 1994). The P1 encompassed scalp electrodes OL & OR, using