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„Can we experience aesthetic pleasure through our imagination – An investigation of aesthetic experiences and pleasure through visual mental imagery"

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Marius Schaffer, BSc

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Mitbetreut von / Co-Supervisor:	Mag. Dr. Julia Sophia Crone

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1. Introduction

Experiencing pleasure seems to be essential for healthy psychological functioning and wellbeing (Becker et al., 2019; Berridge & Kringelbach, 2015; Liang et al., 2020; Wacker et al., 2009). Pleasure can be achieved through a variety of different external stimuli, on one hand through biologically driven stimuli such as food or sex and on the other hand through abstract forms of pleasure like seeing artworks, listening to music or reading poetry (Belfi et al., 2019; Berridge & Kringelbach, 2015; Georgiadis & Kringelbach, 2012; Kühn & Gallinat, 2012; Salimpoor et al., 2011; Small, 2001; Wassiliwizky et al., 2017). However, the neural mechanisms underlying these different phenomena seem to overlap to a surprisingly strong degree (Belfi et al., 2019; Berridge & Kringelbach, 2015; Georgiadis & Kringelbach, 2012; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; Salimpoor et al., 2011; Small, 2001).

Multiple different art domains have been shown to elicit aesthetic experiences and to be associated with strong pleasure responses in individuals (Belfi et al., 2019; Blood et al., 1999; Salimpoor et al., 2011; Vessel et al., 2012; Wassiliwizky et al., 2017).

Visual perception and visual mental imagery are similar in many ways (Dijkstra et al., 2017; Ganis et al., 2004; Henderson et al., 2018; Lee et al., 2012; Lewis et al., 2013; Pearson, 2019; Pearson et al., 2008, 2011, 2015; Tartaglia et al., 2009). Visually imagining an object can act in similar ways as physical perception does (Henderson et al., 2018; Lewis et al., 2013; Pearson, 2019; Pearson et al., 2008, 2011, 2015; Tartaglia et al., 2009). To give examples, imagining oriented lines has similar effects on subsequent perception as perceiving such lines and mental imagery can induce visual perceptual learning in a similar way as physical stimulation (Pearson et al., 2008; Tartaglia et al., 2009). Furthermore, mental imagery has been shown to have a strong influence on emotions, including influence on pleasure (Arntz et al., 2007; Blackwell et al., 2015; Costa et al., 2010; Fors et al., 2002; Hallford et al., 2020; Henderson et al., 2018; Holmes et al., 2008; Holmes & Mathews, 2005; Jacob et al., 2011; Kilts et al., 2001, 2004; Linke & Wessa, 2017; McTeague et al., 2009; Renner et al., 2019; Williams et al., 2013). In accordance with the evidence stated above, research suggests substantial neural overlap between visual mental imagery and visual perception processes (Dijkstra et al., 2017; Ganis et al., 2004; Lee et al., 2012; Pearson, 2019; Pearson et al., 2015). The vividness of the mental imagery (i.e., how vivid a certain mental image is experienced) has been shown to influence participants´ neural responses, to have an effect on subsequent perception and evidence suggests it may be associated with emotional changes in individuals (Blackwell et al., 2013, 2015; Cui et al., 2007; Dijkstra et al., 2017; Fulford et al., 2018; Lee et al., 2012; Pearson et al., 2011; Renner et al., 2019).

However, sufficient research regarding the phenomenon of visual mental imagery is still lacking, especially in the context of aesthetic experiences and pleasure. There are still many outstanding questions that need to be answered. Is the feeling of aesthetic pleasure dependent on external stimuli or can it also be achieved through mental imagery? Do we need visual input from the outside world for aesthetic experiences or are they also possible through our mere imagination? What are neural similarities and differences between visual mental imagery and visual perception? And what role does the vividness of the mental imagery play? To address this questions, this master´s thesis combines the emerging interdisciplinary field of neuroaesthetics whose main focus lies in the understanding of human aesthetic experiences with mental imagery research (Belfi et al., 2019; Chatterjee & Vartanian, 2014; Pearce et al., 2016; Vessel et al., 2013).

Mental imagery plays an important role in psychopathology (American Psychiatric Association, 2013; Blackwell, 2019; Holmes & Mathews, 2010; Sack, 2005; Weßlau & Steil, 2014). Besides advancing the scientific evaluation of the connection between visual mental imagery and aesthetic experiences, with a special focus on aesthetic pleasure, this work could help contribute to the development of new methods for increasing the wellbeing of individuals and could inspire new treatment methods for psychiatric patients.

1.1 Pleasure/Reward

The terms “hedonic” and “reward” are used frequently in this thesis. To counteract any potential misunderstandings, I will shortly explain the terms in this section. The word “hedonic” originally comes from the Greek word “*hedone*” for pleasure, which is derived from the word “*hedys*” meaning “sweet" or “pleasant” (Encyclopedia Brittanica, n. d). Today the word hedonic refers to pleasure derived through all kinds of different stimuli (Berridge & Kringelbach, 2015; Kringelbach & Berridge, 2009). The word “reward” is used to describe events which produce a pleasant or positive affective experience and events that increase the probability or rate of a certain behavior when the event is induced by the behavior (White, 2011). On a neuronal level, reward mechanism include processes related to learning, approach behavior, decisions and emotions (Schultz, 2015).

The capacity for experiencing hedonic responses is essential for the healthy psychological functioning and wellbeing of an individual and numerous affective disorders can either induce a pathological absence of pleasure (e.g., clinical anhedonia) or can result in excessive displeasure (e.g., pain, disgust, anxiety) (Becker et al., 2019; Berridge & Kringelbach, 2015; Liang et al., 2020; Wacker et al., 2009). Besides abnormal pleasure responses, abnormal reward-related processes in general seem to play a crucial role in many psychiatric and neurological disorders (Zald & Treadway, 2017).

It is important to distinguish different mechanisms related to pleasure and reward. “Liking” processes are characterized as pleasure reactions to hedonic impact (Berridge & Kringelbach, 2015; Berridge & Robinson, 2003; Kringelbach & Berridge, 2009).
Pleasure derived through “liking” can be translated into motivational processes by activation of a different mechanism termed “wanting” or “incentive salience”. The role of “wanting” processes is to make stimuli attractive to the individual and they seem to be strongly related to the mesolimbic dopamine system (Berridge & Kringelbach, 2015; Berridge & Robinson, 2003, 2016; Koranyi et al., 2020; Kringelbach & Berridge, 2009). Each of these mechanisms further consist of conscious as well as non-conscious elements and has discriminable neural correlates (Berridge & Kringelbach, 2015; Berridge & Robinson, 2003, 2016; Kringelbach & Berridge, 2009). “Wanting” typically dominates the initial appetitive phase while “liking” dominates the subsequent consummatory phase (Berridge & Kringelbach, 2015; Berridge & Robinson, 2003; Kringelbach & Berridge, 2009). To give an example of the difference between “wanting” and “liking”, an individual can intensely “want” a certain reward without particularly “liking” it, a phenomenon sometimes present in drug addiction (Berridge & Robinson, 2016; Koranyi et al., 2020; Kringelbach & Berridge, 2009).

Pleasure or “liking” can be experienced through a variety of different stimuli (Belfi et al., 2019; Berridge & Kringelbach, 2015; Georgiadis & Kringelbach, 2012; Kühn & Gallinat, 2012; Salimpoor et al., 2011; Small, 2001; Wassiliwizky et al., 2017). These pleasures may subjectively feel very distinct from one another. However, even though the pleasure of eating delicious food can subjectively feel very different than sexual pleasure, pleasure derived from chemical substances or the pleasure of listening to one´s favorite music, the neural mechanisms underlying these phenomena seem to overlap to a surprisingly strong degree (Belfi et al., 2019; Berridge & Kringelbach, 2015; Georgiadis & Kringelbach, 2012; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; Salimpoor et al., 2011; Small, 2001).

More specifically, research suggests that brain mechanisms involved in fundamental, more biologically driven pleasures such as sexual pleasure or pleasure through food, overlap with brain mechanisms used for higher-order, more abstract pleasures such as artistic or musical pleasure (Belfi et al., 2019; Berridge & Kringelbach, 2015; Georgiadis & Kringelbach, 2012; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; Salimpoor et al., 2011; Small, 2001). It seems that these different kinds of pleasure all draw upon the same neurobiological roots which originally evolved for sensory pleasures and involve the same hedonic brain systems (Berridge & Kringelbach, 2015; Kringelbach & Berridge, 2009).

Brain areas linked to pleasure responses have been identified in several subcortical basal ganglia regions like the ventral pallidum and striatum including the nucleus accumbens (NAc) and caudate nucleus as well as in cortical regions of the orbitofrontal cortex (OFC), cingulate cortex, medial prefrontal cortex and insular cortex (Belfi et al., 2019; Berridge & Kringelbach, 2015; Blood & Zatorre, 2001; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; Sabatinelli et al., 2007; Salimpoor et al., 2011; Small, 2001).

A brain region that seems to be particularly strongly linked to pleasure and reward-related processes is the NAc (Belfi et al., 2019; Berridge & Kringelbach, 2015; Blood & Zatorre, 2001; Costa et al., 2010; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; Sabatinelli et al., 2007; Salimpoor et al., 2011). Research has found neural activity in the NAc to be associated with multiple kinds of pleasure including musical pleasure, art pleasure as well as pleasure through erotic stimuli (Belfi et al., 2019; Blood & Zatorre, 2001; Sabatinelli et al., 2007; Salimpoor et al., 2011). Furthermore, a meta-analysis considering 40 different neuroscientific studies has linked the ventral striatum including the NAc to subjective pleasure (Kühn & Gallinat, 2012). Another striatum area, the caudate nucleus, has been shown to be associated with pleasure when perceiving artworks and music (Belfi et al., 2019; Salimpoor et al., 2011; Vessel et al., 2012).

A multitude of research links the cortex region of the OFC to pleasure processes (Berridge & Kringelbach, 2015; Blood et al., 1999; Blood & Zatorre, 2001; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; Small, 2001). Neural activity in this region has been shown to correlate strongly with pleasure derived through a variety of different stimuli including food and music (Blood et al., 1999; Blood & Zatorre, 2001; Kringelbach, 2003; Kühn & Gallinat, 2012; Small, 2001). The comprehensive meta-analysis by Kühn and Gallinat (2012) further confirms the important role of the OFC regarding pleasure.

1.2 Neuroaesthetics/Aesthetic Experiences

Neuroaesthetics is an interdisciplinary scientific research field concerned with understanding the neural processes and biological base underlying aesthetic experiences (Belfi et al., 2019; Chatterjee & Vartanian, 2014; Pearce et al., 2016; Pelowski et al., 2017; Vessel et al., 2013). The general goal is to understand the neural substrates of human aesthetic appreciation (Pearce et al., 2016). It is a merge of the disciplines of empirical aesthetics and cognitive and affective neuroscience and includes interactions with art-objects like paintings as well as interactions with non-art objects like faces, natural objects and scenes and also include interactions with non-visual stimuli like music or poetry (Chatterjee & Vartanian, 2014; Pearce et al., 2016; Salimpoor et al., 2011; Vessel et al., 2013; Wassiliwizky et al., 2017).

Aesthetic experiences seem to arise from a complex interplay of factors related to the individual, the object and the context (Jacobsen, 2006; Leder et al., 2004; Leder & Nadal, 2014; Pearce et al., 2016; Pelowski et al., 2017). According to Chatterjee and Vartanian (2014) aesthetic experiences emerge from the interaction between neural systems involved in sensory-motor, emotion-valuation and meaning-knowledge processing and thus include a wide range of cognitive processes and regions in the brain. They occur when we appraise objects and include emotions, valuations, actions evoked by these objects and the neural processes underlying their production and interpretation (Chatterjee & Vartanian, 2014). A variety of different emotional experiences such as “aesthetic chills”, “feeling touched”, “feeling absorbed” and “feeling moved” and positive feelings like enjoyment, awe, beauty, pleasure or appreciation as well as negative feelings like sadness, disgust and fear seem to be associated with aesthetic experiences (Belfi et al., 2019; Hanich et al., 2014; Ishizu & Zeki, 2011; Salimpoor et al., 2009, 2011; Silvia & Nusbaum, 2011; Vessel et al., 2012; Wassiliwizky et al., 2017). Multiple different domains including artworks, faces, music and poetry have been shown to be linked to them and their associated emotional experiences and feelings (Belfi et al., 2019; Blood & Zatorre, 2001; Kawabata & Zeki, 2004; Leder et al., 2016; O’Doherty et al., 2003; Salimpoor et al., 2011; Vessel et al., 2012; Wassiliwizky et al., 2017). However, it is important to note here that the researched concepts of aesthetic experiences are not clearly defined. For example, studies that use faces as stimuli tend to equate beauty with facial attractiveness; while subjects rate how attractive a face is, the findings are discussed within the framework of beauty (Hönekopp, 2006; Leder et al., 2016; O’Doherty et al., 2003). The question remains how well these various stimuli used in the literature are comparable to each other.

Neural correlates of aesthetic experiences seem to be strongly overlapping with and related to brain mechanism and areas linked to pleasure and reward as discussed above (Belfi et al., 2019; Blood et al., 1999; Blood & Zatorre, 2001; Ishizu & Zeki, 2011; Kawabata & Zeki, 2004; Kim et al., 2007; Kühn & Gallinat, 2012; O'Doherty et al., 2003; Salimpoor et al., 2011; Vessel et al., 2012; Wassiliwizky et al., 2017). Research by Belfi et al. (2019) suggests aesthetic appreciation and pleasure derived through artworks to be associated with basal ganglia regions, including the NAc and caudate nucleus. Vessel et al. (2012) found increased activity in the striatum in a region straddling the dorsal and ventral striatum for highly moving and pleasing artworks. Evidence from a functional magnetic resonance imaging (fMRI) study by Salimpoor et al. (2011) suggests the caudate nucleus to be involved in the anticipation and the NAc to be involved during the experience of peak emotional responses or "chills" to music, an indicator of intense subjective pleasure (Salimpoor et al., 2009). Activation in the NAc and caudate nucleus corresponded to increases in self-reported pleasure and NAc activity peaked during chill epochs (Salimpoor et al., 2011). Chills typically involve a "shivers down the spine" feeling and show a clear and discrete pattern of arousal of the autonomic nervous system (Blood & Zatorre, 2001; Salimpoor et al., 2009, 2011; Wassiliwizky et al., 2017). Interestingly, research on chills related to poetry has found activation of the NAc during the "pre-chill" period and activation of the caudate nucleus during the experience (Wassiliwizky et al., 2017). However, NAc and caudate nucleus both seem to be important for chills, although their exact roles are not yet clear.

The OFC also seems to be a promising brain area regarding this subject. A study by Ishizu and Zeki (2011) reported neural activity in the medial orbitofrontal cortex (mOFC) to be associated with aesthetic experiences of visual beauty and musical beauty, with the strength of neural activation in the mOFC even being proportional to the strength of the reported intensity of the experience for musical beauty. Kawabata and Zeki (2004) could show an increase in neural activity in the mOFC for beautiful artworks compared to neutral or ugly artworks (especially for portraits). Research suggests activity in the mOFC to be connected to facial attractiveness and face preferences (Kim et al., 2007; O'Doherty et al., 2003). Moreover, Blood and Zatorre (2001) and Blood et al. (1999) found evidence for the OFC to be linked to musical pleasure.

1.3 Visual Mental Imagery

Imagination is a powerful ability of humans. With imagination we can travel through space and time testing and simulating different (hypothetical) objects, worlds, plans and experiences and can even change our emotions and mood through it (Arntz et al., 2007; Blackwell et al., 2013, 2015; Blackwell & Holmes, 2010; Fors et al., 2002; Hallford et al., 2020; Holmes et al., 2008; Holmes & Mathews, 2005; Jacob et al., 2011; Kilts et al., 2001, 2004; Linke & Wessa, 2017; McTeague et al., 2009; Moulton & Kosslyn, 2009; Pearson, 2019; Taylor et al., 1998; Williams et al., 2013). Although mental imagination can involve all sensual modalities, visual imagery (along with auditory imagery) tends to be experienced as particularly vivid by most individuals (Schifferstein, 2009). Therefore, research on mental imagery has predominantly focused on visual mental imagery, analog to the main focus on visual perception in perception research (Pearson, 2019).

When we think of an external object like our favorite food, most of us will have a conscious visual experience of that object, although possibly a vague or weak visual experience. That is visual mental imagery. So apart from visual experiences being caused by external events like seeing a particular object in the outside world (visual perception), visual experiences can also be caused by internal events like visual mental imagery (Dijkstra et al., 2017; Horikawa & Kamitani, 2017; Kosslyn, 2005; Naselaris et al., 2015; Pearson, 2019). To give an appropriate explanation of the two terms, "visual perception occurs while a stimulus is being viewed, and includes functions such as visual recognition (i.e., registering that a stimulus is familiar) and identification (i.e., recalling the name, context, or other information associated with the object)" (Kosslyn, 2005, S. 334). In visual perception "bottom-up" mechanisms, driven by the input of the eyes, as well as "top-down" mechanisms, utilizing already stored information in the brain like memories, are used (Dijkstra et al., 2017; Kosslyn, 2005). Visual mental imagery on the other hand is "a set of representations that gives rise to the experience of viewing a stimulus in the absence of appropriate sensory input" (Kosslyn, 2005, S. 334). In visual mental imagery top-down memory information underlies the internal events that produce the visual mental experience without appropriate sensory input from the eyes (Kosslyn, 2005).

Research has shown a stronger increase in top-down coupling during visual mental imagery compared to visual perception (Dijkstra et al., 2017). During visual perception, bottom-up influences from the retina ultimately cause activations of visual representations in the visual cortex, whereas during visual mental imagery such exogenous factors are absent (Dijkstra et al., 2017). However, top-down mechanisms play an important role for visual perception as well and overall research suggests an substantial neural overlap between visual mental imagery and visual perception processes (Dijkstra et al., 2017; Ganis et al., 2004; Lee et al., 2012; Muckli, 2010; Muckli & Petro, 2013; Pearson, 2019; Pearson et al., 2015).

Visual mental imagery is not always a voluntary experience. For example, individuals with synesthesia and individuals during various visual illusions can experience vivid colors without corresponding color information stimulating the retina (see Pearson & Westbrook, 2015). Other forms of involuntary and often disruptive visual mental imagery exists across a wide range of mental and neurological disorders such as post-traumatic stress disorder (PTSD), depression, anxiety disorders and schizophrenia (American Psychiatric Association, 2013; Holmes & Mathews, 2010; Weßlau & Steil, 2014).

But how do we generate visual mental representations and images in our brain? Since the days of the imagery debate (starting in the 1970s and continuing in the 2000s) in which researchers were still trying to figure out the nature of visual mental representations, more specifically, whether these representations were stored in a depictive format (i.e., like in a picture in a two-dimensional space) or rather in a more symbolic propositional format, research has come a long way (Kosslyn, 2005; Pearson, 2019; Pearson & Kosslyn, 2015; Z. Pylyshyn, 2003; Z. W. Pylyshyn, 1973). In a paper by Pearson and Kosslyn (2015) the authors declared an end to the decade lasting imagery debate with the evidence strongly pointing to a depictive format of mental representations. Nowadays with the help of multivariate decoding algorithms and fMRI, the content of visual mental imagery can even be decoded from early visual areas providing researchers with information about the content participants were thinking about during scanning sessions (Albers et al., 2013; Horikawa & Kamitani, 2017; Naselaris et al., 2015). Interestingly, machine learning decoders trained on presented images can also be used to predict content of imagined objects indicating substantial similarities between visual perception and visual mental imagery (Horikawa & Kamitani, 2017).

To explain (voluntary) visual mental imagery, a promising model of “reverse visual hierarchy” has been proposed (Dentico et al., 2014; Pearson, 2019). The name gives credit to the fact that when imagining an object, the process seems to work in the reverse order of the involved steps compared to visual perception of that object. According to the model, the action to create a mental image first starts in the frontal cortex followed by retrieving memory information from more posterior regions such as the medial temporal areas in the next step. At last, sensory and spatial representations of the imagined content are formed. If movement and spatial information are also needed for the imagery content, other brain areas might also be involved. Thus, stored memories seem to play a crucial role for visual imagery.

Evidence suggests that visual mental imagery may act in similar ways as physical perception does (Henderson et al., 2018; Lewis et al., 2013; Pearson, 2019; Pearson et al., 2008, 2011, 2015; Tartaglia et al., 2009). For example, imagining oriented lines can have similar effects on subsequent perception as perceiving such lines and mental imagery can induce visual perceptual learning similarly to physical stimulation (Pearson et al., 2008; Tartaglia et al., 2009). Associative learning also seems to be possible through visual mental imagery. Research by Lewis et al. (2013) showed that after the conditioning of voluntary visual mental images with emotion-evoking stimuli, perceptual stimuli of the same content as the mental images also produced the associated emotional responses. Interestingly, participants pupil diameter changes in response to imagined dark or bright objects and scenarios are also similar to pupil diameter changes the perception of such stimuli evokes (Laeng & Sulutvedt, 2014). Furthermore, Bray et al. (2010) showed that imagining rewarding experiences engages similar neural correlates as the experience of real rewards.

Mental imagery also seems to have a strong influence on our emotions (Arntz et al., 2007; Blackwell et al., 2015; Costa et al., 2010; Fors et al., 2002; Hallford et al., 2020; Henderson et al., 2018; Holmes et al., 2008; Holmes & Mathews, 2005; Jacob et al., 2011; Kilts et al., 2001, 2004; Linke & Wessa, 2017; McTeague et al., 2009; Renner et al., 2019; Williams et al., 2013). Holmes and Mathews (2005) and Holmes et al. (2008) could show that mental imagery can elicit positive as well as negative emotional responses in participants. In a study by Costa et al. (2010) participants reported feelings of pleasure and arousal caused by mental imagery of certain events and situations. Evidence from Hallford et al. (2020) found that mental imagery of positive future and past events increased anticipated and anticipatory pleasure for future events in healthy individuals and Renner et al. (2019) reported similar findings showing that mental imagery of future activities increased anticipated pleasure and reward in participants. Kilts et al. (2001) and Kilts et al. (2004)

found that cocaine-related mental imagery was associated with increases of drug craving in cocaine-dependent participants. Interestingly, drug-related mental imagery even influenced participants heart rate (Kilts et al., 2001). Moreover, McTeague et al. (2009) showed that mental imagery of fearful events can elicit patters of physiological reactivity in individuals similar to real events and according to Fors et al. (2002) pleasant mental imagery might be effective in the reduction of pain. Furthermore, mental imagery of pleasant and unpleasant stimuli can elicit pupil diameters changes in participants which further indicates mental imagery to be able to influence nervous system activation. All these findings taken together suggest substantial similarities between mental imagery and perception.

In terms of neurobiological findings on mental imagery related to pleasure and reward, the striatum areas of the NAc and caudate nucleus and the cortex area of the mOFC were shown to be promising areas regarding the subject (Bray et al., 2010; Costa et al., 2010; D'Argembeau et al., 2008). Research by Costa et al. (2010) found that the NAc was activated through mental imagery of pleasant events with NAc activity corresponding to the ratings of the experienced pleasure through mental imagery. The caudate nucleus has been shown to be engaged during mental imagery of positive future events (D'Argembeau et al., 2008). Furthermore, research by Bray et al. (2010) indicates the mOFC to be involved in the mental imagination of rewards in a similar way as during the exposure to real rewards.

1.3.1 Vividness of Visual Mental Imagery

Research has shown that the vividness of visual mental imagery (i.e., how vivid/detailed a certain mental image is experienced) influences participants´ brain activity during visual mental imagery (Cui et al., 2007; Dijkstra et al., 2017; Fulford et al., 2018; Lee et al., 2012). The degree of vividness of mental imagery an individual generates also seems to influence emotions (Blackwell et al., 2013, 2015; Renner et al., 2019). For example, higher vividness of mental imagery has been shown to be associated with higher optimism in individuals (Blackwell et al., 2013). According to research by Blackwell et al. (2015), increased vividness during an imagery cognitive behavior therapy intervention (imagery CBT) is related to a greater reduction of symptoms of depression. Increased vividness of mental imagery of positive future events was also shown to be associated with an increase in behavioral activation in depressed participants and higher anticipation of the reward of engaging in the imagined events (Renner et al., 2017, 2019). Moreover, vividness of mental imagery seems to affect participants´ subsequent perception. Pearson et al. (2011) found that higher ratings of vividness predicted the strength of participants perceptual bias following visual mental imagery.

How vivid mental images can be experienced is not equal for everybody. Strong differences in vividness of mental imagery between individuals exist (Cui et al., 2007; Fulford et al., 2018; Marks, 1973; McKelvie, 1994). Interestingly, research suggest that participants with smaller primary visual cortices tend to experience more vivid visual mental imagery and strength of vividness seems to be positively correlated with prefrontal cortex volume (Bergmann et al., 2016).

The research stated above implicates that the degree of the vividness of mental imagery a participant generates influences participants´ neural activity and frequency and strength of aesthetic experiences. A higher degree of vividness may be associated with more and/or stronger aesthetic experiences and corresponding brain activity. Vice versa, a lower degree of vividness may be associated with little/no aesthetic experiences and corresponding brain activity. Vividness of mental imagery may act as a highly confounding variable and thus it is of utter importance for the study paradigm to work to control for it.

1.3.2 Application of Visual Mental Imagery

Mental imagery plays an important role in psychopathology (American Psychiatric Association, 2013; Blackwell, 2019; Holmes & Mathews, 2010; Sack, 2005; Weßlau & Steil, 2014). Intrusive emotional mental imagery is a harmful symptom across a wide range of mental and neurological disorders including PTSD, anxiety disorders, depression and schizophrenia (American Psychiatric Association, 2013; Holmes & Mathews, 2010; Weßlau & Steil, 2014). To give examples, PTSD is characterized by involuntary intrusive imagery such as flashbacks or unwanted upsetting memories and in schizophrenia mental imagery such as hallucinations play a significant role (American Psychiatric Association, 2013; Sack, 2005).

Interestingly, mental imagery can also serve as effective treatment for many mental and neurological disorders (Arntz et al., 2007; Blackwell et al., 2015; Blackwell & Holmes, 2010; Jacob et al., 2011; Linke & Wessa, 2017; Renner et al., 2017, 2019; Williams et al., 2013). It is already applied in the clinical context and multiple therapeutic methods involving mental imagery show promising results (Arntz et al., 2007; Blackwell et al., 2015; Blackwell & Holmes, 2010; Jacob et al., 2011; Linke & Wessa, 2017; Renner et al., 2017, 2019; Williams et al., 2013). For example, in cognitive behavioral therapy (CBT) an approach called “imaginal exposure” is successfully used to treat PTSD (Arntz et al., 2007). In “imaginal exposure” patients mentally recall details of a traumatic event in order to reduce symptoms of fear and avoidance (Arntz et al., 2007). Moreover, evidence suggests that CBT interventions aimed at promoting positive imagery may be effective in the treatment of depression and may help improve anhedonia, a reduced ability to experience pleasure and/or diminished interest in pleasurable activities, in depressed patients (American Psychiatric Association, 2013; Blackwell et al., 2015; Blackwell & Holmes, 2010; Williams et al., 2013). Linke and Wessa (2017) revealed that mental imagery of positive thoughts, feelings and sensations increases wanting and reward sensitivity towards these stimuli and could reduce depressive symptoms. Furthermore, Jacob et al. (2011) found that mental imagery was effective in increasing positive affect in individuals with borderline personality disorder and Hallford et al. (2020) showed that mental imagery of positive future and past events influenced anticipated and anticipatory pleasure for future events in healthy participants. Boosting positive imagery could be useful to promote optimism, pleasure and wellbeing in individuals (Blackwell et al., 2013, 2015; Hallford et al., 2020; Linke & Wessa, 2017).

1.4 Synopsis

To sum up, research has shown that visual perception and visual mental imagery are similar in many ways, that a substantial neural overlap between visual mental imagery and visual perception processes exist and that mental imagery can have a strong influence on emotions (i.e., it can elicit positive as well as negative emotions) (Costa et al., 2010; Dijkstra et al., 2017; Ganis et al., 2004; Holmes et al., 2008; Holmes & Mathews, 2005; Lewis et al., 2013; Pearson, 2019; Pearson et al., 2015; Tartaglia et al., 2009). Furthermore, evidence suggests that the vividness of visual mental imagery could be an important factor in the matter (Blackwell et al., 2013, 2015; Cui et al., 2007; Dijkstra et al., 2017; Fulford et al., 2018; Lee et al., 2012; Pearson et al., 2011; Renner et al., 2019). However, sufficient research regarding the phenomenon is still lacking, especially not in the context of aesthetic experiences and aesthetic pleasure.

It should be noted here that the present study underlaying this master´s thesis is based on a prior master´s thesis investigating visual mental imagery and aesthetic beauty experiences via fNIRS (functional near-infrared spectroscopy) (Schneider, 2020). However, because of methodological issues of the prior study as well as the limitation of fNIRS to cortical areas, the original idea was adapted. In this work fMRI was chosen instead of fNIRS and the main focus lies on aesthetic experiences in general and not merely experiences of beauty.

This master´s thesis aims to combine the emerging interdisciplinary field of neuroaesthetics, whose main focus lies in the understanding of human aesthetic experiences, with mental imagery research to help answer the questions listed below (Belfi et al., 2019; Chatterjee & Vartanian, 2014; Pearce et al., 2016; Vessel et al., 2013). Is the feeling of aesthetic pleasure dependent on external stimuli or can it be achieved through visual mental imagery as well? Do we need visual input from the outside world for aesthetic experiences or are there also possible through our mere imagination? What are neural similarities and differences between visual mental imagery and visual perception? And what role does the vividness of the mental imagery play in the matter?

Besides advancing the scientific evaluation of visual mental imagery, aesthetic experiences and hedonic responses, this work could contribute to the development of methods for increasing the wellbeing of healthy individuals as well as inspire new treatment methods for psychiatric patients.

In short, this master´s thesis aims to investigate whether aesthetic experiences are possible through visual mental imagery with a special focus on aesthetic pleasure. It does so by evaluating behavioral measures as well as brain activation during visual mental imagery and visual perception with fMRI. It is important to mention that this master´s thesis is a pilot study as a proof of concept of the research method. It is meant to serve as a guide for developing subsequent studies. For this pilot study, data of five subjects were analyzed. Therefore, results should be viewed with caution.

2. Hypotheses

2.1 Regions of interest (ROIs)

For this thesis the orbitofrontal cortex (OFC), the nucleus accumbens (NAc) as well as the caudate nucleus were selected as regions of interest since these areas have been shown to be highly involved in the processing of pleasure, reward and aesthetic experiences during perception as well as imagery (Belfi et al., 2019; Berridge & Kringelbach, 2015; Blood et al., 1999; Blood & Zatorre, 2001; Bray et al., 2010; Costa et al., 2010; D'Argembeau et al., 2008;

Delgado et al., 2000, 2003; Ishizu & Zeki, 2011; Kawabata & Zeki, 2004; Kim et al., 2007; Kringelbach & Berridge, 2009; Kühn & Gallinat, 2012; O'Doherty et al., 2003; Sabatinelli et al., 2007; Salimpoor et al., 2011; Small, 2001; Vessel et al., 2012; Wassiliwizky et al., 2017)..

2.2 Main hypotheses

Considerable evidence indicates that visually imagining an object acts in similar ways as physical perception of that object does (Henderson et al., 2018; Lewis et al., 2013; Pearson, 2019; Pearson et al., 2008, 2011, 2015; Tartaglia et al., 2009). As discussed above, research suggests substantial neural overlap between visual mental imagery and visual perception processes (Dijkstra et al., 2017; Ganis et al., 2004; Lee et al., 2012; Pearson, 2019; Pearson et al., 2015). Furthermore, mental imagery has been shown to have a strong influence on a wide range of emotions, including influences on pleasure (Arntz et al., 2007; Blackwell et al., 2015; Costa et al., 2010; Fors et al., 2002; Hallford et al., 2020; Henderson et al., 2018; Holmes et al., 2008; Holmes & Mathews, 2005; Jacob et al., 2011; Kilts et al., 2001, 2004; Linke & Wessa, 2017; McTeague et al., 2009; Renner et al., 2019; Williams et al., 2013). Neurobiological findings on visual mental imagery related to pleasure and reward suggest NAc, caudate nucleus and OFC to be promising areas (Bray et al., 2010; Costa et al., 2010; D'Argembeau et al., 2008). Costa et al. (2010) found NAc activation through mental imagery of pleasant events with NAc activity corresponding to the ratings of the experienced pleasure through mental imagery. Research by D'Argembeau et al. (2008) suggests that the caudate nucleus is engaged during mental imagery of positive future events and Bray et al. (2010) indicates that the mOFC is involved in the mental imagination of rewards in a similar way as during the exposure to real rewards.

However, evidence demonstrating that visual mental imagery and visual perception can induce similar aesthetic experiences is still lacking, and it is not yet scientifically clear whether such experiences are possible through mere visual mental imagery or not. Therefore, the following hypothesis was investigated:

1. I expect to find that the pleasure ratings of aesthetic stimuli between visual perception and visual mental imagery are equivalent.

In addition, it has not been shown whether brain processes underlying an aesthetic experience are similar between visual perception and visual mental imagery. Thus, the following hypothesis was investigated:

2. I expect a significant increase in neural activation for visual perception as well as visual mental imagery of more pleasurable rated aesthetic stimuli compared to less pleasurable rated aesthetic stimuli in the ROIs.

Vividness of mental imagery further has been shown to have an effect on subsequent perception and to influence participants´ neural responses (Cui et al., 2007; Dijkstra et al., 2017; Fulford et al., 2018; Lee et al., 2012; Pearson et al., 2011). Furthermore, evidence indicates that higher vividness may be associated with stronger emotional changes through mental imagery in individuals (Blackwell et al., 2013; Blackwell & Holmes, 2010; Renner et al., 2019). However, sufficient research for clarifying the role that vividness plays for visual mental imagery is missing. Therefore, the following hypothesis was investigated:

3. I expect the ratings of pleasure for visual mental imagery to be positively correlated with the ratings of vividness of visual mental imagery within participants.

3. Methods

The here presented study consists of two main parts: the selection of stimuli (see Section 3.1 and 3.2) and the main fMRI study (see Section 3.3). To be able to draw comparisons and to diversify the investigation, two different categories of stimuli were used: faces and artworks. Using more than two different categories would have been superior, however, due to limited resources the focus was exclusively on artworks and faces in this study. Artworks were chosen because there is abundant research linking them to aesthetic experiences (Belfi et al., 2019; Kawabata & Zeki, 2004; Leder et al., 2016; Vessel et al., 2012). For information about the artwork stimuli selection see Section 3.2. Faces were chosen because they are crucial visual stimuli for humans providing a multitude of different types of social information and intuitively draw visual attention towards them in a stronger way compared to other stimuli, even from the earliest childhood on (Bindemann et al., 2005; Jack & Schyns, 2015; Langton et al., 2008; Little et al., 2011; Simion & Giorgio, 2015). Considering this important and unique role of face stimuli in human visual perception, they could possibly also be easier to visually imagine compared to other stimuli.

3.1 Prestudy for Face Stimuli Selection

For selection of the face stimuli for the fMRI study, a prestudy was conducted. This was done to ensure that a sufficient number of high-rated stimuli are used in the fMRI experiment, which was crucial for the study paradigm to work. The prestudy consisted of questions about demographic information, an adapted and translated version of the Aesthetic Experiences Scale (AES), the face rating task, and an additional assessment comprised of two questions asking what the concept of "aesthetically moving" signifies to a participant and whether participants felt inhibited to negatively rate faces (Silvia & Nusbaum, 2011). Several variables were assessed within the scope of the prestudy (for more information about the assessed variables see Section 3.1.4), however, the focus of this master´s thesis regarding the prestudy only lies in the selection of appropriate face stimuli for the fMRI experiment. Therefore, only results important for the face stimuli selection are reported in this thesis. The face rating task of the prestudy was designed to be most similar to the procedures employed in the studies of Schäfer (2015) and Spee et al. (2021), from which the artwork stimuli used in the fMRI experiment were adopted. The variables and instructions of Schäfer (2015) and Spee et al. (2021) were also adopted to ensure comparability.

3.1.1 Study Design and Procedure

A within-subject study design was used. The prestudy was implemented in "labvanced", a tool for creating questionnaires and experiments and conducted online via PC (Finger et al., 2017). Tablet and cellphone execution were prevented. The whole procedure took approximately 45 minutes. All Participants were informed about the procedure, risks, intention, data recording, data protection and benefits and costs of taking part in the study and gave informed consent. Participants could decline or discontinue the study at any time without specification and without disadvantages. Participants were encouraged to answer in a "brutally honest" way and not take social norms into account in order to reduce participants social inhibition to negatively rate faces. Participants were first asked about demographic information, followed by the Aesthetic Experiences Scale and the face rating task. At the beginning of the face rating task, six example faces were presented. Afterwards, the 50 face stimuli were shown to participants (56 minus the six example stimuli). Participants answered six questions about each face stimulus on a continuous rating scale ranging from 1 to 100 (1: not at all, 100: extremely) by controlling a slider with their computer mouse. Between trials, a fixation cross was shown for 2 seconds to separate the face stimuli. After completion of 50% of the face rating task, the calculation task was presented and after completion of 66,6% of the face rating task, the distraction task was presented. Afterwards, the two questions of the additional assessment were asked (the exact questions can be found in the appendix).

3.1.2 Participants

A sample size estimation in G*Power was calculated simultaneously to conducting the prestudy (Faul et al., 2007). The effect size used for calculating the sample size estimation was based on the values of the beauty ratings (see explanation in Section 4.1.2) of the first 10 participants and was calculated so that the preselected high-rated faces would significantly differ from a mean of 50 for the variable "beauty" (see section below) (one sample case; one-tailed test; used scale in prestudy: 1-100). The following parameters were used for the sample size estimation: An effect size of ≈ 1.017 (Cohen´s d), an α-error of .05, a power of 0.8. The estimated sample size was 8.

Participants were recruited over the LABS-System, an online recruitment platform of the University of Vienna. Since the LABS-System mostly consists of psychology students who are mandatory members because of curricular activities, most participants of the prestudy for face stimuli selection were psychology students. Participants received 4 credits (1 credit = 15 minutes) for participation. Participants were sent a link and the experiment was conducted online via PC. Inclusion criteria for participants was an age of at least 18 years and the ability to speak German either as native language or with excellent German skills. Participants´ data was anonymized. Only the principal investigator and staff had access to the data. Five participants were excluded. Three because of their declaration to feel socially inhibited to negatively rate faces. One participant was excluded for conspicuous rating behavior (consecutive ratings of 1) and one participant was excluded for being underage. 16 participants were evaluated in the prestudy for face stimuli selection (for more information on the sample see Section 4.1.1).

3.1.3 Stimuli

The “Chicago Face Database” (Ma et al., 2015), the “Face Research Lab London Set” (DeBruine & Jones, 2017) and a face database originally used by Schacht et al. (2008) were used as foundation for the face stimuli selection. Three different databases were combined because there were not enough high-rated faces in each individual database alone. This procedure is generally not recommended because it could create unnecessary confounding variables. However, for this study, in which maximizing participants likelihood of experiencing strong aesthetic emotions is crucial and conditions are compared within-subject, the benefits outweigh possible confounds.

The face stimuli were selected based on a mixture of ratings of four researchers and ratings of the stimuli gathered by the authors of the databases (DeBruine & Jones, 2017; Ma et al., 2015; Schacht et al., 2008). Preselection of the stimuli was necessary due to limited length of time for the prestudy. It was not possible to randomly select faces because this could have led to not having enough high and neutral-rated faces in the sample for the paradigm to be successfully tested. After the preselection, 56 faces (11 high-rated female, 11 high-rated male, 11 neutral-rated female, 11 neutral-rated male, 6 low-rated female, 6 low-rated male) were chosen as stimuli for the prestudy. The low-rated faces were only included to counteract a potential downward bias in the prestudy ratings resulting from the presence of only high and neutral-rated faces. Since the face stimuli came from three different databases, some adjustments had to be made to standardize the stimuli. These adjustments were mainly red and yellow color tone corrections, image size changes and standardization of image backgrounds to grey.

3.1.4 Behavioral Assessment and Tasks

Demographic information. Age, gender identity, sexual attraction, country of origin and participants´ level of German was assessed prior to the start of the prestudy.

Aesthetic Experiences Scale (AES). An adapted and translated version of the Aesthetic Experiences Scale by Silvia and Nusbaum (2011) was used to evaluate participants´ frequency of experiencing aesthetic experiences. The Aesthetic Experiences Scale has been shown to have high reliability (Harrison & Clark, 2016; Nusbaum & Silvia, 2011; Silvia & Nusbaum, 2011). It consists of 10 items (along with two questions assessing the art domain that elicits the strongest response in a participants and the frequency of exposure to that domain) and is rated on a 7-point Likert scale (e.g., „Wie oft fühlen Sie einen Schauer über Ihren Rücken laufen?“. Engl. = “How often do you feel chills down your spine?”). The whole questionnaire can be found in the appendix. Unfortunately, there was no German version available. Thus, three native German speakers translated the English AES scale to German, followed by three native English speakers translating the German version back to English. The different versions were then compared, and the most analogous translations were chosen. For analysis of the instrument, a sum score was used. A higher score signifies a higher frequency of experiencing aesthetic experiences and a lower score signifies a lower frequency of experiencing aesthetic experiences.

Face Rating Task. The following six variables were assessed during the face rating task: “aesthetically moving”, “arousal”, “beauty”, “interest”, “liking” and “valence”. These questions were adopted from the VAPS database (Schäfer, 2015; Spee et al., 2021). The exact questions assessing these variables as well as the way the faces and scales were presented to participants can be found in the appendix (see Face Rating Task and Figure 8). For every participant six faces (out of the 56 face stimuli) were randomly chosen and used to explain the task (two high-rated, two neutral-rated and two low-rated faces). The example stimuli were excluded from the ratings. A calculation task, in which subjects had to solve an easy math problem (8 + 16), was used to verify that participants paid attention and to relieve participants attention by providing a short task variation from the otherwise monotonous face ratings. The calculation task was presented after conduction of 50% of the face rating task. Additionally, a distraction task was used to evaluate participants attentional status while conducting the face rating. In the distraction task, participants were asked to move the slider all the way to the left, simultaneously an example picture was shown to mask the task. The distraction task was presented after conduction of 66.6% of the face rating trials.

Additional Assessment. At the end of the prestudy two additional questions were asked. The first question assessed what “aesthetically moving” signifies to a participant via an open-ended text field in order to examine whether participants understood the concept behind it (“Was bedeutet für Sie ästhetisch bewegend?”. Engl.= “What does aesthetically moving signify to you?”). The second question asked whether participants felt inhibited to negatively rate faces via a yes-no question ("Fühlten Sie sich gehemmt, Gesichter, die Sie als hässlich empfanden, dementsprechend negativ zu bewerten?". Engl.= "Did you feel inhibited to rate faces that you perceived as ugly in a negatively way?").

3.1.5 Data Analyses

The analysis for the prestudy was done in R version 4.0.4 on Mac (R Core Team, 2020). Effect sizes for the sample size estimation were calculated with the package "effsize" (Torchiano, 2020). Additionally, the following packages were used: data.table (Dowle & Srinivasan, 2021), dplyr (Wickham et al., 2021), ggplot2 (Wickham, 2016), plyr (Wickham, 2011), rcpp, (Eddelbuettel & François, 2011), tidyverse (Wickham et al., 2019).

3.2 Artwork Stimuli Selection

For the fMRI study two sets of stimuli were used: artworks and faces (for information about the prestudy for face stimuli selection see Section 3.1.4). Artworks were chosen as stimuli because there is abundant research linking them to aesthetic experiences (Belfi et al., 2019; Kawabata & Zeki, 2004; Leder et al., 2016; Vessel et al., 2012). Data for the artwork stimuli selection was used from the study of Schäfer (2015) which established the "Viennese Art Picture System" database (VAPS), an extensive database containing 1000 artworks of different styles and genres and featuring ratings of a variety of different variables (Schäfer, 2015; Spee et al., 2021). The data of 78 participants was evaluated for the artwork stimuli selection (for more information on the sample see Section 4.2).

The analysis for the artwork stimuli selection was done in R version 4.0.4 on Mac (R Core Team, 2020). The following packages were used: data.table (Dowle & Srinivasan, 2021), dplyr (Wickham et al., 2021), ggplot2 (Wickham, 2016), haven (Wickham & Miller, 2021), readr (Wickham et al., 2022), readxl (Wickham & Bryan, 2019), tidyverse (Wickham et al., 2019).

3.3 fMRI Study

3.3.1 Study Design, Participants and Procedure

Participants were recruited via posters at various locations near the University of Vienna, Austria. The posters included a short introduction describing the aim of the fMRI study, and information about duration, location, and financial reward. Furthermore, it included a checklist for potential participants to pre-evaluate their fMRI suitability. Participants had to be at least 18 years old, right-handed, currently not pregnant, not have any non-removeable metal parts in their bodies (e.g., piercings, fixed braces) and not suffer from claustrophobia. Application was arranged via an email address provided on the flyers.

Prescreening of Participants. Since the study paradigm depended on participants to be able to experience strong emotional and/or physiological responses to aesthetic stimuli and to be able to vividly visually imagine certain stimuli, a prescreening was conducted in order to select suitable participants for the fMRI study. The prescreening consisted of questions assessing demographic information and fMRI suitability, an adapted and translated version of the Aesthetic Experiences Scale (AES and an adapted and shortened German version of the Vividness of Visual Imagery Questionnaire (VVIQ) (Marks, 1973; Schneider, 2020). The questionnaire was implemented in “labvanced”, an online tool for experiment and questionnaire creation (Finger et al., 2017).

To pass the prescreening, participants had to generally be suitable for fMRI testing (no metal parts in body, not pregnant, no claustrophobia, etc..), be right-handed, at least 18 years old and not have uncorrected severely impaired vision. Participants further had to have a sum score of 35 or higher in the AES (maximum possible score: 70) and a sum score of at least 25 in the VVIQ (maximum possible score: 40). These thresholds were chosen to ensure that participants at least possessed a neutral ability in visual mental imagery and frequency of aesthetic experiences, which was defined as half of the maximum possible scores in the used instruments. The whole procedure for the prescreening took participants approximately 10 minutes. Participants were first asked demographic questions, followed by questions about their fMRI suitability, the AES and the VVIQ.

fMRI Procedure. After participants passed the prescreening, they were scheduled for the fMRI study. For this pilot study, five participants were scanned (for more information on the sample see Section 4.3.1). The study was conducted at the Neuroimaging Center of the University of Vienna. The design for the fMRI task included two within-participants factors which were the type of stimulus (face or artwork) and condition (perception or visual mental imagery). Participants first had to sign a declaration of consent and were given an MRI safety screening questionnaire and a sheet regarding their monetary compensation. They then received instructions for the fMRI experiment on a computer. In the instructions, participants were informed about the procedure of the experiment and were given an explanation about the mental imagery task and the four questions (pleasure, beauty, aesthetically moving, vividness of visual mental imagery) along with the rating scales. This was done to ensure that participants truly understood the concepts they were rating. The exact way the four questions and the mental imagery task were described can be seen in the appendix. The instructions were implemented in "labvanced" (Finger et al., 2017).

Participants were then asked several questions about the instructions to ensure their correct understanding of the matter. Afterwards participant underwent a personal MRI safety check and were placed in the MRI. Participants then completed a short test run followed by the fMRI experiment. The fMRI experiment was split into four separate parts to give participants time to recover their concentration and to minimize the risk of rerunning an hour scanning in case of any interruption. Each part took around 13-14 minutes to complete and consisted of 10 trials. In each trial a different artwork or face image was presented, the order in which the images were presented was randomized over all experiment parts. Breaks between each scan were used to communicate with participants and discuss potential questions. The breaks lasted between several seconds and a few minutes during which participants remained in the MRI-scanner. After completion of the four functional MRI parts, a structural scan was conducted.

3.3.2 Stimuli

Artworks and faces were used as stimuli. The first category of stimuli consisted of 20 artworks taken from the "Viennese Art Picture System" database (VAPS), an extensive database containing 1000 artworks of different styles and genres and featuring ratings of a variety of different variables (Schäfer, 2015; Spee et al., 2021). Example stimuli can be found in the appendix. To maximize participants´ likelihood of experiencing strong aesthetic responses and/or aesthetic chills through a stimulus, artworks were chosen after the criterium of a general high mean rating and many outliers on the higher end of the scale (outlier greater than 90 on a 101 scale) in the variable "beauty" (for more information on the artwork selection see Section 4.2)

The face stimuli for the fMRI-experiment consisted of 20 colored photographs of male and female faces and were selected within the scope of the prestudy for face stimuli selection. Example stimuli can be found in the appendix. The face stimuli were originally taken from the “Chicago Face Database”, “Face Research Lab London Set” and the face database used by Schacht et al. (2008) (DeBruine & Jones, 2017; Ma et al., 2015). Because the faces originally came from three different databases, some adjustments were made to standardize them. These adjustments mainly consisted of red and yellow color tone corrections, image size changes and standardization of background colors. Similar to the artwork stimuli selection, the face stimuli were selected with the intent of maximizing participants´ likelihood of experiencing strong aesthetic responses and/or aesthetic chills through a stimulus and were chosen after the criterium of a general high mean rating and many outliers on the higher end of the scale (outlier greater than 89 on a 100 scale) in the variable “beauty”.

3.3.3 Behavioral Assessment and Tasks

Demographic Information. Age, gender identity, sexual attraction, county of origin as well participants level of German was assessed. The same questions as in the prestudy for face stimuli selection were used. The exact questions can be found in the appendix.

fMRI Suitability. Participants´ fMRI suitability was evaluated with several questions assessing potential safety risks and exclusion criteria. The exact questions can be found in the appendix.

Aesthetic Experiences Scale (AES). For a discussion of the AES, see Section 3.1.4. Small modifications in comparison with the AES used for the prestudy for face stimuli selection were made. The question “Bitte wählen Sie die Kunstdomäne aus, die bei Ihnen die stärksten Emotionen bzw. das stärkste ästhetische Empfinden auslöst“. (Engl.= "Please select the art domain that elicits the strongest emotions or aesthetic experiences in you“) was adapted to “Bitte wählen Sie die Kunstdomäne aus, die bei Ihnen am häufigsten starke Emotionen bzw. ästhetisches Empfinden auslöst“ (Engl.= “Please select the art domain that most often elicits strong emotions or aesthetic experiences in you”). This was done because the frequency of experiencing strong emotions and aesthetic experiences in participants was deemed as more important than the strength of such experiences for the fMRI experiment. Furthermore, an additional question assessing the frequency of the selected art domain eliciting strong emotions and/or aesthetic experiences was added ("Wie häufig löst die von Ihnen angegebenen Kunstdomäne in etwa starke Emotionen bzw. ein starkes ästhetisches Empfinden aus?". Engl.= "How often does the art domain you selected elicit strong emotions and/or aesthetic experiences in you").

Vividness of Visual Imagery Questionnaire (VVIQ). A translated, revised and shortened version of the Vividness of Visual Imagery Questionnaire (VVIQ) was used for assessing participants´ ability for visual mental imagery (Marks, 1973; Schneider, 2020). The original VVIQ and several revised versions have been used in a multitude of studies, have been demonstrated to possess high reliability and construct validity and have been shown to be corresponding to more objective measures of vividness of mental imagery like the binocular rivalry technique (Campos, 2011; Campos et al., 2002; Campos & Pérez-Fabello, 2009; Fulford et al., 2018; Marks, 1973; Pearson et al., 2011; Rossi, 1977).

The VVIQ used for the prescreening consisted of 8 items in 2 groups of 4 items and was rated on a 5-point Likert scale (e.g., „Schließen Sie die Augen. Denken Sie an eine mit Ihnen verwandte oder befreundete Person, die Sie häufig sehen (aber die im Moment nicht bei Ihnen ist), und betrachten Sie sorgfältig das Bild, das Sie vor Ihrem geistigen Auge sehen.". Engl. = "Close your eyes. Think of some relative or friend whom you frequently see (but who is not with you at present) and consider carefully the picture that comes before your mind´s eye."). The whole questionnaire can be found in the appendix. For analysis of the instrument, a sum score was used. A higher score signifies a stronger vividness of visual mental imagery; a lower score signifies a weaker vividness of visual mental imagery.

fMRI Paradigm. Participants first saw a fixation cross for a randomized period of time between three and five seconds, followed by the presentation of an image (artwork or face) for 15 seconds. A duration of 15 seconds for the visual perception task (as well as the visual mental imagery task) was chosen because results from Belfi et al., (2019 suggests that the NAc and caudate nucleus only correspond to aesthetic appreciation during longer trial durations (5 and 15 seconds) but not for shorter time duration (1 second). After stimuli presentation, participants rated three questions assessing the variables "beauty" ("Wie schön fanden Sie das Image?". Engl.= "How beautiful was the image"), "aesthetically moving" ("Wie ästhethisch bewegend fanden Sie das Image?". Engl.= "How aesthetically moving was the image“) and “pleasure” (“Wie viel Vergnügen bereitete Ihnen das Image?”. Engl.= “How pleasurable was the image”) a 7-point Likert scale. Each question was presented for six seconds. Participants who answered faster had to wait for the remaining seconds. The order in which the questions were presented was randomized across trials. Then a text cue was presented for five seconds instructing participants to close their eyes (“Vorstellen, Augen schließen”. Engl.= ”Imagine, close your eyes”) followed by a blackscreen for 15 seconds in which participants visually imagined the prior seen image. Afterwards participants were asked about the vividness of their visual mental imagery (“Wie anschaulich war ihre Vorstellung?”. Engl.= “How vivid was your mental imagery) followed by the three questions assessing “beauty”, “aesthetically moving” and “pleasure” again. The exact questions and the associated labels can be found in the appendix. The paradigm was divided into four sessions of 13-14 minutes length. The fMRI paradigm can be seen in Figure 1. It is important to note that in the scope of the fMRI study multiple variables were assessed (beauty, aesthetically moving, pleasure and vividness of visual mental imagery). However, in this master´s thesis only pleasure and vividness are investigated.

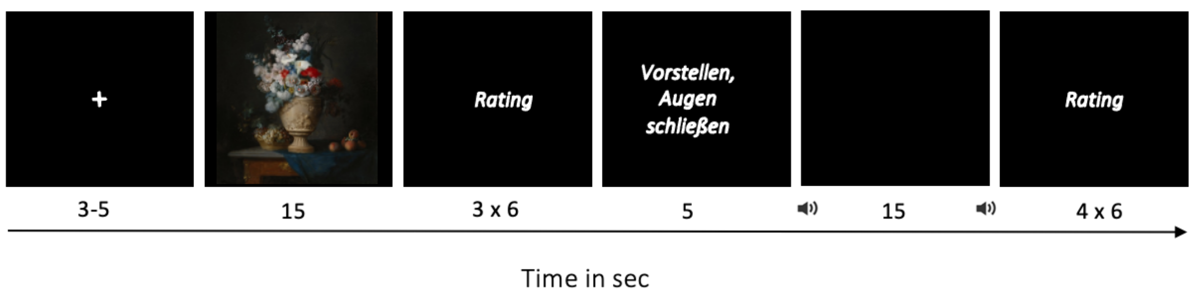


Figure 1. Experimental paradigm of the fMRI experiment.

MRI Data Acquisition. For each participant, functional and anatomical MRI images were acquired on a Siemens MAGNETOM Skyra 3 Tesla MRI Scanner. The anatomical image was acquired with an MPRAGE sequence (repetition time (TR) = 2300 ms, echo time (TE)= 2.29, flip angle = 8 deg). The functional images were acquired with an EPI sequence (repetition time (TR) = 915 ms, echo time (TE) = 34 ms, flip angle = 55 deg).

3.3.4 Data Analyses

Prescreening. The evaluation of the data collected in the prescreening was done in R version 4.0.4 on Mac (R Core Team, 2020). The following packages were used: data.table (Dowle & Srinivasan, 2021), tidyverse (Wickham et al., 2019).

Preprocessing of MRI Data. For brain extraction of the anatomical files an algorithm by Lutkenhoff et al. (2015) was used based on FSL BET. Since motion is a severe issue in fMRI research, in a first step the recommendations made by Parkes et al. (2018) were followed and the framewise displacement (FD) (calculated using fsl_motion_outliers function with the option -fdrsm) was checked to make sure that all subjects did not exceed a threshold of 0.2 mean FD, 20% outliers, or maximal FD of 5mm. The following preprocessing steps were done using FSL FEAT: For motion correction, MCFLIRT was utilized (Jenkinson et al., 2002). For brain extraction of the functional files FSL FEAT´s inherent BET brain extraction tool was used. Interleaved slice timing correction was applied. Spatial smoothing was performed with 5 FWHM (mm). Additionally, high-pass temporal filtering was implemented with a cut-off at 100Hz. For registration of the functional image to structural space, the brain extracted anatomical image was used as main structural image with enabled BBR. Participants´ images were registered into MNI standard space with 12 DOF (normal search) using a nonlinear registration with a warp resolution of 10 mm.

Behavioral Data Analysis. To test whether the ratings of aesthetic stimuli (faces and artworks) between visual perception and visual mental imagery are equivalent (hypothesis 1), an equivalence test with paired samples was conducted in R (package: "TOSTER") (Lakens, 2017; R Core Team, 2020). Because the data was ordinal, the equivalence test was performed using the non-parametric Wilcoxon signed rank test. Values were excluded from both conditions if one or both values were missing from a stimulus. The equivalence test was calculated with decreasing raw scale equivalence bound values approximating zero up to a magnitude of -0.001 and 0.001 at which differences on a 7-point Likert scale are neglectable. An alpha value of 0.05 was used. For testing hypothesis 3 (whether the ratings of pleasure for visual mental imagery and the ratings of vividness of visual mental imagery are positively correlated) Spearman´s Rho was calculated. A nonparametric measure for correlations instead of the commonly used Pearson´s *r* was used because of the ordinal structure of the underlying data.

The behavioral data was analyzed with R version 4.0.4 on Mac (R Core Team, 2020). Additionally to the package "TOSTER" (Lakens, 2017), the following packages were used: data.table (Dowle & Srinivasan, 2021), dplyr (Wickham et al., 2021), ggplot2 (Wickham, 2016), readxl (Wickham & Bryan, 2019) and tidyverse (Wickham et al., 2019) were used.

Whole Brain Functional Activity Analysis. To understand the influence of (aesthetic) pleasure elicited through visual perception as well as visual mental imagery on brain activity, the preprocessed data was used in a first-level analysis using FSL FEAT. The fMRI stimuli were divided into high (pleasure ratings of 5-7 on a 7-point Likert scale) and low-rated (pleasure ratings of 1-3) for each condition (visual perception and visual mental imagery). The explanatory variables (EVs) included high-rated and low-rated trials for perception and imagery, respectively, plus missing trials for perception and imagery as well as standard and extended motion parameters as nuisance regressors were entered in the GLM design using fixed effects modeling (including prewhitening). In a second-level analysis, all sessions of all subjects were combined using fixed effects modeling. In a third-level analysis, mixed effects modeling was implemented with the COPE images from the lower-level analyses using FLAME1.

Region of Interest (ROI) Functional Activity Analysis. For this thesis, the orbitofrontal cortex (OFC), the nucleus accumbens (NAc) and the caudate nucleus were chosen as regions of interest since these areas seem to be highly involved in the processing of pleasure, reward, and aesthetic experiences. To address the second hypothesis (i.e., whether a significant increase in neural activation for visual perception as well as visual mental imagery of more pleasurable rated aesthetic stimuli compared to less pleasurable rated aesthetic stimuli in the ROIs exists) the results were masked using the three different ROIs described above. The binary masks were created from the Harvard-Oxford cortical atlas using fslmaths with the option -bin.

The z-values for each contrast (high-rated stimuli and low-rated stimuli for each condition, that is, visual perception and visual mental imagery, respectively) were extracted for each of the three ROIs using fslmeants and the created masks described above. These z-values were then tested in paired sample one-sided t-tests (alpha = 0.5). For the visual perception condition in the OFC, a paired sample one-sided Wilcoxon signed rank test instead of a t-test was conducted because results from the Shapiro-Wilk test (alpha = 0.05) indicated that the data was not normally distributed (W = 0.841, p = 0.047). The significant testing of the z-values was done on R version 4.0.4 on Mac (R Core Team, 2020). Additionally, the package "ggplot2" was used (Wickham, 2016).

4. Results

4.1 Prestudy for Face Stimuli Selection

4.1.1 Sample

Overall, the sample consisted of more men than women (62.6%) and had an age range from 21 to 59 (M_{age} = 28.6, *SD = 11.63).* Participants´ sexual attraction (i.e., what sex/sexes participants felt attracted to) was equally distributed between "female" (6), "male" (5) and "female and male" (5). The home countries of participants were Austria (11) and Germany (5). All participants were fluent in German; almost all had German as their native language (15). The sample description can be seen in Table 1.

Table 1
Sample description

N	16
Women, *n* (%)	6 (37.5%)
Men, n (%)	10 (62.5%)
Age	
Range (years)	21 - 59
Mean	28.6
SD	11.63
Sexual Attraction	
Female	6
Male	5
Female and Male	5
Home Country	

Austria	11
Germany	5
German Skills	
German as native language	15
Very good German skills	1

4.1.2 Face Stimuli Selection

Several variables were assessed within the scope of the prestudy (for more information see Section 3.1.4), however, the focus of this master´s thesis regarding the prestudy lies in the selection of appropriate face stimuli for the fMRI experiment. Therefore, only the results in conjunction with the face stimuli selection are reported.

The face stimuli for the fMRI-experiment were selected with the intent of maximizing participants´ likelihood of experiencing strong aesthetic responses and/or experiencing aesthetic chills through a face stimulus and were chosen based on the criteria of a general high mean rating and many outliers on the higher end of the scale (outlier greater than 89 on a 100 scale) in the variable "beauty". Originally, it was planned to use 10 high-rated and 10 neutral-rated faces (along with 10 high-rated and 10 neutral-rated artworks) as stimuli for the fMRI experiment to be able to compare the high-rated and neutral-rated conditions. However, there was such a high variance in the stimuli ratings (see Section 4.1.3 and 4.1.4) that even for the on average highest rated stimuli many subjects still rated them neutral or low (see Figures 2 and 3). Since the emergence of strong aesthetic responses and/or aesthetic chills in participants was fundamental for the study paradigm to work, it was decided to not use a neutral-rated stimuli condition, and all stimuli were selected solely to maximize participants´ likelihood of aesthetic experiences.

"Beauty" and not "aesthetically moving" was chosen for the face stimuli selection mainly for two reasons: Participants 'mean ratings in "aesthetically moving" were lower than for "beauty" (see Table 2 and 3 and Figure 2 and 3). Furthermore, results from the additional assessment of the prestudy, asking participants about what aesthetically moving signifies to them, indicated that many participants did not understand the concept of aesthetically moving and/or thought it was the same as beauty (e.g., "wenn ich etwas persönlich als schön empfinde und ich es gerne lange betrachte". Engl. = "when I personally find something beautiful and I like to look at it for a long time".). This result did not come unexpected. It would have been superior giving participants an explanation of aesthetically moving prior to the ratings. However, the data used for the artwork stimuli selection was adopted from prior research by Schäfer (2015) who did not explain the concept of aesthetically moving to participants prior to the ratings. Since the procedure of the prestudy was intended to be as similar as possible to the procedure used for the artwork stimuli selection, the concept was not explained to participants prior to the face rating as well.

4.1.3 Summary Statistics for Beauty

The means and standard deviations of the variable "beauty" can be seen in Table 2. The scatterplots showing outliers of the variable "beauty" are reported in Figure 2.

Table 2
Means and standard deviations of beauty

Face ID	*M*	*SD*
9	83.93	15.82
8	82.6	12.25
5	77.14	15.62
7	76.79	16.53
10	76	15.21
4	74.33	12.64
2	74.14	16.23
33	73.93	12.47
11	73.14	16.22
37	72.71	17.27
3	72.53	18.84
6	72.53	22.98
32	69.33	18.15
38	68.64	17.03
1	68.07	14.36
30	66.14	17.68
29	63.33	26.46
36	63.29	18.45
31	60.36	23.33
12	59.73	20.98
40	58.6	21.14
18	58.07	21.27
39	57.86	18.76
21	57	16.06
48	54.83	14.31
34	54.27	25.7
15	53.93	16.74
41	51.85	22.46
46	50.71	13.72
22	50.2	17.21
13	49.85	17.25
35	49.79	21.26

44	48.31	18.85
20	47.69	18.47
45	47.08	19.3
14	45.21	19.33
19	43.92	21.55
47	43.86	24.03
49	37.92	20.43
42	37.5	21.1
43	34.57	13.33
50	32	17.85
17	31.8	20.97
16	30.29	15.33
27	28.5	22.27
26	27	17.77
24	25.54	17.01
52	25.23	13.69
23	24.85	17.75
56	23.14	13.5
54	22.69	21.13
51	20.31	16.03
55	19.25	13.11
53	17.92	15.03
28	13.36	14.05
25	12.38	14.44

Note. M and *SD* are used to represent mean and standard deviation; N = 16.

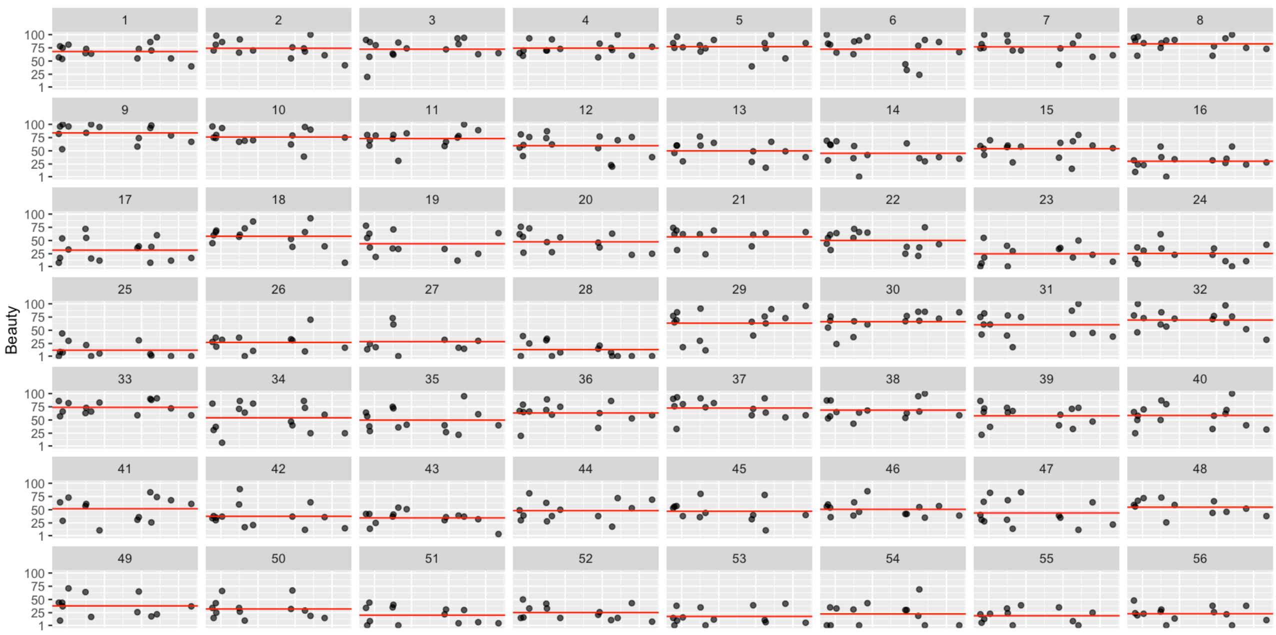


Figure 2. Scatterplots of beauty ratings for each face stimuli.

Each graph represents one face stimulus; numbers above the graphs represent the face ID; x-axis: black dots represent each subject´s rating for beauty; y-axis: beauty rating scale (1 - 100); red line: mean.

4.1.4 Summary Statistics for Aesthetically Moving

The means and standard deviations of the variable “aesthetically moving” are reported in Table 3. The scatterplots showing outliers of the variable “aesthetically moving” can be seen in Figure 3.

Table 3

Means and standard deviations of aesthetically moving

Face ID	*M*	*SD*
9	79.36	19.52
7	78.79	12.55
33	75	13.68
8	74.67	11.54
2	72.46	17.32
5	71.64	16.3
6	70.47	20.01
37	69.71	14.22
10	69.23	18.25
32	68.2	16.24
30	67.93	11.17
38	67.79	18.12
31	67.73	18.06
1	66.8	15.61
36	63.93	17.7
29	63.4	24.37
4	63.21	16.77
11	62.93	22.09
3	62.27	24.03
34	54.93	24.5
12	54.87	16.88
18	53	20.72
39	51.93	22.34
35	49.5	16.76
40	49.27	24.23
48	47.54	19.2
41	47	22.74
21	45.83	15.44
13	44.67	15.69
45	42.31	16.95
15	42.13	15.95
42	41.64	22.82
47	41.14	15.55
19	40.79	22.09
46	40.14	14.64
22	38.71	17.73
20	38.17	14.6
44	38	13.9
27	35	18.68
51	34.08	20.66
52	33.23	24.42

50	32.57	15.84
14	31.64	16.13
28	31.64	27.5
49	30.92	14.3
43	30.38	17.17
17	30.36	17.66
55	29.08	23.47
24	27	21.97
26	26	19.25
54	23.23	21.66
16	19.62	12.6
56	17.85	14.84
23	17.85	14.89
25	14.62	16.51
53	12.23	8.71

Note. M and *SD* are used to represent mean and standard deviation; N = 16.

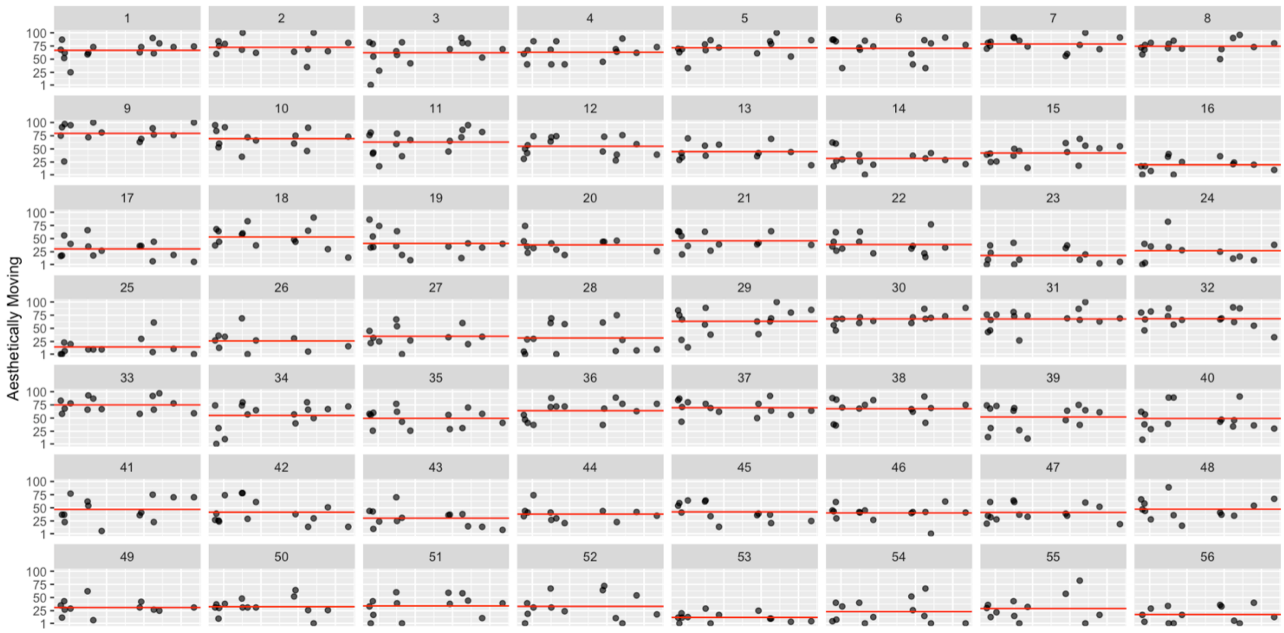


Figure 3. Scatterplots of aesthetically moving ratings for each face stimuli.

Each graph represents one face stimulus; numbers above the graphs represent the face ID; x-axis: black dots represent each subject's rating for aesthetically moving; y-axis: aesthetically moving rating scale (1 -100); red line: mean.

4.2 Artwork Stimuli Selection

For the artwork stimuli selection, the data of Spee et al. (2021) was used. The sample consisted of 78 psychology students recruited at the University of Vienna (55 female; age range: 19-35, M_{age} = 24.23, *SD* = 3.45). Again, due to the high variance in ratings across subjects (see Figures 4 and 5), artworks were chosen in order to maximize participants´

likelihood of being strongly moved and/or experiencing aesthetic chills though a stimulus after the criterium of a general high mean rating and many outliers on the higher end of the scale (outlier greater than 90 on a 101 scale) in the variable "beauty". Similar to the face stimuli selection, "beauty" and not "aesthetically moving" was chosen for the artwork stimuli selection because of the low mean ratings in "aesthetically moving" and because the concept of aesthetically moving was not explained to participants prior to the ratings and results from the prestudy for face stimuli selection indicated that many participants do not understand the concept without prior explanation.

4.2.1 Summary Statistics for Beauty

The means and standard deviations of the variable "beauty" are reported in Table 4. The scatterplots showing outliers of the variable "beauty" can be seen in Figure 4.

Table 4
Means and standard deviations of beauty

Artwork ID	*M*	*SD*
31605	71.58	21.49
20411	66.72	22.69
31411	65.85	26.55
33003	65.71	23.99
31601	64.54	25.23
30709	61.31	26.77
21407	59.03	26.4
40806	55.27	29.88
30806	54	22.58
23005	53.95	24.95
31405	53.91	23.49
30802	52.6	28.94
21409	50.9	26.16
41403	50.74	27.14
41612	50.21	27.01
21609	49.72	22.99
21610	49.04	25.07
30701	48.42	27.08
23006	48.37	27.37
40713	47.32	24.27
20402	45.73	25.68
20809	44.72	24.11
32404	44.65	27.1
30702	44.54	24.41
31406	44.42	25.62
40802	43.64	22.52
43006	43.64	28.89
30801	43.62	22.88

40717	42.86	28.35
31603	41.79	26.78
20807	41.03	24.94
41402	40.95	26.57
22403	39.79	24.83
32405	39.06	28.93
41616	39.05	26.24
42406	38.82	24.71
32401	38.45	25.09
22401	37.76	27.66
33006	37.35	24.6
20409	36.77	23.4
42401	36.64	25.72
20814	36.46	23.33
21602	34.99	23.53
43010	34.19	24.25
23007	32.79	23.65
33005	32.67	27.54
41401	32.5	22.99
21401	31.94	21.85
40702	31.5	24.84
43009	30.55	21.81
41610	29.31	22.16
42402	29.19	24.58
22407	26.27	22.02
40801	25.46	22.73

Note. M and *SD* are used to represent mean and standard deviation; N = 78.

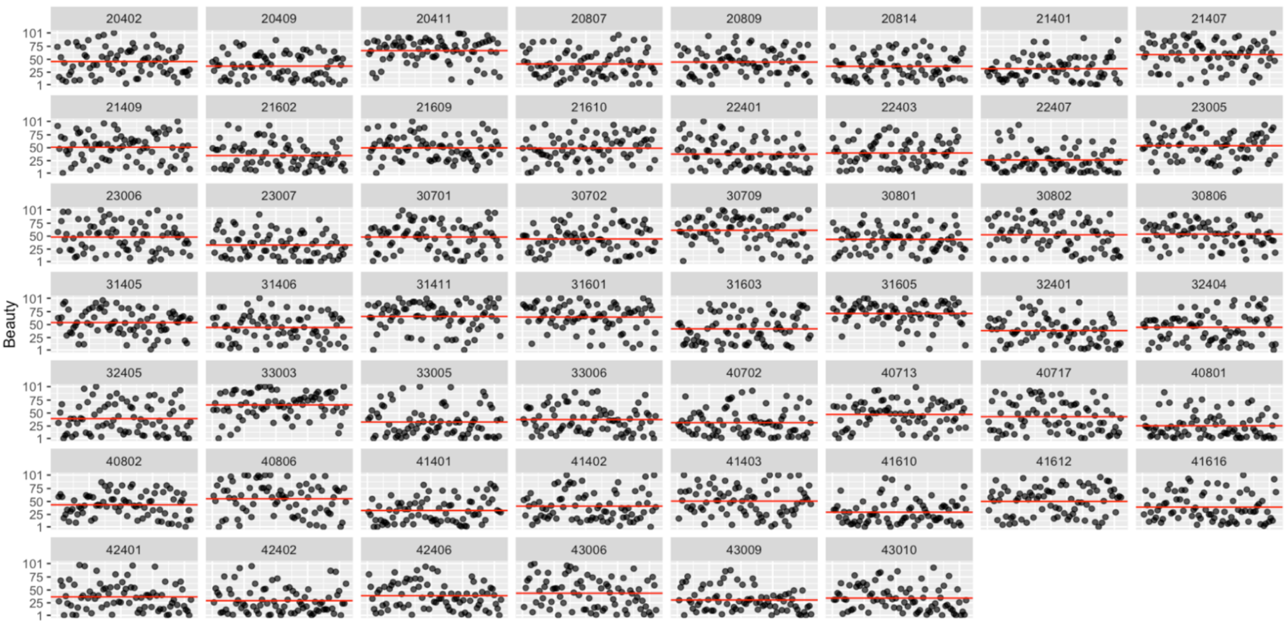


Figure 4. Scatterplots of beauty ratings for each artwork stimuli.

Each graph represents one artwork stimulus; numbers above the graphs represent the artwork ID; x-axis: black dots represent each subject's rating for beauty; y-axis: beauty rating scale (1 -101); red line: mean.

4.2.2 Summary Statistics for Aesthetically Moving

The means and standard deviations of the variable "aesthetically moving" can be seen in Table 5. The scatterplots showing outliers of the variable "aesthetically moving" are reported in Figure 5.

Table 5
Means and standard deviations of aesthetically moving

Artwork ID	*M*	*SD*
31605	61.47	25.52
31411	56.13	26.28
20411	55.94	26.34
33003	54.69	25.24
23005	49.77	28.04
31601	49.58	25.52
21609	48.71	25.11
22401	47.97	25.45
21407	47.86	26.43
30709	47.59	28.06
23006	44.92	22.38
30806	44.53	23.18
43006	44.45	28.86
21610	43.83	26.24
31405	43.03	26.28
22403	42.64	24.64
40806	42.44	30.94
40717	42.06	25.35
32401	41.55	24.31
41616	41.51	25
40713	41.46	25.17
21409	40.78	25.56
43010	40.74	24
40702	39.73	29.03
42406	39.56	23.69
30802	39.26	24.87
41403	39.18	25.23
33006	38.99	25.03
23007	38.5	27.56
32405	38.24	28.54
21401	37.72	24.5
20402	37.65	25.19
40802	37.6	23.54
20809	36.72	24.26
31406	36.59	25.1
33005	36.5	26.81
43009	36.47	24.1
40801	36.22	27.15
31603	35.4	26.51
22407	35.26	25.46
32404	34.71	25.88

41612	34.58	26.47
30701	34.01	23.44
20807	33.14	21.05
30702	33.1	21.29
20409	33.01	22.91
42401	32.91	23.2
42402	32.4	24.01
21602	32.24	22.43
30801	31.97	20.73
20814	31.31	19.5
41402	31.28	24.12
41401	26.73	22.94
41610	22.27	19.98

Note. M and *SD* are used to represent mean and standard deviation; N = 78.

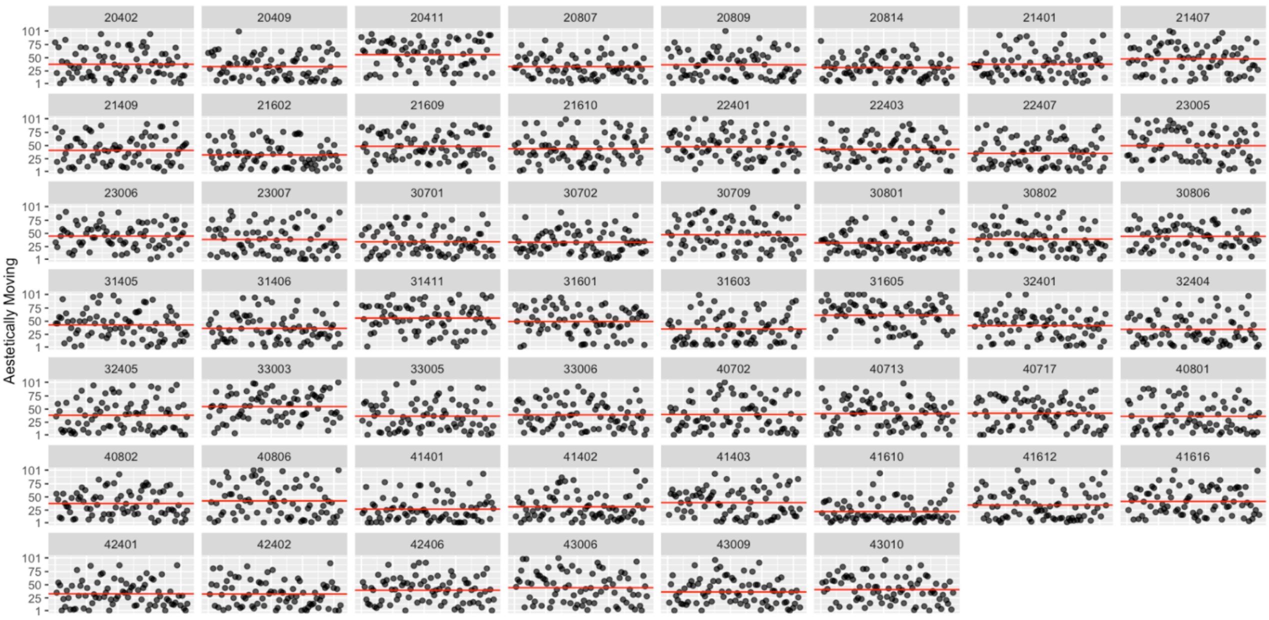


Figure 5. Scatterplots of aesthetically moving ratings for each artwork stimuli. Each graph represents one artwork stimulus; numbers above the graphs represent the artwork ID; x-axis: black dots represent each subject's rating for aesthetically moving; y-axis: beauty rating scale (1 -101); red line: mean.

4.3 fMRI Study

4.3.1 Sample

Overall, the sample for the fMRI pilot study consisted of five subjects (three men and two women). The age range was from 19 to 31 (M_{age} = 25.2, *SD* = 4.37). Three participants declared to be sexually attracted to males, two declared to be sexually attracted to females. The home countries of participants were Germany (3), Austria (1) and Italy (1). All participants had German as their native language (15). The sample description can be seen in Table 6.

Table 6
Sample description fMRI study

N	5
Women, *n* (%)	2 (40%)
Men, n (%)	3 (60%)
Age	
Range (years)	19 - 31
Mean	25.2
SD	4.37
Sexual Attraction	
Male	3
Female	2
Home Country	
Germany	3
Austria	1
Italy	1
German Skills	
German as native language	5

4.3.2 Hypothesis 1

For testing whether the ratings of aesthetic stimuli (faces and artworks) between visual perception and visual mental imagery are equivalent (hypothesis 1), a paired- samples equivalence test using the Wilcoxon signed rank test was performed (Lakens, 2017). The equivalence test was significant ($V = 6242$, $p = 0.001$) given equivalence bounds of -0.001 and 0.001 (on a raw scale) and an alpha of 0.05. The null hypothesis test was non-significant ($V = 2456$, $p = 0.622$). Based on the equivalence test and the null hypothesis test combined, it can be concluded that the observed effect is statistically equivalent to zero and that the ratings of aesthetic stimuli between visual perception and visual mental imagery are equivalent. In accordance with the results from the equivalence test, the means of the pleasure ratings for visual perception and visual mental imagery were very similar (visual perception: M = 4.08, SD = 1.53; visual mental imagery: M = 4.037, SD = 1.6). The mean difference was only 0.037 (7-point Likert scale, p = 0.622).

4.3.3 Hypothesis 2

Hypothesis 2 tested whether an increase in neural activation in the three ROIs (NAc, caudate nucleus, OFC) for visual perception as well as visual mental imagery of more pleasurable rated aesthetic stimuli compared to less pleasurable aesthetic stimuli exist. To test this, the z-values for each contrast (high-rated stimuli and low-rated stimuli for each condition, that is, visual perception and visual mental imagery, respectively) were extracted for each of the three ROIs. These z-values were then tested in paired sample one-sided t-tests (alpha = 0.5).

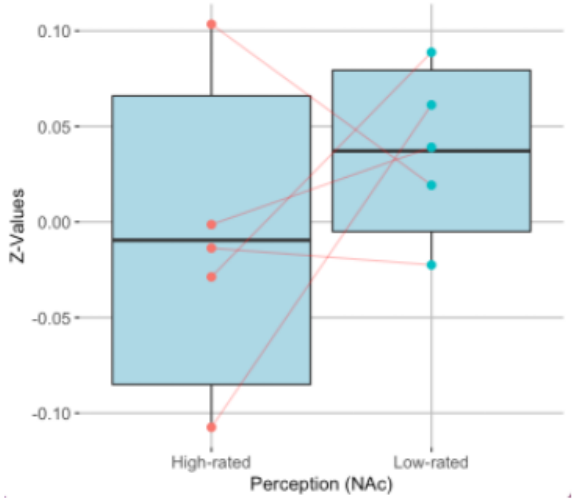
For the NAc, results were non-significant and did not confirm hypothesis 2 for visual perception nor for visual mental imagery (visual perception: $t(4) = -1.042$, p = 0.822; visual mental imagery: $t(4) = 1.264$, p = 0.138). Likewise, for the caudate nucleus no significant results were found (visual perception: $t(4) = -1.081$, p = 0.83; visual mental imagery: $t(4) = -0.275$, p = 0.601). For the OFC, results were non-significant as well (visual perception: V = -14, p = 0.063; visual mental imagery: $t(4) = 0.1$, p = 0.463). Means and SDs of the z-values for high-rated stimuli and low-rated stimuli for visual perception as well as for visual mental imagery in the ROIs are shown in Table 7 and are graphically depicted in Figure 6 (A-F).

Table 7

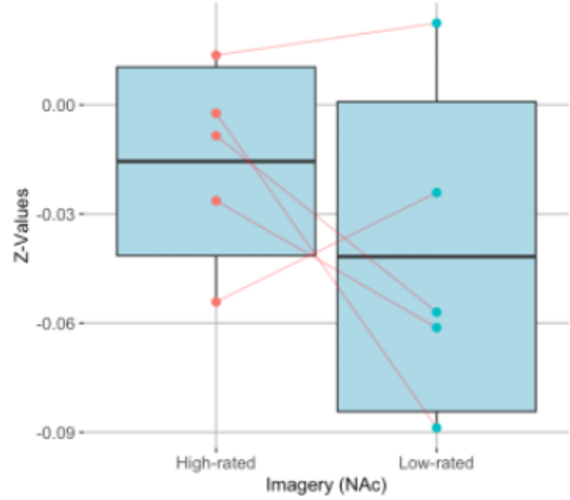
Means and SDs of z-values for high and low-rated stimuli for visual perception and visual mental imagery in ROIs.

	Perception				**Imagery**			
	High		Low		High		Low	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
NAc	-0.01	0.076	0.037	0.042	-0.016	0.026	-0.042	0.043
Caudate	-0.013	0.059	0.017	0.049	-0.027	0.041	-0.017	0.042
OFC	0.014	0.025	-0.017	0.05	0.023	0.026	0.019	0.081

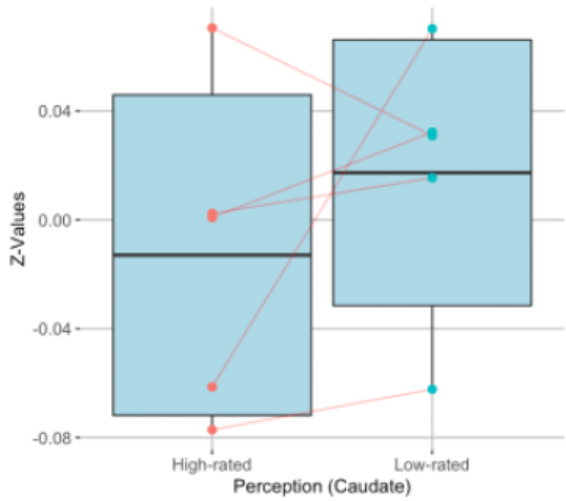
Note. *M* and *SD* are used to represent mean and standard deviation; N = 5.


0.10
0.05
0.00
-0.05
-0.10
Z-Values
High-rated
Low-rated
Perception (NAc)

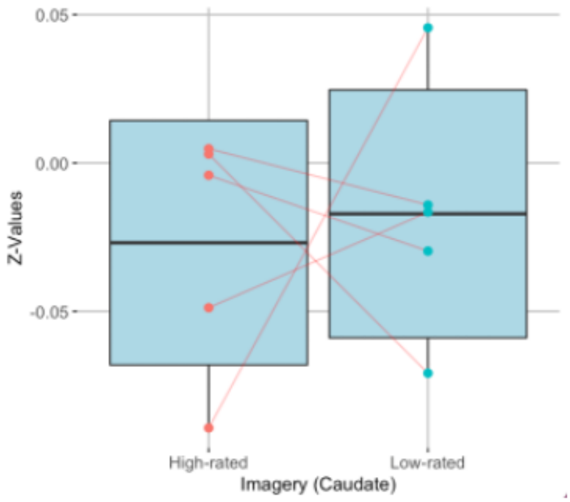
A


0.00
-0.03
-0.06
-0.09
Z-Values
High-rated
Low-rated
Imagery (NAc)

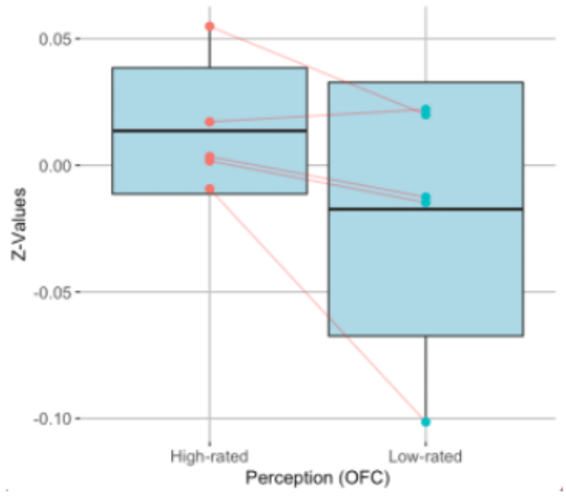
B


0.04
0.00
-0.04
-0.08
Z-Values
High-rated
Low-rated
Perception (Caudate)

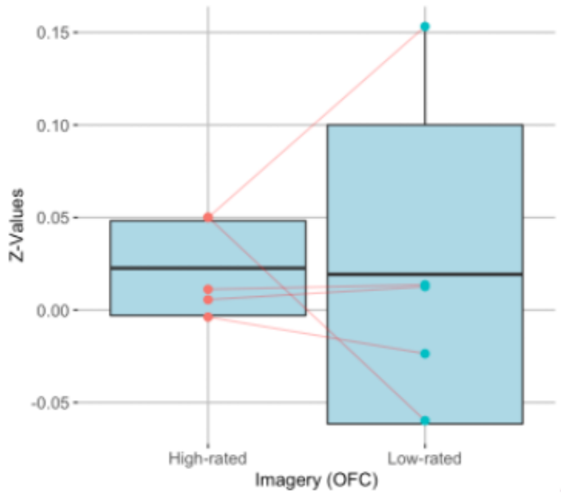
C


0.05
0.00
-0.05
Z-Values
High-rated
Low-rated
Imagery (Caudate)

D


0.05
0.00
-0.05
-0.10
Z-Values
High-rated
Low-rated
Perception (OFC)

E


0.15
0.10
0.05
0.00
-0.05
Z-Values
High-rated
Low-rated
Imagery (OFC)

F

Figure 6. Boxplots of z-values for high-rated stimuli and low-rated stimuli in ROIs for visual perception and visual mental imagery.

Middle line in boxplot represent mean; upper and lower border of boxplot represent SD; red lines between dots indicate the same subject. X-axis: high-rated and low-rated stimuli; y-axis: z-values in each ROI. (A) Visual perception task in NAc. (B) Visual mental imagery task in NAc. (C) Visual perception task in caudate nucleus. (D) Visual mental imagery task in caudate nucleus. (E) Visual perception task in OFC. (F) Visual mental imagery task in OFC.

4.3.4 Hypothesis 3

For testing whether the pleasure ratings for visual mental imagery and the ratings of vividness of visual mental imagery are positively correlated, Spearman´s Rho was calculated. In accordance with hypothesis 3, results showed a correlation of ρ (rho) = 0.52 (S = 474929, p < 0.001). The distribution of the data can be seen in Figure 7.

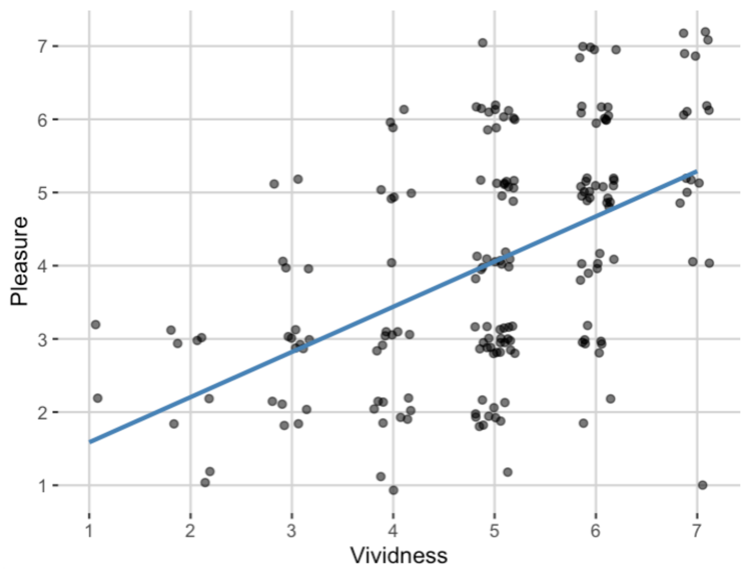


Figure 7. Scatterplot of pleasure and vividness of visual mental imagery ratings.

X-axis: vividness of visual mental imagery ratings; y-axis: pleasure ratings for visual mental imagery; blue line: regression line.

5. Discussion

This master´s thesis combines the emerging interdisciplinary field of neuroaesthetics (whose main focus lies in the understanding of human aesthetic experiences) with mental imagery research. It investigates the question whether aesthetic experiences, particularly aesthetic pleasure, are dependent on external stimuli or can also be achieved through visual mental imagery and examines the neural differences and similarities between visual mental imagery and visual perception regarding aesthetic pleasure. Furthermore, the role of vividness (i.e., how vivid/detailed a certain mental image is experienced) in visual mental imagery was investigated. To examine the questions specified above, behavioral measures as well as fMRI brain activation during visual mental imagery and visual perception of artwork and face stimuli were evaluated.

This master´s thesis is a pilot study. It is aimed to gather first insights, provide a proof of concept of the research method and to serve as a guide for developing subsequent studies. The data of only five subjects were analyzed. Therefore, interpretation of the results should be viewed with caution.

5.1 Hypotheses

Hypothesis 1. Results show that the (aesthetic) pleasure ratings of aesthetic stimuli (faces and artworks) between visual perception and visual mental imagery are equivalent (in line with hypothesis 1). These findings indicate that similar aesthetic pleasure can be derived through visual mental imagery and visual perception and that no direct visual input from the outside world is needed for an aesthetic experience. If visual mental imagery can elicit similar pleasure responses as visual perception of the same stimulus, these results may be generalizable to other aesthetic experiences as well. Mental imagery might generally be able to elicit similar experiences as visual perception in many individuals. However, further research is needed to evaluate this.

The results of the equivalence test were clear, proving equivalence even for very low raw scale equivalence bound values (approximating zero up to a magnitude of -0.001 and 0.001). Furthermore, the mean difference between pleasure elicited through visual mental imagery and pleasure elicited through visual perception was only 0.037 (7-point Likert scale, $p = 0.622$). Differences of this small magnitude in relation to a 7-point Likert scale are neglectable. Considering the clear results found in this pilot study, it can be expected to find similar results in subsequent research using a larger sample size.

Besides advancing the scientific evaluation of visual mental imagery and hedonic responses, these findings could have huge implications. Considering the important role that mental imagery plays in many psychiatric diseases and mental imagery´s potential for treatment interventions, they could contribute to the development of new methods for increasing the wellbeing of healthy individuals and inspire new treatment methods for psychiatric patients (American Psychiatric Association, 2013; Arntz et al., 2007; Blackwell, 2019; Blackwell et al., 2015; Blackwell & Holmes, 2010; Holmes & Mathews, 2010; Jacob et al., 2011; Linke & Wessa, 2017; Renner et al., 2017, 2019; Sack, 2005; Weßlau & Steil, 2014; Williams et al., 2013). However, it should be noted that in the fMRI study only subjects that demonstrated at least a neutral ability in visual mental imagery and frequency of aesthetic experiences were examined. Thus, the preliminary results are only applicable for subjects that possessing these traits.

Hypothesis 2. The second hypothesis examined whether an increase in neural activation in the three ROIs (NAc, caudate nucleus, OFC) for visual perception as well as visual mental imagery of more pleasurable aesthetic stimuli compared to less pleasurable rated aesthetic stimuli exist. For none of the ROIs significant results were found.

However, as can be seen in Figure 6, the preliminary results show interesting unique patterns for each ROI. In the NAc opposing trends for visual perception and visual mental imagery can be observed. For visual mental imagery, higher activation of the NAc during the experience of high pleasure compared to low pleasure was found. For visual perception on the other hand, results are pointing in the other direction of what was expected, a trend towards a higher activity during low pleasure was found. Likewise, in the caudate nucleus, results for visual perception and visual mental imagery show a trend towards higher activity during low pleasure compared to high pleasure. In the OFC, results for the visual perception condition were not significant (p = 0.063) but show a clear trend towards higher activation during the experience of high pleasure compared to low pleasure (in line with hypothesis 2). The non-significant results could be due to the low power of the small sample size. Thus, this trend should definitely be considered in future research using a larger sample size. In contrast, for the visual mental imagery condition, high pleasure and low pleasure appear to induce similar levels of neural activity.

Considerable variance in in the data and numerous outliers exists (see Figure 6). Interestingly, in the NAc the same subject is responsible for the outlier with the z-value for high-rated stimuli = 0.103 (and the z-value for low-rated stimuli = 0.02) in the visual perception condition and for the outlier with the z-value for high-rated stimuli = -0.054 (and the z-value for low-rated stimuli = -0.024) in the visual mental imagery condition. Without including this outlier in the analysis, the trend for the NAc would be clearer.

To sum up, the results show unique patterns for each region and condition when looking at the single-subject data (see Figure 6). This may indicate a possible direction for an investigation with a larger sample size. Thus, this pilot study, despite the small number of subjects, indicates that there is an interesting dissociation in the neural activity when comparing the regions involved in the processing of pleasure during visual perception and visual mental imagery. As mentioned, only five subjects were scanned in the fMRI study. In a larger sample size, outliers would not have such a large effect and results may paint an even clearer picture. Due to the substantial variance in the data and the mostly small and non-significant mean differences, no valid conclusions can be drawn. From the current data, it is not clear whether the high variance in the data is caused by confounding variables or whether they represent real differences between participants. Research by Ishai et al., (2000) found stronger neural responses during visual mental imagery in the left hemisphere and stronger neural responses during visual perception in the right hemisphere in the temporal cortex. Maybe a similar mechanism in the NAc, caudate nucleus and OFC exists. Independently investigating the right and left hemispheres might produce more coherent results. More research is needed to evaluate the subject.

Hypothesis 3. The third hypothesis investigated whether the ratings of pleasure for visual mental imagery and the ratings of vividness of visual mental imagery are positively correlated. Results are in accordance with hypothesis 3; a large effect of ρ (rho) = 0.52 (S = 474929, $p < 0.001$) was found. This indicates that vividness plays a substantial role in visual mental imagery and its effect on the experience of pleasure despite the small sample size. However, given the design of the study no causal conclusions can be drawn and further research is needed to confirm these findings. In any case, results show that vividness of mental imagery could act as a highly confounding variable and thus, it is highly important for future mental imagery studies to control for it. The investigation of vividness of visual mental imagery´s influence on brain activity was beyond the scope of this master´s thesis. This matter should be examined with subsequent research.

5.2 Limitations and Future Research

Several limitations of the current study underlaying this master´s thesis as well as prior research in the field exist. These limitations should be considered when developing future studies.

Prior Research. As already mentioned in the introduction, in much of the literature on beauty, pleasure, attractiveness and liking, the underlaying concepts are not clearly defined and no consistent definitions exist. Many studies in the field equate beauty with facial attractiveness, more specifically, participants rate the attractiveness of faces, but the findings are discussed within the framework of beauty. Approaches like this hinder the comparison across studies. Future studies should clearly state and define the researched concepts.

A similar problem exists for the concept of aesthetic experiences. A uniform definition is lacking. This is especially obstructive since results from the prestudy demonstrated that the concept of aesthetic experiences does not seem to be intuitively clear to many people. Many participants did not understand the concept of aesthetically moving without prior explanation. Thus, giving a uniform and clear definition of the concept and describing the exact procedure in their publications is highly important for researchers as well as for subjects. For this work, aesthetic experiences are defined as a multitude of strong physical and emotional reactions to a broad spectrum of different aesthetic stimuli ranging from art-objects like paintings to non-art objects like faces, natural objects or scenes, and also include non-visual stimuli like music or poetry. This work is supposed to aid in the development of such a uniform and clear definition, however, more work is needed.

Current Study. The samples used in the prestudy for face stimuli selection and for the fMRI study were relatively small. The estimated sample size of eight participants for the prestudy surpasses the 16 participants analyzed, however, the sample size is still relatively low. For the fMRI analysis only five participants were used, thus, results can only be a general guideline for future larger investigations. Nevertheless, the results presented here demonstrate the feasibility of the approach and the possibility for interesting and significant findings.

A problem for the used research paradigm is that it is very hard to induce aesthetic experiences during fMRI. For most people, aesthetic experiences are not frequently experienced even under comfortable circumstances. Being inside an MRI machine is a stressful and uncomfortable situation for many people. There are frequent loud and disturbing noises and participants are fixed and cannot move. Thus, being inside an MRI could undermine aesthetic responses in participants. Furthermore, strong aesthetic experiences are rare and one´s art taste can be highly individual. Future studies should let participant choose individual stimuli that elicit strong aesthetic experiences in them prior to the fMRI scanning. This approach might be more arduous but will likely result in a much higher frequency and strength of participant´s aesthetic experiences.

In this thesis, face and artwork stimuli were combined and not analyzed separately. The aim of this study was to investigate aesthetic pleasure and experiences generally. This could be examined without differentiating between stimuli conditions. On a neural level, combing multiple stimulus types might even be beneficial because it could result in less confounds caused by specific attributes of a certain stimulus type. But especially, since the pilot study had such a low sample size, this approach ensured higher statistical power. However, differentiating between stimuli conditions would provide valuable insights and should be further investigated in subsequent research.

Furthermore, because of the complexity of the method (which would have been beyond the scope of this master´s thesis), ROIs were not segmented at the individual level but at the standard level. However, segmentation of the ROIs at the individual level would have been superior and may have improved the high variance found in the results.

In the scope of the fMRI study several variables were assessed (for more information see Section 3.3.3). However, in this master´s thesis only the pleasure and vividness variables were investigated. Thus, it is important to also examine the other assessed variables (i.e., beauty and aesthetically moving) in future research and compare them.

For the prescreening (as well as the prestudy), an adapted and translated version of the AES by Silvia and Nusbaum (2011) was used. The AES evaluates the frequency of aesthetic experiences in the art domain that elicits the strongest aesthetic responses in a participant. These domains are not limited to visual art and also include listening to music, literature, theatre and one own´s creative work. In the fMRI study, only aesthetic experiences through visual stimuli were investigated. Thus, it would have been superior to prescreen participants only based on their frequency of aesthetic experiences related to visual domains.

Furthermore, it was highly difficult to translate specific items of the AES into German (e.g., pleasure chill, aesthetic experiences, etc.). Thus, for some of the items very broad translations had to be used. This could distort results obtained by the German version in comparison to the original version.

5.3 Conclusion

The goal of this master´s thesis was to gather first insights, provide a proof of concept of the research method, show its limitations and to serve as a guide for developing subsequent studies. Behavioral results show that similar aesthetic pleasure can be derived through visual mental imagery and visual perception indicating that no direct visual input from the outside world is needed for aesthetic experiences. Evaluation of the fMRI data of aesthetic pleasure, elicited through visual mental imagery compared to visual perception, produced unique patterns for each ROI and condition. These patterns, although not significant, should be further tested in a larger sample. Furthermore, results suggests that vividness plays a substantial role in visual mental imagery and its influence on aesthetic experiences. Besides advancing the scientific evaluation of visual mental imagery, aesthetic experiences and hedonic responses, this work, if verified by subsequent research, could contribute to the development of new methods for increasing the wellbeing of healthy individuals as well as inspire new treatment methods for psychiatric patients.

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Abbreviations

AES	Aesthetic Experiences Scale
CBT	Cognitive behavioral therapy
FD	Framewise displacement
fMRI	functional magnetic resonance imaging
fNIRS	functional near-infrared spectroscopy
mOFC	medial orbitofrontal cortex
NAc	Nucleus accumbens
OFC	Orbitofrontal cortex
PTSD	Post-traumatic stress disorder
TE	Echo time
TR	Repetition time
VVIQ	Visual Imagery Questionnaire

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7. Appendix

Abstract

English. Research has shown that visual mental imagery and visual perception are similar in many ways, that a substantial neural overlap between visual mental imagery and visual perception processes exist and that visual mental imagery can have a strong influence on emotions. However, research on visual mental imagery used in the aesthetic context is still lacking. This master´s thesis aims to close that gap and tries to answer the questions, whether it is possible to experience aesthetic pleasure through our mere visual mental imagery and what neural similarities and differences between visual mental imagery and visual perception in the aesthetic context exist. To investigate this, brain activity in the nucleus accumbens (NAc), the caudate nucleus and the orbitofrontal cortex (OFC) during visual perception and visual mental imagery, measured via functional magnetic resonance imaging (fMRI), was analyzed in a within-subject design. In addition, behavioral data assessing participants experienced aesthetic pleasure was evaluated. A sample of five participants was shown images of artworks and faces and subsequently visually imagined the prior seen images. Behavioral results show that similar aesthetic pleasure can be derived through visual mental imagery and visual perception indicating that no direct visual input from the outside world is needed for aesthetic experiences. MRI data produced interesting but non-significant results. Furthermore, results suggests that vividness plays a substantial role in visual mental imagery. This master´s thesis is a pilot study to provide a proof of concept for subsequent studies. Thus, results should be viewed with caution.

German. Die Forschung hat gezeigt, dass visuelle Vorstellung (engl. = „visual mental imagery“) und visuelle Wahrnehmung in vielerlei Hinsicht ähnlich sind, dass es erhebliche neuronale Überschneidungen zwischen visueller Vorstellung und visueller Wahrnehmung gibt und dass visuelle Vorstellung einen starken Einfluss auf Emotionen haben können. Es fehlt jedoch an Forschung über visuelle Vorstellung und visuelle mentale Bilder im ästhetischen Kontext. Die vorliegende Masterarbeit will diese Lücke schließen und versucht die Fragen zu beantworten, ob es möglich ist, ästhetisches Vergnügen allein durch visuelle Vorstellung zu erleben und welche neuronalen Ähnlichkeiten und Unterschiede zwischen visueller Vorstellung und visueller Wahrnehmung im ästhetischen Kontext existieren. Um dies zu untersuchen wurde die Hirnaktivität im Nucleus accumbens (NAc), dem Nucleus caudatus und dem Orbitofrontalkortex (OFC) während visueller Wahrnehmung und visueller Vorstellung mittels funktioneller Magnetresonanztomographie (fMRI) in einem „Within-Subject-Design“ analysiert. Darüber hinaus wurden Verhaltensdaten zu dem ästhetischen Vergnügen der Teilnehmer ausgewertet. Einer Stichprobe von fünf TeilnehmerInnen wurden Bilder von Kunstwerken und Gesichtern gezeigt, anschließend stellten sich die TeilnehmerInnen die zuvor gesehenen Bilder visuell vor. Die Verhaltensdaten zeigen, dass ein ähnliches ästhetisches Vergnügen durch visuelle Vorstellung wie durch visuelle Wahrnehmung hervorgerufen werden kann, was darauf hindeutet, dass für ästhetische

Empfindungen kein direkter visueller Input aus der Außenwelt erforderlich ist. Die fMRI-Daten lieferten interessante, aber nicht signifikante Ergebnisse. Darüber hinaus deuten die Ergebnisse darauf hin, dass die Anschaulichkeit der mentalen Bilder (engl. = „vividness“) eine wesentliche Rolle für die visuellen Vorstellung spielt. Bei dieser Masterarbeit handelt es sich um eine Pilotstudie. Die Ergebnisse sollten mit Vorsicht betrachtet werden.

Prestudy for Face Stimuli Selection

Assessment of Demographic Information *(also used in Prescreening)*

Wie würden Sie Ihre Deutschkenntnisse beschreiben?

geringe oder keine Kenntnisse
mäßige Kenntnisse
gute Kenntnisse
sehr gute Kenntnisse
Muttersprache

Wie alt sind Sie (in Jahren)?
(Open Question)

In welchem Land/welchen Ländern sind Sie aufgewachsen?
(Open Question)

Welchem Geschlecht fühlen Sie sich zugehörig?
weiblich
männlich
divers
andere
Zu welchem Geschlecht fühlen Sie sich hingezogen?
männlich
weiblich
männlich und weiblich
zu keinem der genannten

Aesthetic Experiences Scale (AES) *(also used in Prescreening with slight modifications)*

Bitte wählen Sie die Kunstdomäne aus, die bei Ihnen die stärksten Emotionen bzw. das stärkste ästhetische Empfinden auslöst:
Musik hören
Videos schauen (Fernsehen, Kino, Youtube, etc.)
Bildende Kunst (Gemälde, Malerei, Kunstfotografie, etc.)
Literatur
Tanzaufführungen
Theater
Eigenes kreatives Schaffen

Andere

Wie häufig sind Sie der von Ihnen angegebenen Kunstdomäne in etwa ausgesetzt?
täglich
mehrmals die Woche
einmal die Woche
ein- bis zweimal im Monat
alle paar Monate
ein- bis zweimal im Jahr
noch seltener

Bitte beantworten Sie die folgenden Fragen ***in Bezug auf die eben von Ihnen ausgewählte Kunstdomäne.*** *Dabei sollen Sie beurteilen, wie oft die folgenden emotionalen und physischen Zustände bei Ihnen ausgelöst werden, wenn Sie dieser Kunstdomäne ausgesetzt sind:*

Wie oft fühlen Sie sich vollkommen eingenommen von und versunken in ihr Erleben?
niemals oder selten1 2 3 4 5 6 7 fast immer

Wie oft verlieren Sie vollkommen das Zeitgefühl?
niemals oder selten1 2 3 4 5 6 7 fast immer

Wie oft fühlen Sie einen Schauer über Ihren Rücken laufen?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft bekommen Sie eine Gänsehaut?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft haben Sie das Gefühl ganz woanders zu sein?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft haben Sie das Gefühl, dass Ihnen die Haare zu Berge stehen?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft haben Sie das Gefühl, weinen zu müssen?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft fühlen Sie sich tief berührt?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft fühlen Sie sich von Ihrer Umgebung losgelöst?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Wie oft fühlen Sie sich von Ehrfurcht und Staunen ergriffen?
niemals oder selten 1 2 3 4 5 6 7 fast immer

Face Rating Task

Image and Scale Presentation

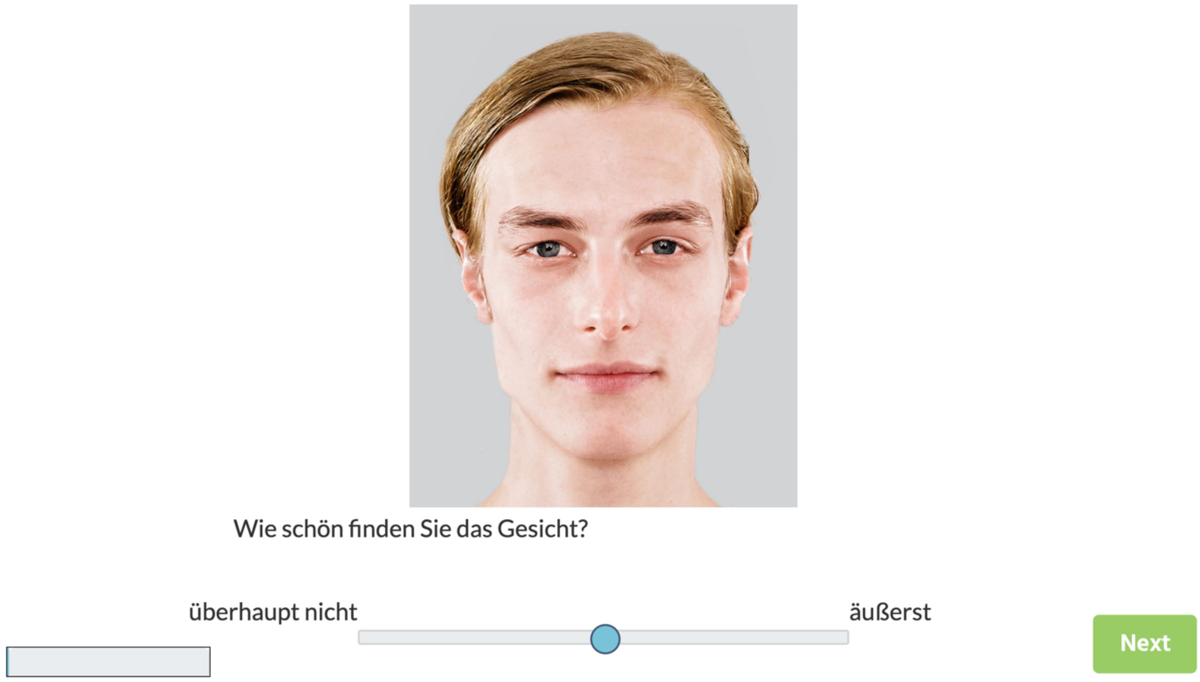


Figure 8. Image and scale presentation.
The exact way the face images and used scales were presented to participants.

Assessed Questions/Variables

(beauty)
Wie schön finden Sie das Gesicht?
überhaupt nicht äußerst

(interest)
Wie interessant finden Sie das Gesicht?
überhaupt nicht äußerst

(arousal)
Wenn ich dieses Gesicht betrachte, fühle ich mich..,
sehr ruhig sehr
aktiviert

(valence)
Wenn ich dieses Gesicht betrachte, fühle ich mich..,
sehr negativ sehr positiv

(liking)
Wie sehr gefällt Ihnen das Gesicht persönlich?
überhaupt nicht äußerst

(aesthetically moving)
Wie ästhetisch bewegend finden Sie das Gesicht?
überhaupt nicht äußerst

Additional Assessment

Was bedeutet für Sie ästhetisch bewegend?
(Open Question)

Fühlten Sie sich gehemmt, Gesichter, die Sie als hässlich empfanden, dementsprechend negativ zu bewerten?
Ja
Nein

Prescreening of Participants

fMRI Suitability

Sind sie Rechtshänder?
Ja
Nein
Ich bin mir nicht sicher

Sind sie derzeit schwanger?
Ja
Nein
Ich bin mir nicht sicher

Haben sie elektrische, magnetische oder mechanische Implantate (Herzschrittmacher, Cochlea-Implantat, Insulinpumpen, etc.) oder andere medizinische Implantate oder Prothesen (Kupferspirale, festsitzende Zahnspange)?
Ja
Nein
Ich bin mir nicht sicher

Verfügen sie über Metallteile in/an Ihrem Körper (nicht entfernbare Piercings, Aneurysmen-Clips, Kugel/Kugelsplitter, Metallsplitter im Auge, etc.)?
Ja
Nein
Ich bin mir nicht sicher

Haben Sie ein unkorrigiertes (nicht durch Brille oder Kontaktlinsen korrigiertes) stark beeinträchtigtes Sehvermögen?
Ja
Nein
Ich bin mir nicht sicher
Haben in der Vergangenheit an neurologischen Störungen gelitten oder Hirnverletzungen gehabt?

Ja
Nein
Ich bin mir nicht sicher

Leiden sie unter Klaustrophobie?
Ja
Nein
Ich bin mir nicht sicher?

Haben Sie weitere Fragen bzw. Anmerkungen?
(Open Question)

Vividness of Visual Imagery Questionnaire (VVIQ)

Schließen Sie die Augen. Denken Sie an eine mit Ihnen verwandte oder befreundete Person, die Sie häufig sehen (aber die im Moment nicht bei Ihnen ist), und betrachten Sie sorgfältig das Bild, das Sie vor Ihrem geistigen Auge sehen. Bewerten Sie anschließend die folgenden Aspekte danach, wie anschaulich Sie diese vor Ihrem geistigen Auge gesehen haben:

Die genaue Kontur von Gesicht, Kopf, Schultern und Körper.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Charakteristische Kopfhaltung, Körperhaltungen, etc.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Die genaue Haltung, Schrittlänge etc. beim Gehen.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Die verschiedenen Farben der Kleidung, die die Person häufig trägt.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Denken Sie daran, dass Sie vor einem Laden stehen. Betrachten Sie sorgfältig das Bild, das Sie vor Ihrem geistigen Auge sehen. Bewerten Sie anschließend die folgenden Punkte:

Das Gesamtbild des Ladens von der gegenüberliegenden Straßenseite aus.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Eine Schaufensterdekoration mit Farben, Formen und Details von einzelnen Verkaufsartikeln.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Sie sind in der Nähe des Eingangs. Die Farbe, Form und Details der Tür.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

Sie betreten den Shop und gehen zur Theke. Die Thekenkraft bedient Sie. Geld wechselt den Besitzer.
überhaupt nicht anschaulich 1 2 3 4 5 äußerst anschaulich

fMRI Study

Instructions

Die **Fragen**:

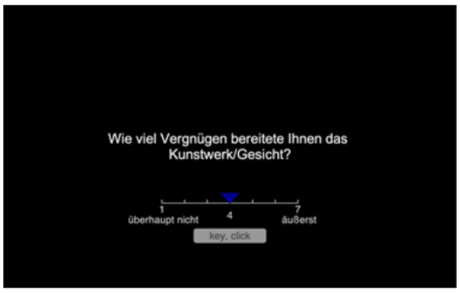
„Wie schön fanden Sie das Image?“

Bei dieser Frage geht es uns darum, dass Sie auf einer Skala von 1-7 angeben, wie schön Sie das Gesicht/Kunstwerk fanden, wobei 1 bedeutet, dass Sie das Gesicht/Kunstwerk überhaupt nicht schön fanden und 7 bedeutet, dass Sie das Gesicht/Kunstwerk extrem schön fanden. Auf dem Bildschirm wird bei 1 “überhaupt nicht” und bei 7 “äußerst” zu sehen sein.

Zurück **Weiter**

“Wie viel Vergnügen bereitete Ihnen das Image”

Bei dieser Frage geht es darum, dass Sie auf einer Skala von 1-7 angeben, wie viel Vergnügen Ihnen das Betrachten des Gesichts/Kunstwerks bereitet, wobei 1 bedeutet, dass Ihnen das Betrachten überhaupt kein Vergnügen bereitet hat und 7 bedeutet, dass Ihnen das Betrachten äußerst viel Vergnügen bereitet hat.



Zurück **Weiter**

„Wie ästhetisch bewegend fanden Sie das Image?“

Bei dieser Frage geht es uns darum, dass Sie auf einer Skala von 1-7 angeben, wie ästhetisch bewegend Sie das Gesicht/Kunstwerk fanden, wobei 1 “gar nicht bewegend” und 7 “sehr bewegend” bedeutet.

"Ästhetisch bewegend” bedeutet, dass das Image Sie emotional oder physiologisch bewegt oder berührt. Dies drückt sich durch das Erleben von intensiven Emotionen (aller Art) aus, möglicherweise auch durch körperliche Veränderungen: wie Herzklopfen, Gänsehaut, Veränderung der Atemfrequenz, ein Schauer, der den Rücken runterläuft, etc. Oft treten sogenannte “Chills” auf. Chills äußern sich z.B indem Ihnen ein kalter Schauer über den Rücken läuft oder Sie eine Gänsehaut bekommen. Viele Menschen erleben Chills, wenn sie emotionale Musik hören oder einen emotionen Film schauen. Jeder Mensch empfindet Chills aber anders, manche empfinden gar keine körperliche Reaktionen."

Zurück | Weiter

Anschließend werden Ihnen die gleichen Fragen gestellt wie eben besprochen, die Sie wieder mittels der Button Box so schnell wie möglich beantworten. Zusätzlich wird noch eine vierte Frage gestellt:

Bei dieser Frage geht es uns darum, dass Sie auf einer Skala von 1-7 angeben, wie klar und anschaulich Sie das vorgestellte Gesicht/Kunstwerk vor Augen hatten, wobei 1 bedeutet, dass Sie gar kein Gesicht/Kunstwerk vor Ihrem geistigen Auge gesehen haben und 7 bedeutet, dass Sie eine so klare Vorstellung hatten, als ob Sie das Image wirklich betrachten würden. Auf dem Bildschirm wird bei 1 “überhaupt nicht” und bei 7 “äußerst” zu sehen sein.

Zurück | Weiter

Nachdem Sie alle Fragen beantwortet haben, erscheint eine Aufforderung sich das zuvor betrachtete Gesicht/Kunstwerk vorzustellen ("Vorstellen, Augen schließen"). Schließen Sie dabei bitte die Augen und fangen Sie sofort an, sich das Gesicht/Kunstwerk vorzustellen. Wenn der erste Ton ertönt, sollten Sie das Image schon gut vor Ihrem inneren Auge sehen. Sobald der zweite Ton ertönt, öffnen Sie bitte wieder Ihre Augen.

fMRI Questions

(beauty)
Wie schön fanden Sie das Image?
überhaupt nicht äußerst

(aesthetically moving)
Wie ästhetisch bewegend fanden Sie das Image?
überhaupt nicht äußerst

(pleasure)
Wie viel Vergnügen bereitete Ihnen das Image?
überhaupt nicht äußerst

(vividness)
Wie anschaulich war ihre Vorstellung?
überhaupt nicht äußerst

Example Face Stimuli

Figure 9. Example face stimuli.
Two of the 20 face stimuli used in the fMRI experiment.

Example Artwork Stimuli

Figure 10. Example artwork stimuli.
Two of the 20 artwork stimuli used in the fMRI experiment.