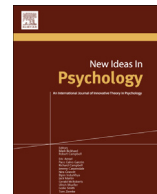




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## Aesthetic shapes our perception of every-day objects: An ERP study

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## 1. Introduction

Taking up a research interest as old as scientific psychology itself (Fechner, 1871; Wundt, 1874), in the 1970s, Berlyne (1971, 1974) developed an extensive framework for explaining the aesthetic value of artwork in psychobiological terms. He took into account—but did not limit his examination to—emotional and perceptual factors, including arousal, reward and aversion, and information and uncertainty of the stimulus. Since this proposal, in recent decades several authors have investigated the perceptive and cognitive basis of the aesthetic experience and have tried to ground their results in general theories of brain and cognitive system function. Overall, the neuroaesthetics literature paints a highly complex picture in which many brain areas associated with perceptual, emotional, and cognitive processing interact to determine the aesthetic experience. This paper aims to explore the temporal dynamics of aesthetic experience resulting from the interplay of emotional value with perceptual and cognitive factors (perception, attention, decision making, and action selection).

## 1.1. The neural basis of the aesthetic experience

Neuroimaging studies converge on the notion that aesthetic appreciation is related to activity in three functionally distinct sets of neural regions (Cela-Conde, Agnati, Huston, Mora, & Nadal, 2011; Nadal, 2013). The aesthetic experience is related to an increase in the activity of cortical regions involved in the allocation of attentional resources and evaluative judgments, including the prefrontal cortex (dorsolateral and ventrolateral), temporal pole, posterior cingulate cortex, and precuneus (Cela-Conde et al., 2013; Cupchik, Vartanian, Crawley, & Mikulis, 2009; Jacobsen, Schubotz, Höfel, & Cramon, 2006; Lengger, Fischmeister, Leder, & Bauer, 2007). Aesthetic appreciation also involves an attention-related enhancement activity in visuo-perceptual areas (bilateral fusiform gyri, angular gyrus, and the superior parietal cortex) (Cela-Conde et al., 2009; Cupchik, Vartanian, Crawley, & Mikulis, 2009; Ishizu & Zeki, 2013; Lacey et al., 2011; Lengger et al., 2007). Finally, aesthetic experiences activate the neural reward network including the anterior cingulate, orbitofrontal, insular, and ventromedial prefrontal cortex and amygdala, the thalamus, and the hippocampus (Bar & Neta, 2007; Brown, Martinez, & Parsons, 2004; Cupchik et al., 2009; Di Dio, Canessa, Cappa, & Rizzolatti, 2011; Harvey, Kirk, Denfield, & Montague, 2010; Ishizu & Zeki, 2013; Kawabata & Zeki, 2004; Kirk, Skov, Christensen, & Nygaard, 2009; Kirk, Skov, Hulme, Christensen, & Zeki, 2009; Lacey et al., 2011; Vartanian & Skov, 2014).

As pertains the temporal course of the aesthetic experience, the few electrophysiological studies that have been undertaken (magnetoencephalographic: Cela-Conde et al., 2004; Munar et al., 2012; event-related potential [ERP]: Höfel & Jacobsen, 2007; Jacobsen & Höfel, 2003; Righi, Orlando, & Marzi, 2014) showed two stages in the processing of attractiveness. First, an initial general appraisal of the aesthetic value of a visual stimulus (perceived as “beautiful” or “not beautiful”) is performed around 300–400 ms in the dorso-lateral prefrontal cortex. Later in the time course (from 400 to 1000 ms), the aesthetic judgment is indexed by an enhanced parietal positivity for stimuli that are perceived as beautiful compared to stimuli that are perceived as ugly (de Tommaso et al., 2008a; Höfel & Jacobsen, 2007; Jacobsen & Höfel, 2003).

All these observations support the idea that the brain areas mediating aesthetic responses to artwork overlap those that mediate emotions and the appraisal of objects of evolutionary

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importance (such as the desirability of food items or the attractiveness of potential mates) (Rolls, 2004, 2013b, 2015). Therefore, the essence of aesthetic processing can be equated to emotional and object appraisal processes that span pleasure to repulsion (Brown, Gao, Tisdelle, Eickhoff, & Liotti, 2011; Rolls, 2013a, 2013b, 2015; Xenakis & Arnellos, 2015). Both emotion and aesthetic experience attribute valence to the stimuli driving and supporting actions or meaning in interaction with the environment (Xenakis & Arnellos, 2014; 2015).

### 1.2. Theories of the aesthetic experience

Since Berlyne (1971, 1974), several authors have proposed their own theories about the aesthetic experience (Brattico, Bogert, & Jacobsen, 2013; Leder, Belke, Oeberst, & Augustin, 2004; Ramachandran & Rogers-Ramachandran, 2006; Zeki & Nash, 1999) which are currently under neuroscientific, psychological, and philosophical debate. For example, Zeki proposed that constancy and abstraction are fundamental laws of the visual brain that may explain aesthetic experiences and art production. In a similar vein, Ramachandran provided an extended framework that aimed at understanding visual art, aesthetics, and design. Here, we will briefly focus on the seminal ideas of Berlyne and a more recent information-processing stage model (Leder et al., 2004). Neither perspective limits its focus to a specific function; rather, they both stress the interaction between a variety of different factors (perceptual, emotional, and cognitive).

Berlyne's proposal played a pivotal role in introducing aesthetics into the mainstream of experimental psychology, but today its value is mainly historical, given that progress in neuroscience has disproved several of his framework's predictions. Berlyne's theory is grounded in the idea that arousal is a determinant of aesthetic preference. In particular, aesthetic value is related to arousal-producing items and this preference changes as a function of such attributes and as a function of the arousal level of the observer. For the purposes of this paper, we will stress that Berlyne's work emphasized the roles of different components of the aesthetic experience as well as the interactions between those components. Moreover, he suggested that the interplay between emotional arousal and the aesthetic subjective value of artwork is mediated by the neural circuits for reward and aversion.

More recently, Leder et al. (2004) developed an information processing stage model to explain the aesthetic experience. The model assumes the continuous development of changes in the affective state determined by both bottom-up and top-down cognitive processes. More specifically, the model includes five processing stages: perception, implicit memory integration, explicit classification, cognitive mastering and evaluation, together with a continuously ongoing emotional evaluation. Among the main contributions of the model we can cite are its modular nature and the possibility of taking an integrative view of the cognitive and affective processes involved in aesthetic judgment. This suggests how single-factor explanations (based, for example, on complexity, arousal, or prototypicality) (Berlyne, 1971; Eysenck, 1941; Martindale, Moore, & West, 1988) are unable to account for empirical findings. Crucially, the Leder et al. (2004) model explains the aesthetic experience in terms of an interaction between perceptual, cognitive, and affective processes.

According to the original model and subsequent empirical and theoretical findings (Leder & Nadal, 2014; Tinio & Leder, 2009), those different processes modulate and constrain each other. Reviewing ten years worth of contributions related to the original model (Leder et al., 2004), Leder and Nadal (2014) emphasize that the dynamic interaction between cognition and emotion is still open for debate. Indeed, the original work proposed a close

interplay between those two processes even though little evidence was available at the time.

Recent studies (Cupchik et al., 2009; Wagner, Menninghaus, Hanich, & Jacobsen, 2014) suggest how this interaction can be more deeply compared to the model's assumptions. For example, art experts exhibit a peculiar pattern of attenuated emotional response when observing artwork (Leder, Gerger, Brieber, & Schwarz, 2014). Moreover, there is evidence that it is possible to appreciate disgusting objects when one believes that they are works of art, even when subjectively experiencing disgust (Wagner et al., 2014).

Leder and Nadal (2014) conclude that more detailed neurobiological explanations are needed to understand neuroaesthetics. Following Leder and Nadal (2014), Singer (2013) advocate going beyond the classical view of information processing in the brain (i.e., isolating single brain regions and aesthetic states related to particular processes) that has dominated neuroaesthetics in the last decade. Indeed, they encourage more studies aimed at determining the dynamics of the neural activities underpinning the cognitive and affective processes of aesthetic experience and their interplay. This paper is aimed to respond to this call.

### 1.3. Experimental hypothesis

To address the research gap identified by Leder and Nadal (2014), some recent studies have investigated the neural dynamics underlining the aesthetic experience. By using the ERP technique, Righi et al. (2014) evaluated the relationship between affordance perception and aesthetic value for objects. Indeed, when compared to artwork, everyday objects represent an ideal category of stimuli to investigate how perception, cognition (for example, with regard to affordance, in other words the "action possibilities" suggested by an object), and aesthetic judgments interact. Results suggested that the processing linked to sensorial gating and object characteristic extraction (indexed by N1) was sensible to action affordance as well as aesthetic.

Moving forward in time course analysis, N3, P3 and the late positive potential (LPP) showed an augmented response for objects with high affordance and aesthetic levels. The authors concluded that the highly attractive objects that are perceived as highly functional engage a privileged neural activation. This supports the hypothesis that affordance perception coupled with the subjective experience of attractiveness<sup>1</sup> may facilitate interaction with everyday objects, thereby enhancing the detection of potential actions through privileged neural and cognitive processing. This agrees with the Brattico et al. (2013) model which suggests that different brain structures collaborate with the full subjective liking/disliking experiences by inducing emotions that modulate the temporal dimension of the cognitive processes.

Taking this into account, and considering that emotions and cognition strongly interact in the brain and jointly contribute to adaptive behavior (Damasio & Carvalho, 2013; Okon-Singer, Hender, Pessoa, & Shackman, 2015; Pessoa, 2008), it may also be that the aesthetic experience, especially in everyday life, may modulate cognitive processes similarly to emotions. In general terms, if the aesthetic experience can (at least partially) be equated to emotion, it could be assumed that one aspect of the functional value of the aesthetic experience is to be attracted to the object experienced as

<sup>1</sup> In line with Righi et al. (2014) and other neuroimaging and behavioral studies (Cunningham, 1986; Cunningham, Roberts, Barbee, Druen, & Wu, 1995; De La Rosa & Suárez, 2015; O'Doherty et al., 2003), in this paper we will avoid considering beauty as a philosophical category and instead evaluate the attractiveness of a stimulus according to its quality of being pleasing or appealing to the senses.

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