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The role of the lateral occipital cortex in aesthetic appreciation of representational and abstract paintings: A TMS study

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ABSTRACT

Neuroimaging studies of aesthetic appreciation have shown that activity in the lateral occipital area (LO)—a key node in the object recognition pathway—is modulated by the extent to which visual artworks are liked or found beautiful. However, the available evidence is only correlational. Here we used transcranial magnetic stimulation (TMS) to investigate the putative causal role of LO in the aesthetic appreciation of paintings. In our first experiment, we found that interfering with LO activity during aesthetic appreciation selectively reduced evaluation of representational paintings, leaving appreciation of abstract paintings unaffected. A second experiment demonstrated that, although the perceived clearness of the images overall positively correlated with liking, the detrimental effect of LO TMS on aesthetic appreciation does not owe to TMS reducing perceived clearness. Taken together, our findings suggest that object-recognition mechanisms mediated by LO play a causal role in aesthetic appreciation of representational art.

1. Introduction

The eighteenth century philosopher Friedrich Schiller believed that beauty had the potential to reconcile what he viewed as humans' inherently conflicting sensual (material) and formal (spiritual) essences. The appreciation of beauty, Schiller (1895) argued, emerges from a harmonious relation between intellectual contemplation and bodily sensation, between thinking and feeling. Converging psychological and neurophysiological evidence accumulated during the last fifty years supports Schiller's insight: aesthetic appreciation indeed involves a complex interaction among cognitive, sensorimotor, and emotional processes (Chatterjee, 2011; Chatterjee & Vartanian, 2014; Leder, Belke, Oeberst, & Augustin, 2004; Nadal & Skov, 2013). Neuroimaging and neurophysiological studies continue to shed light on the distributed network of brain regions that underlies aesthetic appreciation (e.g., Cela-Conde et al., 2004, 2009, 2013; Cupchik, Vartanian, Crawley, & Mikulis, 2009; Ishizu & Zeki, 2011; Kawabata & Zeki, 2004; Lacey et al., 2011; Salimpoor et al., 2013; Vartanian & Goel, 2004). However, the specific role of the component regions, and the factors that modulate their activity, require further clarification (Nadal, 2013).

Here we focus our attention on the lateral occipital area (LO). Although LO is a key region within the object recognition pathway, involved in many aspects of objects processing (for reviews, Grill-Spector, 2003; Lacey & Sathian, 2011), such as extracting shape information from both two- and three-dimensional objects (Kourtzi & Kanwisher, 2000; Malach et al., 1995), object size judgments (Eger, Ashburner, Haynes, Dolan, & Rees, 2008; Pourtois, Schwarts, Spiridon, Martuzzi, & Vuilleumier, 2009), and even semantic aspects (i.e., object categorization and naming) (Eger et al., 2008), its functions may go beyond mere shape detection and object recognition. Specifically, LO is one of the brain regions whose activity has been related to aesthetic experience of visual art in neuroimaging studies (Cupchik et al., 2009; Ishizu & Zeki, 2013; Lacey et al., 2011; Vartanian & Goel, 2004). Importantly for our study, Lacey et al. (2011) found that activity in right LO correlated positively with aesthetic evaluation of artistic images. Therefore, it seems that LO activity during the viewing of artworks is not strictly related to the extraction of low-level shape/object information: it is also related to the aesthetic appreciation of an image, at least when the image

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is artistic, and hence more naturally fosters an aesthetic orientation (Huang, Bridge, Kemp, & Parker, 2011; Kirk, Skov, Hulme, Christensen, & Zeki, 2009; Noguchi & Murota, 2013).

However, whether LO plays a *causal* role in aesthetic appreciation of art is currently not known, as available neuroimaging evidence is by definition only correlational. In this study, we aimed to address this issue by using transcranial magnetic stimulation (TMS), given that brain stimulation allows the assessment of causal links between brain activity and behavior (Pascual-Leone, Walsh, & Rothwell, 2000). Previous work has shown the potential of TMS to clarify the role of target brain regions in aesthetic appreciation. For instance, the aesthetic appreciation of human bodies is altered by applying TMS over sensory and motor brain regions (Calvo-Merino, Urgesi, Orgs, Aglioti, & Haggard, 2010; Cazzato, Mele, & Urgesi, 2014). In our study, we presented participants with a series of images, and asked them to indicate whether they liked each of them or not, and to further indicate the extent to which they liked them on a 1–7 Likert scale, while interfering with LO activity using TMS. The images were representational and abstract paintings. Lacey and colleagues only used representational paintings, but there is evidence that aesthetic appreciation of abstract and representational paintings may rely on at least partially different brain mechanisms (e.g., Cattaneo et al., 2014a,b; Lengger, Fischmeister, Leder, & Bauer, 2007). Hence, if the contribution of LO to aesthetic processing is strictly related to object-recognition mechanisms, then TMS over LO should selectively interfere with the appreciation of representational but not abstract artworks, given that the latter lack all discernible object content. If, on the contrary, applying TMS to LO also decreases liking of abstract paintings, the role of LO in aesthetic appreciation must go beyond the mere processing of object information.

2. Experiment 1

2.1. Method

2.1.1. Participants

Fourteen right-handed (Oldfield, 1971) participants (6 males, age: $M = 24.3$ years, $SD = 3.1$) with no previous training or special knowledge about art, volunteered to take part in the study. All had normal, or corrected to normal, vision including color perception (based on self-report) and did not present any contraindications related to the use of transcranial magnetic stimulation (Rossi, Hallett, Rossini, & Pascual-Leone, 2011). Prior to the experiment, participants signed an informed consent. The protocol was approved by the local ethical committee, and participants were treated in accordance with the Declaration of Helsinki.

2.1.2. Stimuli

Stimuli consisted of 80 paintings (see Appendix A for list). Forty abstract and 40 representational paintings were selected from a set of images used in previous work (Cela-Conde et al., 2004, 2009). Twenty-two of the representational stimuli were realistic, and 18 were impressionist or postimpressionist. All of them were created by renowned artists and belonged to the catalogues of European or American museums. In order to avoid the undesired effects of familiarity, only relatively unfamiliar works were selected. Whenever possible, for instance, we chose pictures that have not commonly been exhibited in the museum that owns them. Thus, this set of images is generally unfamiliar to laypeople (Cela-Conde et al., 2004, 2009, 2013). The paintings had been homogenized in terms of pictorial complexity, color spectrum, luminosity, and reflected light (for details, see Cela-Conde et al., 2004). Abstract stimuli lacked any discernible representation of objects, whereas all representational stimuli contained depicted objects, but no close view of human faces or bodies to avoid the activation of facial-recognition brain mechanisms.

2.1.3. Procedure

Participants were seated in front of a 17″ PC (1280×800 pixels) screen, at an approximate distance of 57 cm, in a quiet room with normal illumination, and asked to perform a computerized rating task. Fig. 1 depicts the timeline of an experimental trial. Each trial started with a fixation cross presented for 2500 ms on a white background, after which a painting (20×15 degrees visual angle) was presented at the center of the screen. Participants were instructed to press the left or right keys on a keyboard as soon as possible, using their right index and middle finger, to indicate whether they liked that image or not. Response key assignment for yes/no responses was counterbalanced across participants. Immediately after responding, participants were asked to indicate the extent of their preference for the painting just viewed on a 7-point Likert scale, where 1 was “I do not like it at all” and 7 was “I like it very much”. There was no time restriction on the 7-point response. After the response, a new trial started. Stimuli within the experimental block were presented in random order. The same stimuli were presented twice, once for each of the two TMS sites (see next section).

2.1.4. Transcranial magnetic stimulation

TMS was delivered using a Magstim Rapid^2 stimulator (Magstim Co Ltd, Whitland, UK) connected to a 70 mm butterfly coil at a fixed intensity of 60% of the maximum stimulator output (as in previous TMS studies targeting LO, e.g. Mullin & Steeves, 2011). TMS was delivered to the right LO and to the vertex (control site). The right LO was localized on the basis of Talairach coordinates ($x = 37$, $y = -76$ $z = -5$) taken from previous fMRI research on the neural correlates of aesthetic appreciation (Lacey et al., 2011) showing that aesthetic appreciation for artistic images was directly correlated with activity in right (but not left) LO. The targeted site was identified by means of stereotaxic navigation on individual estimated magnetic resonance images (MRI) obtained through a 3D warping procedure fitting a high-resolution MRI template with the participant’s scalp model and craniometric points (Softaxic, EMS, Bologna, Italy). The vertex was localized as the midpoint between the inion and the nasion and equidistant from the left and right intertrachial notches. For the vertex the coil was oriented tangentially to the scalp parallel to the nasion-inion line, while for the LO the coil orientation was such that the coil handle was pointing upwards and parallel to the midline. The pitch and roll angles were set in order to minimize the distance between the scalp and the cerebral target. Three TMS pulses were delivered at onset of each painting, given prior TMS evidence showing that contribution of LO to object processing takes place within the first 180 ms of stimulus onset (e.g. Mullin & Steeves, 2011), and that triple-pulse 10 Hz TMS has been used before to interfere with underlying cortical activity (e.g., Cohen Kadosh et al., 2007; see Bona, Herbert, Toneatto, Silvanto, & Cattaneo, 2014 for triple-pulse 10 Hz TMS over LO region). Stimulation order was counterbalanced across participants. Prior to the experiment, participants performed a short practice block with 3 different paintings not used in the main experiment, so they could familiarize themselves with the task and sensations generated by TMS. The software E-prime 2.0 (Psychology Software Tools, Pittsburgh, PA) was used for stimulus presentation, data collection and TMS triggering. The whole experiment lasted approximately 90 min.

2.1.5. Data analyses

We analyzed the effects of TMS site (vertex vs. LO) and image category (abstract vs. representational) on participants’ responses and response times by means of generalized linear mixed effects models (Hox, 2010; Snijders & Bosker, 2012). This method