DIPLOMARBEIT

Titel der Diplomarbeit

The Role of the left DLPFC in the Affective Processes underlying Aesthetic Appreciation of Art

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"Without the sensible faculty no object would be given to us, and without the understanding no object would be thought. Thoughts without content are void; intuitions without conceptions, blind."

(Kant, as cited in Politis, p.317, 1991)

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Abstract

Looking at an artwork can evoke several different emotions. These affective parameters represent an integral part in the process of aesthetic appreciation. Uncovering its neural substrates, the left dorsolateral prefrontal cortex (lDLPFC) has been found to play a crucial role in aesthetic processing. In previous studies its stimulation led to an increased appreciation of representational images. By the use of transcranial current stimulation (tDCS), we modified lDLPFC activity and directly tested its contribution to the affective judgments generated in response to representational artworks. The emotional content of the stimuli varied from negative to neutral up to positive affective valence. In a double-blind, within-subject, sham-controlled, crossover design, 33 participants indicated their individual feelings elicited by the stimuli on a visual analogue scale before and after stimulation. Results showed that neutral pictures were perceived significantly more positive after the stimulation of the lDLPFC compared to sham stimulation. The evaluation of negative and positive images did not change due to the stimulation of the lDLPFC. As neutral pictures differ primarily in terms of explicitness, the results suggest an involvement of the lDLPFC for stimuli with ambivalent or flat affective content. The lDLPFC as part of a neural network that involves cognitive evaluation processes as well as it integrates bottom up processes of the amygdala, might play a less relevant role if a stimulus gets clearly classified as positive or negative, but gets consulted for a cognitive evaluation, if the input is ambiguous.

Contents

Introduction

Art appreciation can be described as a very subjective matter. Some people enjoy modern minimalist artworks, some prefer classical, or representational paintings. Some want to understand the message of an artwork, others just enjoy the aesthetic experience. The appreciation of art differs on an interpersonal level in terms of liking, comprehension and elicited emotions. That aesthetic processing itself is nevertheless comparably processed between persons was shown by Kawabata and Zeki (2004) who could illustrate that there are consistent brain activation patterns across subjects watching artworks they classified as beautiful. This is not surprising when we think about that on the perceptual level all of us start with a very similar informational input. When we look at an artwork we commonly respond to it by perceiving different parameters of the object (Ramachandran & Hirstein, 1999; Zeki & Nash, 1999). We register basal information of the image like colorfulness (Zeki, 1980), complexity (Frith & Nias, 1974), contrasts as well as the balance and symmetry of the elements (e.g., Fechner, 1876; Locher & Nodine, 1987). Also we try to recognize the content or even guess a story behind it, in a process which happens to be partly conscious, partly unconscious (Hasenfus, Martindale, & Birnbaum, 1983). Another component which happens to the majority of us while viewing an artistic stimulus is a feeling rising in us based on what we see (Frijda, 1989; Silvia, 2005, 2009, 2013). This affective response varies in its intensity and also in its valence across a continuum from negative to positive. Even though it has to be emphasized, that the comparability of perceptional input is dependent on context and also knowledge variables, which need to be controlled as modulating factors (Churchland, Ramachandran, & Sejnowski, 1994). But what is the decisive factor which determines if an artwork will be finally appreciated or not? This ongoing discussion concentrates mainly on two aspects. On one hand on the emotional reinforcement based on the bottom-up input of the amygdala, and on the other hand on the cognitive analysis of a stimulus, in other words, the relevant top-down operations (Lazarus, 1991; Leder, Belke, Oeberst, & Augustin, 2004; Silvia, 2005; Leder, Gerger, Dressler, & Schabmann, 2012). It is clear that the answer to this question can only be a highly complex interaction of different factors. Like Nadal and Pearce (2011) have already revealed, studying its neural underpinnings using neurophysiological methods like imaging techniques can contribute to the understanding of this complexity and makes it also possible to test existing theoretic frameworks directly. This will allow to gain deeper knowledge about what makes artistic stimuli be liked and how aesthetic judgments themselves be generated.

The present work focuses primarily on the generation of affective judgments towards visual art. The left dorsolateral prefontal cortex (lDLPFC) has been found to play an important role in art appreciation (Cela-Conde et al., 2004; Lengger, Fischmeister, Leder, & Bauer, 2007; Vessel, Starr, & Rubin, 2012; Cattaneo et al., 2014b). We were interested in whether affective judgments of artworks would change due to enhanced activation in this region, like it has already been shown for the liking of images (Cattaneo et al., 2014a). Therefore we used the method of transcranial direct current stimulation (tDCS), which allowed us to artificially modulate lDLPFC activity.

In the following the theoretical background will be explained in detail. This will provide an overview of the relevant models and theories. Thereupon the hypotheses will be formulated proceeded by the procedure of the conducted study. Finally our results and informational outcome will be clarified and discussed.

Aesthetic Experience and Appreciation

Answers to the question about which factors determine if we enjoy an aesthetic experience were already being searched and debated by Greek philosophers. The fact that aesthetic pleasure can also be found in respond to artworks depicting normally unpleasant elements such as ugliness, ascribes a concealed character to art, which engages humans of all cultures and countries.

Its introduction to experimental psychology took place by the work of Gustav Theodor Fechner in 1876. He held the view that the very theoretic philosophical approach to aesthetics 'from above' should be complemented by empirical foundations from 'below'. He was the first who quantitatively investigated the impact of numerous visual features on aesthetic judgments and preference.

But how can aesthetic experience be defined?

A very old assumption relating to this question is the term of 'disinterest interest' (Kant, 1790), which points to the 'dis-utility' of art contrasting other actions providing pleasure such as eating delicious food or having sex. Aesthetic inputs are giving rise to delightful experiences without evoking further desires or bringing additional rewards in an evolutionary sense.

Bergeron and Lopes' (2012) analysis of historically relevant concepts, resulted in three crucial components governing an aesthetic experience. A first category comprises higher cognitive mechanisms, which imply the evaluation of an object as well as its explicit classification. A second important feature of aesthetic experience is its emotional dimension, the subjective sensation which is felt in response to the experience. The third component is summarized as the will to extract a content or even a meaning of an artistic stimulus.

A review of recent imaging data and neuropsychological findings provided by Chatterjee and Vartanian (2014) confirm the presence of the factors mentioned above. Their data suggest that aesthetic experience emerges out of the interplay between three neural systems covering sensory–motor, emotion–valuation, and meaning–knowledge circuits, summarized as the 'aesthetic triad'.

The sensory-motor system refers to the corresponding activation which occurs based on the segragated visual input. This phenomenon is named 'embodiment'. It was already discussed by the philosopher Theodor Lipps in 1903, as cited in Jahoda (2005) and can nowadays scientifically be confirmed. For example, if we look at an artwork where some bodily movement is depicted (like in Figure 1), our motor cortex shows activation simulating the movement (see Thakral, Moo, & Slotnick, 2012).

Figure 1: Example of movement in an image causing activations in the motor system ("*Dance*", Henri Matisse, 1909).

The source of the emotion–valuation system was found in orbifrontal and medial regions as well as anterior cingulate, insula, amygdala and the ventral striatum which build a network responsible for the affective dimension of aesthetic experience (Kawabata & Zeki, 2004; Vartanian & Goel, 2004; Jacobs, Renken, & Cornelissen, 2012).

Studies working with different context variables provided evidence for the existence of the meaning-knowledge system (e.g., Brieber, Nadal, & Leder, 2015).

This system integrates and connects the visual input to prior knowledge and forms expectations, judgments and conclusions.

Two prominent models which complement each other are the model of Leder et al. (2004) and the one of Chatterjee (2004). The model proposed by Chatterjee (2004) focuses primarily on the processing of visual attributes and on the neural correlates determining aesthetic preference. He described perceptual, emotional and cognitive properties as the three essential components, outlining five interconnected stages leading to an aesthetic experience: The phase of 'Early vision'characterizes the recognition of abstract features like color and shape, which is comparable to any other recognition of objects. 'Intermediate vision', describes the discovery of finding connections to already known features and also segregate the input in order to find a categorization or 'representational' domain for the object of interest. Differences in the amount of time we track certain elements due to salient features leads to the stage of 'Attention'. The detailed processing of the artwork brings up associations forming a meaning or content of the stimulus. The recognition and association evoke 'Emotions', which influence the aesthetic experience and finally the aesthetic judgment. This model integrates valuable information concerning the biological basis of aesthetic experience and therefore complements the rather psychological model of Leder et al. (2004).

This second very important framework summarizes fundamental steps, typically executed when confronted with visual art on a psychological dimension. In this process the above mentioned outcomes have been reflected, which resulted in a very holistic stage model. The model has been recently been updated (Leder & Nadal, 2014) and will be fundamental for the present study.

The authors assume that the aesthetic experience consists of the consequent cognitive analysis, permanently accompanied by an affective evaluation process. This procedure was reviewed and specified in Leder and Nadal (2014). The first step is the perceptual analysis of the artwork. Aspects like contrast, complexity, symmetry and so on are important features to assess in this phase. In the following stage of explicit classification, content and style are analyzed and makes categorizations possible. The pre-acquired art-knowledge and the personality trait of art interest alters the approach to experience art. Especially during the step of implicit memory integration, where the input gets connected to self-related meanings this aspect gains relevance. Art experts and people highly interested in art tend to focus more on features like style and epoch, while others get more attracted by the content of an image (see page 16, Questionnaire of Art Interest). This is also important to the subsequent step of explicit classification which marks the unconscious assessment of relations to individual memories. Finally the recipient evaluates the artistic input on understanding and the elicited pleasure. Personality traits and the affective state of the recipient play a continuous role influencing and interacting with every step of the model, which finally leads to the aesthetic judgment. This interaction between emotions and cognition was further clarified by Wagner, Menninghaus, Hanich, and Jacobsen (2014) who investigated the influence of cognitive schemata on affective judgments. Participants were watching the same sets of disgusting stimulus material under two different conditions. The selected photographs were either declared as artistic photographs or as educational material. Participants rated the images more positive when they were classified as artworks. Conversely, negative affective judgment did not differ between the two framing conditions. It can be concluded that two different cognitive schemata got activated which evoked different expectations and thoughts forming the affective judgment, which will be the topic of the following section.

Affective processes

One of the first works emphasizing this interconnection between art and emotions was provided in the 1970s by Daniel Berlyne. In his work on the “new experimental aesthetics" (Berlyne, 1974) he analyzed emotional responses to art and postulated arousal and the so-called 'collative variables', in other words variables of comparison (e.g. complexity, uncertainty, novelty) as most important factors predicting a persons emotional response to art.

A more recent connection from emotions to underlying cognitive mechanisms was drawn by Lazarus (1991). The proposition of appraisal theories which postulate emotions to arise out of the evaluation of situations and how these are matching personal values, interests and goals brought new insights to the topic and can be described as the leading approach of investigations now (e.g., Ellsworth & Scherer, 2003; Roseman & Smith, 2001). Appraisal theories propose a variety of distinct emotions complying diverse functions and rely on different appraisal structures. An obvious reason why events or in a our case scenes, do not predict emotions concerns the uncountable number of different events causing identical emotions (Roseman & Smith, 2001). A diversity of events will lead to the same affective response if the appraisal of the event, in other words the personal goals, values and interests are similar. "[...] the subjective psychological structure of an event is what is critical to emotions" (Silvia, 2005).

Despite this variety of distinct emotions with diverse individual structures, or even because of that, it can be useful to reduce affectivity to its very fundamental bipolarity of negative and positive emotional valence to discover the basic mechanisms.

In the model of Leder et al. (2004) (see also Leder & Nadal, 2014), the emotional valence refers to the stage of explicit classification, the stage of assessing also the content of the image. The emotional valence is defined as the direction of an emotion attributed to the stimulus (negative, neutral, positive) and represents according to Leder et al. (2012) the strongest predictor of liking. In other words, a determining factor to appreciation is the valence we develop by interacting with the content of the picture. This must not match necessarily the 'objective' valence of the image, like in our study the pre-categorizations (see page 14). The affective state is also influenced by personality traits, such as empathy. An emphatic person shares the thoughts and feelings of others. A precondition of empathy is emotional contagion, which is the ability to 'catch' an emotion (Singer & Lamm, 2009), "the tendency to automatically mimic and synchronize movements, expressions, postures, and vocalizations with those of another person and, consequently, to converge emotionally" (Fischer, Shaver, & Carnochan, 1990, p. 153). In the process of unconscious imitation of the transported emotion, an afferent feedback is released which lets people 're-feel' what they see. So the ability of emotional contagion is believed to increase the feeling triggered by an artwork or another affective stimulus (Hatfield, Cacioppo, & Rapson, 1994). Also Freedberg and Gallese (2007) have emphasized the influence of empathy in aesthetic reactions. A particular emotional rapprochement is assumed between recipient and visual object. Based on these assumptions the influence of emotional contagion will be tested within our study design.

The Dorsolateral Prefrontal Cortex

Studies of the neurobiological mechanisms which underlie the experience of art have been analyzed and clustered into three functional components building a network. This network includes 1) prefrontal, parietal and temporal regions, responsible for attention, memory and judgment; 2) a reward circuit, mediated by cortical and subcortical structures, and 3) cortices for sensory processing, which play a role in the perception of specific features, see Nadal (2013) for a detailed overview.

Basically if we talk about affective processes like emotional contagion involved in aesthetic processing, we talk about the reaction to the affective states of others. The generated response, which contains attention, imagination and anticipation seems to be mediated by Nadal's first component: prefrontal and parietal brain regions, which have been associated to evaluative judgment, memory, and attentional processes. The DLPFC showed especially activation in the aesthetic appreciation of artworks, when labeled them as beautiful (Cela-Conde et al., 2004, 2009; Vartanian & Goel, 2004; Lengger et al., 2007; Vessel et al., 2012).

Besides its involvement in pleasurable experience viewing artworks, the lDLPFC is thought to play a crucial role in executive function and goal directed actions. According to Nadal, Munar, Capó, Rossello, and Cela-Conde (2008) it is involved in the "conscious deliberation about different options[...], influenced by emotional information from the orbitofrontal cortex (OFC) and certain limbic areas." DLPFC activity has been assumed to reflect evaluation processes involved in aesthetic orientation and the preference approaching aesthetic qualities of stimuli (Cela-Conde et al., 2004; Cupchik, Vartanian, Crawley, & Mikulis, 2009; Lengger et al., 2007). These mentioned regions are connected in a frontocaudal network, in which the DLPFC seems to play an "engaging" role for detailed appraisals of visual aesthetic features.

Several studies observed increased lDLPFC activity while participants viewed images that participants classified as beautiful (Cela-Conde et al. 2004; Cupchik et al. 2009; Lengger et al. 2007), which leads to the conclusion that especially positive valuated stimuli getting processed there. Beauty experience has also been directly modulated and enhanced by applying brain stimulation on the lDLPFC (Cattaneo et al., 2013, 2014) Moreover it has also been shown that this increase is even greater for stimuli which move the participant emotionally (Vessel et al., 2012). Also the lateral OFC (lOFC) seems to have significant impact on affective evaluations like Munar et al. (2012) found. In their MEG study brain activation was observed while participants were watching positive images and contrasted to activation when the input was negative. Participants showed higher activation in the lOFC while watching images rated as not beautiful, a critical role of lOFC regions theythe generation of negative affects. Recent findings suggest an inverse relation between DLPFC and

OFC (Northoff et al., 2000). Positive stimulus material induced high activation in the DLPFC marked by a negative correlated activity in the OFC, whereas negative pictures led to a strong activation in the OFC and low activation in the DLPFC.

Transcranial Direct Current Stimulation

What needs to be considered regarding findings of neural correlates is that the given activation patterns are not necessarily the direct result of the presented task. For building up a theory on constructs with multiple factors of influence like aesthetic processing, it is mandatory to combine different methods in order to find causal relations. A technique which contributes to this is the method of tDCS. Two electrodes, applied over the region of interest continuously induct weak direct current, flowing between the electrodes (see Figure 3). This changes the permeability of the underlying neuronal membranes by changing their electrical gradient. The induction of fully reversible shifts of cortical excitability allow to directly test the involvement of a specific brain area (in this case the lDLPFC) in a measured behavior (here the perceived emotions). The duration of the change after the end of the stimulation and whether the stimulation activates or inhibits brain activity — is determined by stimulation parameters, such as the time of stimulation and the polarity (anodal or cathodal). In anodal stimulation the current flows from the anodal electrode to the cathodal reference electrode. Thereby the neurons around the active electrode depolarize by the negative charge which increases their excitability. Cathodal stimulation works the other way around and inhibits the neural excitability. Neurons get hyperpolarized and therefore less susceptible for action potentials (Stagg & Nitsche, 2011).

Another advantageous feature of the tDCS procedure is that it is non-invasive and also painless for the participant. A study of Poreisz, Boros, Antal, and Paulus (2007) found mild itching sensations as a frequent reported side effect in the affected area (70.6%). Moreover, some of the participant felt a moderate fatigue after receiving stimulation (35%). The same study showed that only 16.7% of participants could differentiate between real and sham stimulation.

Aims and Hypotheses of the Present Study

Based on the reported findings the present study aimed to modulate the lDLPFC activity using anodal tDCS and to gather data examining an alteration of perceived emotions towards different valence categories of artworks. It was expected that the increase of excitability in the lDLPFC (real tDCS) would effect the valence ratings of the participants in a positive direction compared to sham stimulation. For positive stimuli, positive feelings were predicted to increase due to the lDLPFC involvement in positive affects (Cattaneo et al., 2014a). For negative stimuli the normal activation of the mOFC was awaited to increase but immediately followed by an indirect inhibition by the artificial activation of the lDLPFC due to their inverse relation (Northoff et al., 2000), therefore the positiveness was also assumed to increase for negative pictures. This was also expected to be also true for neutral pictures, as they are also positive and negative but to a lower degree. None of the described changes of affective judgment were believed to occur under sham tDCS stimulation.

It was assumed that participants highly interested in art respond in a more cognitive manner, integrating the stimuli in a theoretic framework of the already known (Millis, 2001). It was expected that this should be expressed in a diminished effect of the brain stimulation on the ratings compared to participants with low art interest.

In addition it was hypothesized that participants with high values in emotional contagion get more affected by the emotional valence of stimuli compared to participants with a low level of susceptibility (Freedberg & Gallese, 2007).

Methods

The present study was embedded in a design where in total four conditions were tested. In order to control for selective impacts of anodal tDCS on valence ratings, we chose the evaluation of colorfulness to be our control condition. Color is a necessary but not sufficient feature of aesthetic preference. Besides the here presented theme of emotional valence and the control condition of colorfulness, there were two additional topics which have been treated. One group was tested on their understanding of the artworks (see Diploma theses of Ruppert, Sebastian, in prep.) and another one rated the pictures on how much they liked them (see Diploma theses of Stark, Viktoria, in prep.). All in all a sample of 74 participants were tested and randomly assigned to one of four conditions: liking, understanding, valence or color. This design allowed all three studies to compare their data to the same control group, which was the condition of color. Also potential influences of the test administrator could be controlled this way as they randomly administered all different conditions.

Participants

For the present study 38 participants have been tested, unfortunately due to a drop out and a saving error the here analyzed sample consists of 33 participants, 17 persons (12 women; age: $M = 26.00$, $SD = 1.33$) in the valence condition and 16 persons (11 women; age: $M = 26.81$, $SD = 4.46$) were part of the control group. Most of the participants were psychology students and have been recruited via the Laboratory Administration for Behavioral Sciences (LABS) of the Faculty of Psychology, University of Vienna and were filtered on right handedness, normal or corrected to normal vision, no neurological or psychiatric diseases and no special interest or education in art. Moreover all participants fulfilled the criteria of a special tDCS-Checklist to prevent any potential risks due to the stimulation.

Stimuli

The stimulus material contained a collection of 240 reproductions of artworks chosen from museum catalogs. The main criterion for the selection was that the depicted content varied concerning its valence from negative to neutral to positive. In order to generate two balanced sets of stimuli, the artworks were evaluated and categorized within two prestudies.

Prestudy 1. In a first prestudy the emotional valence of the pictures has been rated (Gerger, Leder, & Nadal, in prep.). 32 participants (26 women; age: $M = 28.13$, $SD = 4.72$) rated each picture on its valence and arousal. The participants stated their response on a 7-point Likert-scale. Based on tertiles of these ratings the set was segregated into three equal clusters containing 80 pictures each.

(a) negative *(b)* neutral *(c)* positive

Figure 2: Sample stimuli of each valence category. *(a)* "*Acker*", Georg Baselitz, 1962; *(b)* "*Bodegón de las acelgas*", Gustavo Torner, 1955; *(c)* "*Lovers of venice*", Marc Chagall, 1957.

Prestudy 2. The intention of the second prestudy was to build two balanced sets of artworks for the main experiment (set A, set B). Twenty-four participants (15 women; age: $M = 23.83$, $SD = 3.46$) evaluated the images on colorfulness and liking on a 7-point Likert-scale. In order to control the variation of colorfulness and liking between the two sets, the images for each valence cluster were ranged from least to most liked. Thereupon the pictures were assigned to set A and B consecutively: A B B A and so on, ensuring that the liking scores were as similar as possible. Two picture sets of 120 artworks, including all three valence categories and showing equality concerning their liking and colorfulness ratings were the result.
Non-parametric comparisons of means confirmed that set A and B did not differ significantly in liking or colorfulness.

Questionnaires

Checklist for tDCS participants. In order to exclude any health risk for the participants, all criteria of the tDCS checklist had to be excluded to start with the experiment. The list contains 18 questions covering the following aspects: 1) Negative reactions to tDCS in the past, 2) epileptic seizures, 3) stroke, 4) surgery or an operations of the head or brain, 5) metallic objects in the body, 6) implanted devices like cardiac pacemaker, 7) regular suffering from headaches, 8) other problems with the central nervous system, 9) diseases leading to brain damage, 10) psychotropic drugs, 11) pregnancy, 12) epileptic seizures in family, 13) profession involves driving a vehicle, 14) lack of sleep, 15) drugs, alcohol and nicotine, 16) chronic skin diseases, 17) piercings, earrings (should be taken out).

Questionnaire on art interest (Kunstinteressefragebogen - KiF). Like mentioned in the model of aesthetic experiences (Leder et al., 2004), art experts perceive and evaluate art in a different way. Due to their specific knowledge they show a tendency to attribute and integrate artistic stimuli based on their profound theoretical background knowledge which leads to a rather cognitive manner of evaluating artworks compared to non-experts (Millis, 2001). Moreover a study of Leder, Gerger, Brieber, and Schwarz (2014) found that art experts got less affected by the emotional valence of the presented artworks, suggesting general differences in art-processing. Even though art experts have been excluded from the beginning of the study, we still wanted to asses potential differences in contact to art of the participants. For this reason, the questionnaire on art was introduced to examine the general interest in art of the participants and the frequency they visited events on art. Participants were asked to indicate on a seven-point-scale within 15 questions how much they agree with statements like "I like to talk about art with other persons". In a second part the participants were asked how frequent they exposed themselves to art. As an example, "How often do you visit art museums or galleries?".

Emotional Contagion Scale (ECS). The ECS (Doherty, 1997) consists of 15 items (α= .90) in form of statements covering five different emotions (joy, anger, love, fear, sadness) and measures a persons susceptibility to others emotions. Participants were asked to report their tendency to mimic the emotional expression of others on a five-point scale, for example, "If someone I'm talking with begins to cry, I get teary-eyed". The ECS is based on the theory of Hatfield et al. (1994) which postulates that emotional susceptibility is determined by the degree of imitating others emotional expression. The imitated emotions then trigger an afferent feedback which generates a corresponding emotional experience.

Trancranial direct-current stimulation: Parameters

To modulate lDPFC activity in the experiment a tDCS device, manufactured by neuroConn GmbH was utilized. During the active condition, 20 minutes of 2mA direct current was applied to the scalp. Current faded in and out over 20 seconds at the beginning and at the end of the stimulation time. In the sham condition the stimulation lasted 30 seconds to make participants feel the typical itching sensation, then the device stopped stimulating and switched to an impedance control mode until the 20 minutes were reached. A pair of $35cm^2$ sponges, moistened with saline, covered the anodal and cathodal electrode. The anodal electrode was placed over the left DLPFC which corresponds F3 according to the ten-twenty international system for placement of electroencephalogram (EEG) electrodes (see Figure 4). The cathodal electrode was set over the right supraorbital area. To blind also the test leaders, active or sham stimulation was chosen by entering a code, unknown in its meaning.

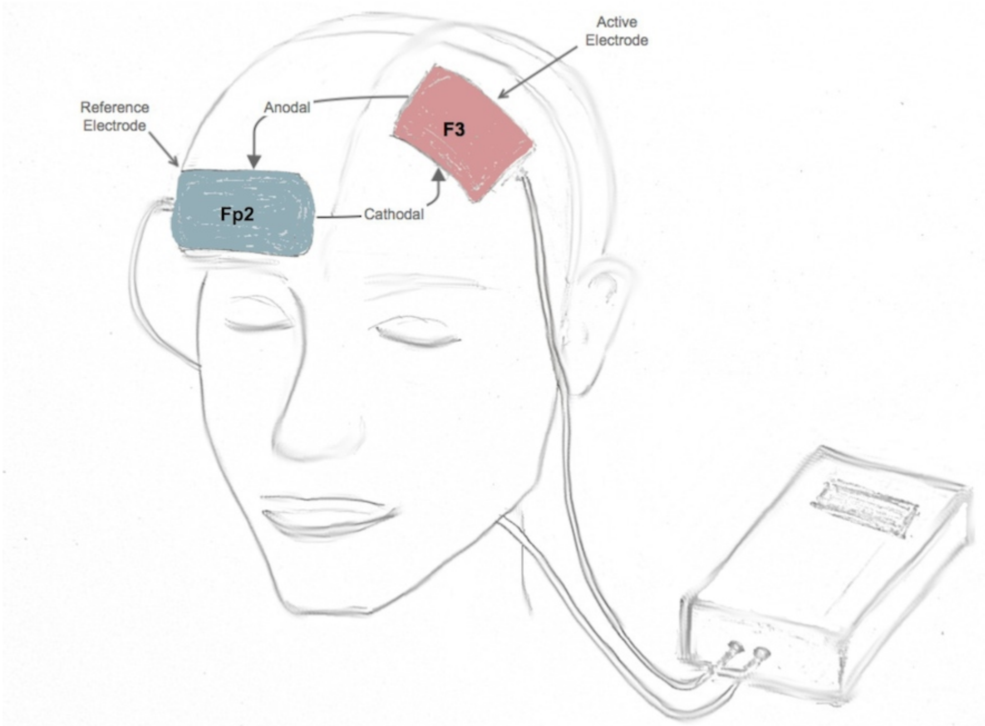


Figure 3: tDCS setup. The active electrode was positioned over the lDLPFC. The reference electrode was placed contralateral over the supraorbital region.

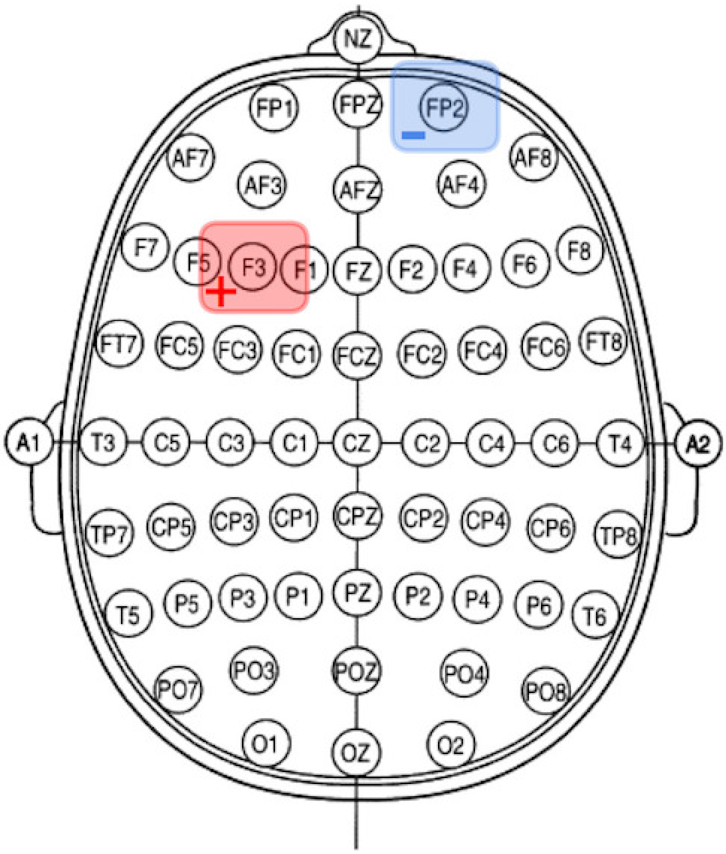


Figure 4: Electrode positioning according to the international 10-20 system. The anode matched F3 (red), the cathode was set up over Fp2 (blue). (Illustration adapted from Nuwer et al., 1998).

Procedure

The experiment was carried out in an artificially illuminated testing room in the Empirical Visual Aesthetics Lab, University of Vienna. In a double-blind within-subjects design, each participant was measured in two sessions, with at least 48 hours of intersession time. Each session began with information about the test procedure and a vision test. Every participant gave written informed consent. After going through the tDCS-checklist they directly started with the first picture rating in the assigned condition (valence or color). The respective set of stimuli (A or B) was presented on a 30"-screen via E-prime 2.0 (see Figure 5). The artworks were shown in randomized order and participants were instructed to respond spontaneous but without a fixed time limit. They indicated their evaluation via a visual analogue scale which showed them a continuum from minus to plus.

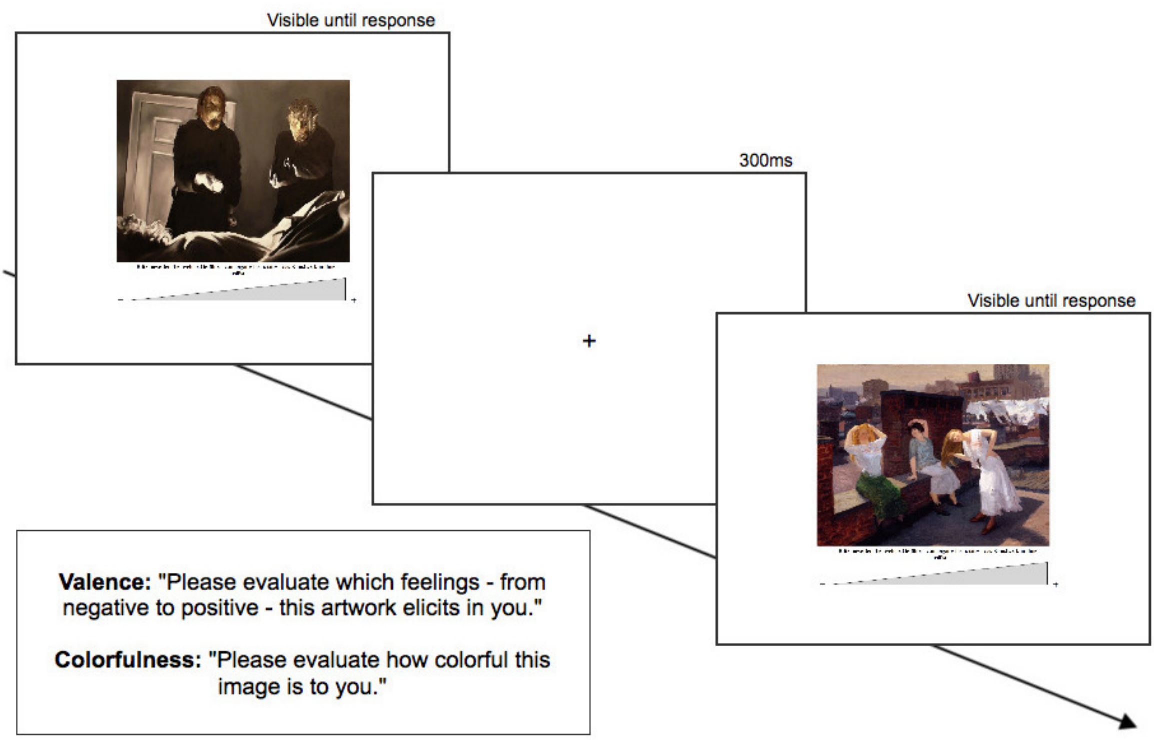


Figure 5: Schematic illustration of the experimental trial.

After the scale input of the participant a fixation cross appeared on the screen for 300ms until the next image showed up. After this part, the electrodes of the tDCS device were placed over the scalp and participants received 20 minutes of real or sham tDCS stimulation according to the randomization process. While the ongoing stimulation, participants watched a silent cartoon. This was followed by the second rating phase of artworks, this time with the other set. At the end of the second session participants filled in the questionnaires ECS and KiF.

Results

Rating Scores

The position of the mouse cursor along the visual analogue scale was converted by the software into percentage rating scores, uncovering the affective or color values given by the participant to the particular stimulus. The comparability between picture set A and B on the basis of the percentage rating scores is shown in Figure 6 . Pearson correlation coefficients of the ratings were calculated for both groups (valance and color) between Set A and B. For the affective evaluation the two sets were found to correlate highly significant which confirms the comparability of the two sets in terms of emotional valence, documented in Table 1. Also the correlational analyses of the color ratings revealed strong positive correlations over all three picture categories.

Table 1: Pearson correlations between the ratings of picture set A and B for each valence category.

(a) Valence group

	Set B		
Set A	Negative	Neutral	Positive
Negative	.98***		
Neutral		.75***	
Positive			.95***

(b) Color group

Set B		
Negative	Neutral	Positive
.95***		
	.95***	
		.94***

$^{***}p < 0.001$

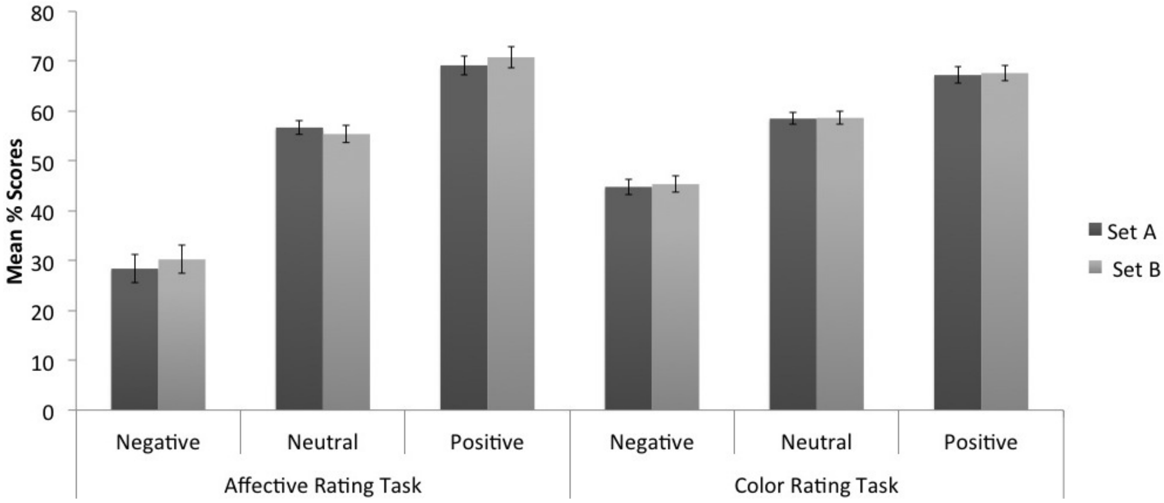


Figure 6: Mean of the percentage rating scores comparing Set A and B for each valence category. Error bars represent ± 1 S.E.

Affective evaluation and influences of the tDCS. For the affective judgments of the experimental group a repeated measures analysis of variance (ANOVA) on the mean percentage rating scores was carried out. Within-subject factors were defined as Picture category (negative, neutral, positive), tDCS type (real or sham) and Time (pre or post). Consistent with the pre-categorization of the three valence clusters a significant main effect of Picture category was found, $\Lambda = .13$, F(2 ,15) $= 50.96$, $p = <.0001$, $n_p^2 = .86$ (more positive ratings for positive images, neutral ratings for neutral images and more negative ratings for negative pictures). No other main effect, nor interaction was significant.

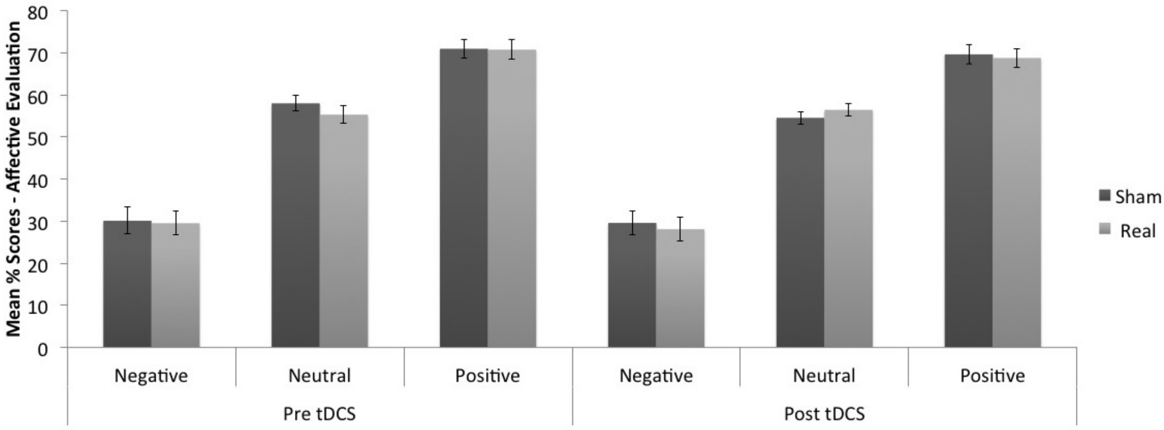


Figure 7: Mean of the percentage rating scores of the affective evaluations in the different experimental conditions. Error bars represent ± 1 S.E.

Additional analyses were performed to see whether a difference could be found by having a distinct look on the pre- and post measurements with Picture category and tDCS type as within subject factors. An ANOVA on the pre-rating data showed that the baseline evaluation (pre- tDCS) was comparable between real and sham stimulation. No other factor as again the main effect of Picture category, $\Lambda = .12$, $F(2\ ,15) = 53.13$, $p = <.0001$, $n_p^2 = .87$ was found to reach significance whereas the separated analysis of the post data showed in addition to the main effect of Picture category a significant interaction by tDCS type, $\Lambda = .58$, $F(2\ ,15) = 5.25$, $p = 0.02$, $n_p^2 = .41$. Post-hoc paired t-tests showed a trend towards more positive emotional response only for the neutral pictures, $t(16) = 2.03$, $p = 0.059$. No differences between sham and real stimulation showed up for the ratings of negative, $t(16) =$ -1.34, $p = 0.27$ and positive images,$t(16) =$ -0.79, $p = 0.44$.

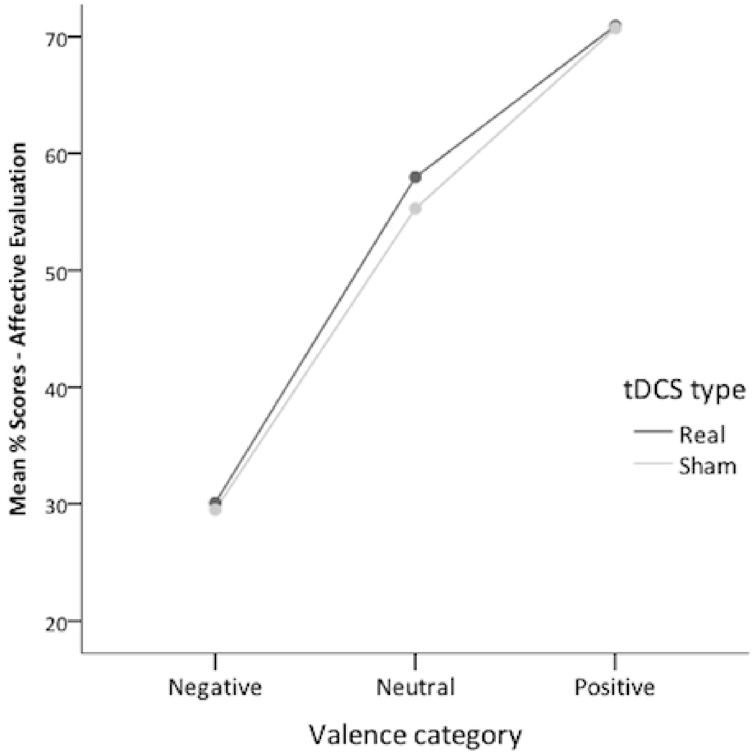


Figure 8: Interaction of Picture category by tDCS type. Neutral pictures were rated more positive after the stimulation of the lDLPFC.

Color evaluation. A repeated measures ANOVA with Picture category (negative, neutral, positive), tDCS type (real or sham) and Time (pre or post) as within subject factors was conducted also for the control group. Interestingly, as depicted in Figure 9, a significant main effect of Picture type was found in the control group as well, $\Lambda = .09$, $F(2\ ,14) = 67.86$, $p = <.0001$, $n_p^2 = .95$. Positive pictures were rated as more colorful than neutral ones, whereas negative images were rated less colorful than the neutral artworks. This indicates that the colorfulness of a stimulus is an important factor generating an emotional response to an image. The more colorfulness was perceived, the more positive feelings were attributed to the stimuli.

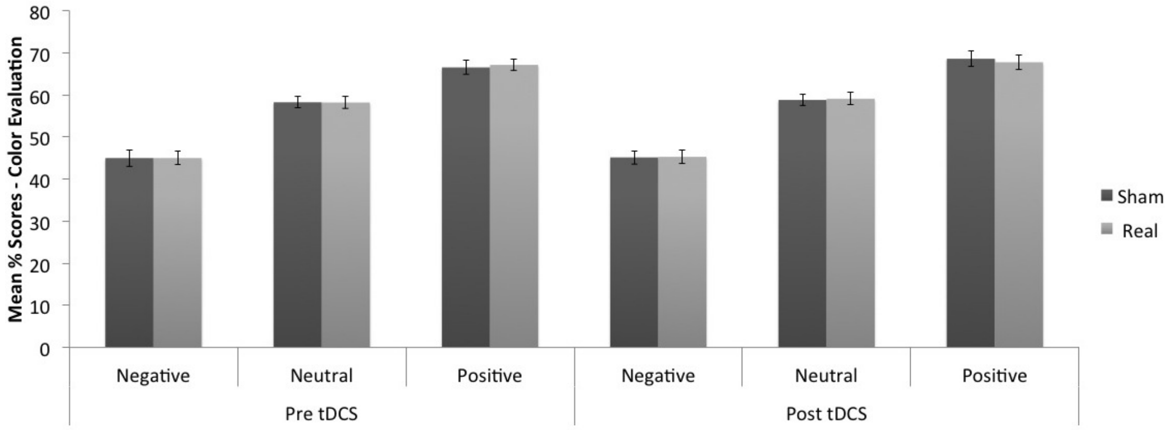
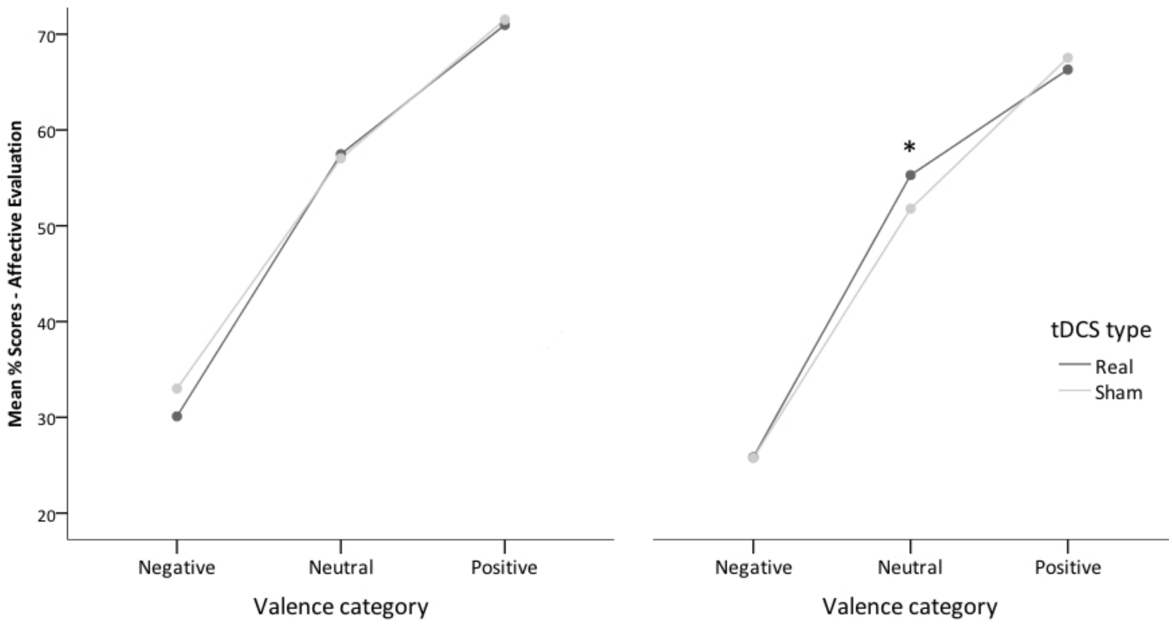


Figure 9: Mean of the percentage rating scores of the color evaluations in the different experimental conditions. Error bars represent ± 1 S.E.

Questionnaires

Art interest. The self reported interest in art of the participants was on average, $M = 56.57$, $SD = 13.16$. Results of the Kolmogorov-Smirnov test indicated that the distribution did not deviate significantly from a normal distribution ($D(33) = 0.07$, $p = 0.2$). An independent samples t-test was carried out to make sure that experimental and control group did not differ concerning their art interest, $t(31) = -2.02$, $p = 0.053$. To see whether the art interest had an influence on the valence rating, results of the art questionnaire were split by median to compare low and high art interest groups directly regarding the rating behavior. Another repeated measures ANOVA was calculated, this time with the between subject factor of art interest. Results showed a significant difference between the two groups ($F(1\ ,15) = 4.91$, $p = .04$). Independent t-tests revealed a significant lower (more negative) rating on neutral pictures for the participants in the lower art interest group, $t(15) = 2.32$, $p = 0.03$, which illustrates that interest and curiosity about the pictures are reflected in the affects participants stated. The same procedure was done for the control group. High versus low interest in art here did not make a difference in perceived colorfulness, $t(14) = 0.82$, $p = 0.42$.

Art interest and affective evaluation. To see whether the earlier reported effect of the tDCS stimulation on the affective rating of neutral pictures in the post session (see Figure 8) gets stronger by excluding the higher interest in art group, an additional t-test was calculated on the post tDCS ratings of the low art interest-experimental group. The effect of the stimulation was still present and now significant, $t(7) = 3.18$, $p = 0.01$. It is unlikely that this points out differences towards the sensitivity to the tDCS stimulation but rather suggests that less interested participants used structures of the lDLPFC to a higher degree which indicates different processing strategies of the stimuli between the two groups. Participants who were highly interested in art showed almost no difference in their rating behavior due to the brain stimulation, as shown in Figure 10.



(a) High interest in art *(b)* Low interest in art

Figure 10: Post tDCS rating comparison high versus low interest in art groups. Affective judgments of the low group get significantly more positive after the lDLPFC stimulation.

Emotional contagion. For each participant a value of their general susceptibility to emotional contagion was obtained by adding the individual points divided by the number of items. The distribution was normal ($D(17) = 0.17$, $p = 0.18$). The experimental group was again split by median into a low and high group of emotional contagion to see whether any differences in rating behavior would appear. The repeated measures ANOVA on the post ratings showed no significant effect of EC-group on the valence rating scores ($F(1\ ,15) = 1.42$, $p = 0.25$), neither did emotional contagion correlate with interest in art ($r =$ -0.1, $p = 0.69$).

Discussion

Overall, our results showed that pictures labeled as neutral were perceived more positive after the stimulation of the lDLPFC compared to sham stimulation. This was not true for positive and negative images. With reference to the post-hoc tests this effect reaches significance by excluding the higher interest in art group. Highly art-interested participants showed almost no alteration concerning their rating behavior due to the brain stimulation (see Figure 10). No influence of the EC values on the ratings was found.

How can it be explained that the involvement of the lDLPFC in the affective judgment towards artworks was not found for positive and negative pictures? To answer this questions it needs to be lined out that the three affective states are defined on a bipolar continuum. By definition negative and positive images have explicit affective content, while in the neutral ones, affective content is null or ambiguous, see Figure 11.

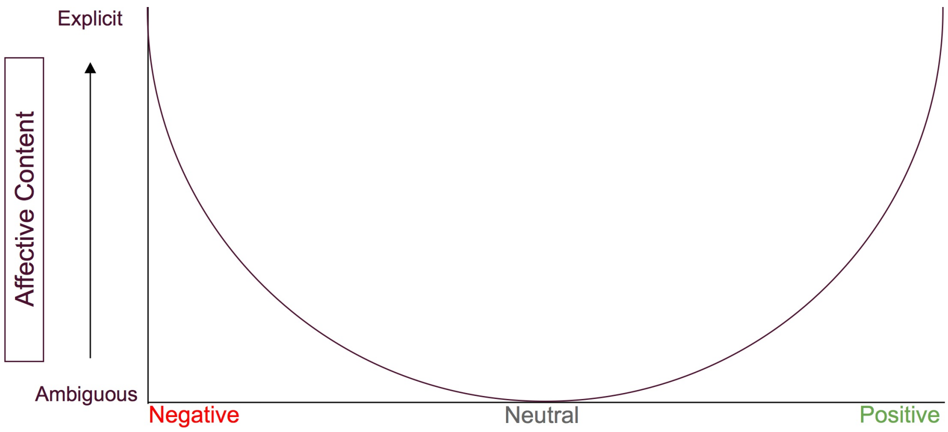


Figure 11: Illustration of content-related explicitness: Differences comparing negative, neutral, and positive stimuli.

Referring to the presented task, to rate a clearly positive or negative picture on its perceived emotional valence evokes different neural processing mechanisms compared to the affective evaluation of a picture with a rather ambivalent content. By classifying images on the basis of their affective valence, the inherent absence of affective content in neutral images might call for a closer evaluation, recognition and association process, executed in the lDLPFC. A tentative explanation could be that the input of emotionally explicit stimuli is clearly pleasant or unfavorable and therefore might get processed faster and without the evaluation processes in the lDLPFC. In other words, the affective response takes precedence then the more cognitive evaluation. In line with this, ambiguous input leaves more space for an evaluation of upcoming affects influencing the resulting judgment compared to emotionally salient stimuli.

Coming back to the model of Leder et al. (2004) the evaluation of an artwork is resulting on one side in an aesthetic emotion and on the other side in an aesthetic judgment. These two outcomes refer to distinct neural processing pathways (see Leder, Markey, & Pelowski, 2015) and match our distinction between neutral and emotionally rich images. The neutral images initiate a process of cognition and perception referring to the aesthetic judgment which takes its way from occipital to frontal regions reaching the lDLPFC for evaluation. The emotionally explicit artworks trigger affective processes who take its course from deeper brain structures through diencephalic regions and finally reach ventral and orbifrontal parts of the brain. These two pathways build an explanation why ratings got only affected by lDLPFC stimulation for neutral artworks.

The assumption of Hatfield et al. (1994), that the personality trait of emotional contagion has an impact on the affective judgment could not be confirmed in our study. Different factors might play a role concerning this outcome: On the one hand, we only measured this trait by a questionnaire, our variable is therefore not an objective value of EC. Applying implicit measures imply always the risk that participants individual estimation does not match the characteristic of the trait of interest. One the other hand our sample size was quite small at least for the division into the subgroups, this aspect must be questioned. In addition it needs to be mentioned that EC as a part of empathy can not necessarily be applied to all of our stimuli. There are not many pictures with concrete scenes of persons to share ones feelings with. Surely emotional contagion also refers also to the general emotional atmosphere and valence of the image, but may be to a lower degree.

Even though in our study only art interest and frequency of engaging with art was surveyed, ratings of the participants highly interested in art got not affected by the stimulation. This confirms that prior knowledge of art is altering the approach of processing art. Differences in activated cognitive schemata play a role here. This is in line with the assumption of Leder et al. (2014) who proposed that art expertise moderates the affective response to an artwork by attentional processes attenuating emotions by focusing and shifting on stylistic features. Thus, high interest leads to a different cognitive processing manner compared to having no conceptions about the artworks, which might lead participants to behave more spontaneous and in guidance of their feelings.

Another point which could play a role concerning these results is the difficulty to separately investigate affective and cognitive processes with regard to their role in the lDLPFC. Research has shown that emotions and cognition should not be seen as opposites. Emotions are not necessarily irrational, neither are cognition independent of emotions (Pouivet, 2000). Our cognitive response interplays with upcoming memories which are bounded to affective parameters. The lDLPFC is part of a neural network that involves cognitive evaluation processes as well as it integrates bottom up processes of the amygdala (Singer & Lamm, 2009). It might play a less relevant role if a stimulus gets clearly classified as positive or negative, but gets involved for a cognitive evaluation, if the input is ambiguous.

Another idea is that the slight but not strong effect of tDCS on affective states speak for only an indirect participation of the lDLPFC. McNamee, Liljeholm, Zika, and O'Doherty (2015) have suggested that its real function is not the deciding part in evaluations but in encoding responses. This option can also be strengthened by the results of an functional magnetic resonance imaging (fMRI) study of Murray and Ranganath (2007). Their results indicate that DLPFC activity predicts the memory of associations. The data suggests that the evaluative function of the lDLPFC builds relations between different inputs - these relations can be seen as a precondition of long term memory formation for associative information. These findings fit our data in terms of that the lDLPFC is presumably recruited for encoding memories of associations in order to execute the task of giving the affective judgment. This memory integration is necessary because as already stated, the emotional value of the neutral stimulus is not clear. However, it has to be emphasized that also the effects in the neutral category are to small to provide a secured interpretation of the data.

An additional factor which could explain the small effect sizes refers to the method of tDCS itself. A recent review of Tremblay et al. (2014) pointed out some substantial shortcomings of this method which led to numerous heterogeneous results and uncertainties. The first problematic point is its polarity. It is not always clear if specific behavior gets enhanced by the inhibition of a specific function (cathodal tDCS) or if the noise reduction in the specific area by anodal tDCS plays the decisive role. Second, when comparing studies, it has to be considered if an online or offline paradigm was used, this might change results in a critical way. And finally inter-subject variations must be taken into consideration. People have different head sizes, fat tissue and so on. This factor has especially impact on small samples and therefore also might have an influence on our data and effect sizes.

After all it is undeniably that establishing a theory of the relationship between neuronal activation patterns and aesthetical appreciation processes is a challenging task. It depends on many different and partly unknown variables. On the other hand neuroscientific techniques have brought the possibilities to study the human brain under certain conditions and neural correlates and networks have already been identified for many constructs. Although the findings of the present study were not very strong, they can contribute to existing theories and future studies who will bring advances to understand the complex network of connectivity patterns in our brain.

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Appendix

List of Figures

List of Tables

Abstract (German)

Die Betrachtung eines Kunstwerks kann viele verschiedene Emotionen hervorrufen. Diese affektiven Parameter repräsentieren einen integralen Bestandteil im Prozess ästhetischer Wahrnehmung. Eine immer wieder auffällige Gehirnregion in der Erforschung zugrundeliegender neuronaler Prozesse ästhetischer Wahrnehmung ist der linke dorsolaterale präfrontale Cortex (lDLPFC). Seine Stimulation führte in der Vergangenheit unter Anderem zu gesteigerten Gefallensurteilen ästhetischer Stimuli. In der vorliegenden Studie wurde unter der Anwendung von transkranieller Galvanisation (tDCS) die Aktivität des lDLPFC moduliert um direkt zu untersuchen, ob der lDLPFC in die affektive Urteilsbildung involviert ist. Der emotionale Inhalt der zu bewertenden Kunstwerke variierte von negativ über neutral bis hin zu positiven Valenzen. In einer Placebo-kontrollierten, doppelblind-Studie wurden 33 Personen getestet. Diese gaben ihre individuellen, durch die Kunstwerke hervorgerufenen Emotionen, jeweils vor und nach der Stimulation auf einer visuellen Analogskala an. Die Ergebnisse zeigen, dass neutrale Bilder nach der wirklichen tDCS positiver wahrgenommen wurden als nach der vorgetäuschten Stimulation. Dieser Effekt konnte für die Bewertung negativer und positiver Bilder nicht gefunden werden, diese veränderte sich nicht durch die tDCS. Da neutrale Bilder sich vor allem hinsichtlich ihrer inhaltlichen Explizität unterscheiden, sprechen die Ergebnisse für eine Involvierung des lDLPFC in der Generierung affektiver Urteile bei Stimuli mit ambivalentem oder affektiv flachen Inhalt. Der lDLPFC als Teil eines neuronalen Netzwerkes, welches sowohl kognitive Evaluationsprozesse ausführt, als auch bottom-up Informationen der Amygdala integriert spielt möglicherweise eine weniger relevante Rolle bei Reizen die eindeutig positiv oder negativ sind, sondern wird erst zur weiteren Evaluation aktiv, wenn die Valenz des Inputs ambigue ist.

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