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„The influence of experienced vividness of visual mental imagery on the similarity of aesthetic ratings between visual perception and visual mental imagery"

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Marc Esmeyer, BSc

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

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1 Introduction

1.1 Theoretical background

Humans are visual creatures, at least when we look at the amount of cortical tissue associated to processing visual information (Pearson, 2019b, p. 624; Wandell et al., 2007). Visual perception plays a fundamental role in a human's everyday live. This is supported by a complex cortical system, which is structured in a dorsal and a ventral stream, both being functionally separated (Mishkin et al., 1983). In short, the ventral stream is involved in object recognition and memory while the dorsal stream is involved in action and attention (Ward, 2019).

We do not perceive the raw sensory input from our eyes, instead we perceive a filtered and modified version of the sensory input. While sensation refers to the effect of a stimulus on the sensory organs, perception includes the elaboration and interpretation of a sensory stimulus (Ward, 2019). With the Kanizsa Illusion (Kanizsa, 1976) the difference between sensation and perception can be illustrated. While there is no white triangle present in the image, we still perceive a white triangle. Our brain superimposes information based on experiences about geometric structures in this case. In other words, top-down processes can influence visual perception to some extent. In fact, top-down processes even can create visual imagery without any sensory input. This ability is called Visual Mental Imagery (VMI). Generally, mental imagery is found in all 5 senses, still research on the visual sense tends to dominate (Pearson, 2019b).

The concept of mental imagery arises in the empirical sciences at the end of the 19th century to then become obsolete again with the upcoming behaviorism. Since the behaviorism, as the dominating paradigm at that time, denies the existence of mental images in general, the research progress of mental imagery was limited until the early 1970s. From then on, when the limitations of the behavioristic view became visible, the cognitive paradigm became the dominating one. This process became known as the cognitive revolution. With it, the research of mental imagery started to rise again. Still, research of mental imagery was facing a serious problem – mental imagery was lacking a proper definition, and it was relying on introspection. Introspection could not be reasonably, scientifically researched, at least not at that time. Back then, before neuroimaging even was invented, VMI was researched behaviorally and was often correlated with the "scanning" process of the eyes (Deckert, 1964). One goal was to identify how VMI is represented in the brain. For example, when we see a photograph, our eyes fixate different parts of the photograph at different times, resulting in a certain pattern. In short, if a similar scanning pattern exists during VMI, one can assume that VMI is represented in a depictive format. At the same time a heated debate started to arise. The so-called "imagery debate" dealt with questions about how visual information is stored in the human's mind. Two views were most prominent in this debate, namely the propositional view and the depictive view. The propositional view states, images are only stored in a language-like manner, while the depictive view states, that images can additionally be stored in a pictorial format – potentially like weak percept. (Pearson & Kosslyn, 2015). The debate seemed to be in a dead end since no experiments could verify one or the other view.

This changed in the early 1990s with the first functional magnetic resonance imaging (fMRI) scans. With fMRI, brain activity can be indirectly measured to identify neural underpinnings of mental processes, like VMI. Studies using fMRI especially checked if VMI activates the primary visual cortex (V1, brodmann area 17) since this is the first cortical area receiving input from the eyes over the lateral geniculate nucleus (Bear et al., 2016; Pearson & Kosslyn, 2015). The primary visual cortex is topographically organized, which means that the structure of the retina is roughly preserved in those areas. Based on this, it is suggested that the primary visual cortex stores visual information in a pictorial format. If VMI activates the primary visual cortex, it would indicate that VMI at least partly relies on representations in form of pictorial information (S. M. Kosslyn et al., 2001b) In 2015, Pearson and Kosslyn claimed the imagery-debate to be resolved (Pearson & Kosslyn, 2015). They argued that "recent empirical evidence now strongly supports the claim that humans can represent information in multiple ways" (Pearson & Kosslyn, 2015, p. 10089). Since research showed that VMI can also rely on pictorial representation, the question arises whether there are interindividual differences in the degree of clarity or vividness, with which images can be seen in front of the mind's eye.

Arguably the first experiment on imagery vividness was performed by Francis Galton in 1880. He told 100 adult men to "think of some definite object -- suppose it is your breakfast-table as you sat down to it this morning -- and consider carefully the picture that rises before your mind's eye" (Galton, 1880) and afterwards asked questions about color, illumination, and the definition of the imagined objects. The replies to the questions about illumination ("Is the image dim or fairly clear? Is its brightness comparable to that of the actual scene?") and the definition ("Are all the objects pretty well defined at the same time, or is the place of sharpest definition at any one moment more contracted than it is in a real scene?") were combined under the single head of "Vividness". Galton then classified the replies according to the degree of vividness, ranging from 1 (“Brilliant, distinct, never blotchy”) to 100 (“My powers are zero. To my consciousness there is almost no association of memory with objective visual impressions. I recollect the breakfast table, but do not see it”). In short, the degree of vividness ranges from the complete absence of VMI known as “aphantasia” (Dawes et al., 2020; Fulford et al., 2018b; Pearson, 2019b; Zeman et al., 2015, 2016) to highly vivid, perception-like imagery, coined “hyperphantasia” (Pearson, 2019b; Zeman et al., 2020). Since Galton’s survey in 1880, a significant number of studies were conducted to get a better understanding of vividness of visual mental imagery (VVMI). Especially studies using imaging procedures like fMRI were able to make an important contribution to this process by beginning to decode the underlying brain networks of VVMI step by step. It could be shown that there are interindividual differences in VVMI (Bergmann et al., 2016; Cui et al., 2007; Dijkstra et al., 2017; Lee et al., 2012). The research on differences within participants is scarce, yet a few studies started to untangle the neural underpinnings of VVMI. Importantly, Dijkstra et al. (2017) found that the more similar the neural response is during VMI compared to visual perception, the more vivid the imagery experience is.

The current study aims at replicating the findings from Dijkstra et al. (2017), who contrasted visual perception and VMI to check for the underlying brain networks. Further, the current study investigates how VVMI modulates the similarity of ratings for aesthetic experiences between visual perception and VMI as well as how VVMI is affected by different stimulus categories.

1.2. Visual Mental Imagery

1.2.1. What is Visual Mental Imagery?

What does your favorite shirt look like? Which socks did you wear yesterday? How many of your shoes fit in your freezer?

To answer those questions, visual mental imagery (VMI) is needed. VMI often is defined as quasi-perceptual experience in the absence of external stimulation (A. W. de Borst & Gelder, 2019, p. 2859; Senden et al., 2019, p. 1167; Thomas, 1999, p. 207). Sometimes it is referred to as “visualizing” or “seeing in the mind’s eye” (Amedi et al., 2005, p. 859; S. M. Kosslyn et al., 2001b; Stephen M. Kosslyn & Thompson, 2003, p. 723; Zeman et al., 2020, p. 426, 2020). VMI can be seen as a set of abilities, which let you see something, that may or may not exist, without visual input (Spagna et al., 2021, p. 201). This set of abilities is crucial for absolving several everyday tasks, since it is among other things associated with working memory (Albers et al., 2013), visual working memory (Pearson & Keogh, 2019), episodic memory (Greenberg & Knowlton, 2014), mental rotation (Cohen et al., 1996), perspective taking (Jackson et al., 2006), future event prospection (D'Argembeau & van der Linden, 2006), dreaming (Horikawa et al., 2013), and sentence comprehension (Just et al., 2004).

Importantly, under the umbrella term *imagery* fall different imagery tasks (Pearson, 2019b). There are VMI tasks in which an image is created and there are tasks in which an image is manipulated, like in a mental rotation task. Since both tasks are functionally different, they should involve different brain areas (Pearson, 2019b). Therefore it is important to note that those tasks must not be confused with each other, especially when comparing brain activation evoked by VMI (Pearson, 2019b).

1.2.2. Neuronal correlates of Visual Mental Imagery

VMI engages many different brain areas, from frontal areas to the primary visual cortex, whereas frontal areas are suggested to play an executive role as they seem to be active during imagery creation and manipulation (Schlegel et al., 2013), independently from the specific content (Ishai et al., 2000; Pearson, 2019a). An important area for the imagery content is the primary visual cortex (see also chapter 1.5.), where the stimulus category can be decoded during VMI (Albers et al., 2013), even 11 seconds before the voluntary decision which stimulus to imagine (Koenig-Robert & Pearson, 2019). Activation concerning nonvisual sensory processing in auditory and somatosensory cortex as well as bottom-up input in early visual areas (i.e. among other structures Brodmann areas 17, 18, and 19) specifically in superior colliculus and lateral geniculate nucleus appears to be inhibited during VMI (Amedi et al., 2005). This inhibition correlates with vividness of visual mental imagery (Amedi et al., 2005). Frontal areas, like the dorsolateral prefrontal cortex (DLPFC), seem to play an executive role in VMI, which is independent from the imagined content (Pearson, 2019b; Ranganath & D'Esposito, 2005; Schlegel et al., 2013). Together with the posterior parietal cortex (PPC), the DLPFC seems to be part of a network that maintains representation in working memory (Schlegel et al., 2013). The results of Schlegel et al. (2013) suggest the default mode network (DMN) plays a role in VMI. Specially, areas like the DLPFC, PPC, posterior precuneus and occipital cortex seem to be involved in the construction and deconstruction of mental images (Pearson, 2019b; Schlegel et al., 2013). Dijkstra et al. (2017) found stronger activity for VMI in contrast to visual perception in insula, left dorsal lateral prefrontal cortex, and medial frontal cortex.

1.3. Vividness of Visual Mental Imagery

Again, visualize your favorite shirt in front of your mind's eye. Do you see it as clear as you would perceive it? Can you visually imagine it at all? Or is it somewhere in between? The research of the variability of vividness of visual mental imagery is getting more attention since fMRI was used for psychological research (Fulford et al., 2018b; Olivetti Belardinelli et al., 2009; Zeman et al., 2020). Commonly, vividness of visual mental imagery is measured with the Vividness of Visual Mental Imagery Questionnaire (VVIQ) (Marks, 1973). The VVIQ is a self-report questionnaire consisting of 16 items, measuring the ability to create clear mental images in front of the mind's eye. The questions are rated on a scale from 1 ('Perfectly clear and as vivid as normal vision') to 5 ('No image at all, you only "know" that you are thinking of the object'). In other words, lower scores in the VVIQ indicate higher vividness. All 16 items are completed twice, once with eyes open and once with eyes shut.

1.3.1. What is Vividness of Visual Mental Imagery?

Vividness of Visual Mental Imagery (VVI) can be defined as the degree of clarity of visual mental imagery (Marks, 1973). VVI ranges, as not only the results of Galton's survey suggest, from the absence of visual mental imagery, also called "aphantasia" (Galton, 1880; Zeman et al., 2015, 2016), to the abundance of visual mental imagery, coined "hyperphantasia" (Pearson, 2019a; Zeman et al., 2020). Research of VVI mainly focused on interindividual differences in the degree of vividness, but more recently, the moment-to-moment variation of vividness became topic of research (Dijkstra et al., 2017). In detail, vividness of visual mental imagery as measured with the VVIQ correlates with the experienced vividness averaged across trials within participant ($r = -0.45$, $p = 0.02$) in a way that lower scoring participants rate their experienced moment-to-moment vividness higher (Dijkstra et al., 2017). Note that lower scores in the VVIQ indicate higher vividness.

1.3.2. Neuronal correlates of Vividness of Visual Mental Imagery

Vividness of Visual Mental Imagery (VVMI) as measured with the VVIQ (Marks, 1973) strongly correlates ($r = -0.73$, $p = 0.04$) with higher activity in early visual cortex during VMI (Cui et al., 2007, p. 476). Note that this correlation is negative, since low VVI scores indicate high visual cortex activity relative to the whole brain activity. Interestingly, there is evidence that both, high-level as well as low-level visual areas, are involved in VVMI tasks. Dijkstra et al. (2017) found an effect of VVMI on activation in the precuneus, right parietal cortex, medial frontal cortex, and parts of the early visual cortex. Prior research has shown that the experienced vividness of visual mental imagery correlates with brain activity in early visual cortex (r = -0.73, p = 0.04) (Cui et al., 2007). In detail this was measured by averaging the relative visual activity over the visualization window and then correlating it with the respective experienced vividness of visual mental imagery score (Cui et al., 2007). Fulford et al. (2018a) found positive correlations between imagery vividness and brain activation in regions of the fusiform gyrus, posterior cingulate, and parahippocampal gyri. Further, Fulford et al. (2018a) found negative correlations between imagery vividness and brain activation in parts of the anterior cingulate cortex and inferior frontal gyrus. Furthermore, brain activity in the early visual cortex is modulated by experienced imagery vividness (Dijkstra et al., 2017). In detail, Dijkstra et al. (2017) found that within-participant fluctuations in the experienced vividness are related to the amount of overlap of neural representations in visual cortex and parietal cortex between VMI and visual perception.

1.4. Relationship between visual perception and Visual Mental Imagery

Is VMI the same as “weak perception”? Early behavioral studies tried to answer that question by comparing the time used between solving an imagery task and a control task (S. M. Kosslyn, 1973; Pearson & Kosslyn, 2015; Shepard, R. N., & Metzler, J., 1971). The interpretation of those results based on reaction times in VMI can be ambiguous, it is difficult to draw clear conclusion from them about the similarity between visual perception and VMI (S. M. Kosslyn et al., 2001a). Further studies found similarities between VMI and visual perception in the spatial correspondence between fixation positions during perception and visual imagery (G. Borst & Kosslyn, 2008; Gurtner et al., 2021, p. 1; Johansson et al., 2012; Richardson & Spivey, 2000; Wynn et al., 2018), indicating a depictive “perception-like” representation of VMI. Furthermore, studies using the binocular rivalry paradigm found that VMI can influence visual perception (Pearson et al., 2008; Slotnick, 2008).

To get a better understanding of the relationship between VMI and visual perception, a closer look at the overlap in brain activity between VMI and visual perception is necessary.

1.4.1. Neural overlap engaged by visual perception and visual mental imagery

Visual perception integrates signals from both bottom-up and top-down pathways in a fashion, that both processes can influence each other (Hsieh et al., 2010, p. 1501; Huang et al., 2021; Kastner et al., 1998; Uithol et al., 2021), while VMI does not rely on sensory bottom-up input to function (Reddy et al., 2010). Since top-down processes are thought to originate in higher cortical areas, it is suggested that the similarity in brain activity between visual perception and VMI is stronger in higher visual areas and declines in lower visual areas

(Pearson, 2019b). Ishai et al. (2000, p. 985) found brain activity during imagery but not perception in regions of parietal and frontal cortex “which may mediate the ‘top-down’ control of generating and maintaining mental images”. Also in frontal and parietal cortices, a stronger overlap between brain areas engaged by visual perception and visual mental imagery was found by Ganis et al. (2004).

The results of some studies suggest that VMI is nothing else but “weak perception”, while others indicate differences between both processes. For example, Amedi et al. (2005) found a deactivation of auditory cortex during imagery but not during visual perception. Lee et al. (2012) even found differences between VMI and visual perception within visual modality processing. Ganis et al. (2004) suggest brain areas engaged by visual imagery to be a subset of those engaged by visual perception. In early visual areas, a correlation ($r=0.691$, $p<0.01$) between the overlap of visual perception and VMI with VVIQ scores was found (Lee et al., 2012) and considering brain activity only in early visual areas (i.e. V1,V2, and V3), mental images are suggested to be „‘perception-like‘ in nature“ (Albers et al., 2013, p. 1431).

In short, this indicates that the early visual cortex might have a special role in VMI.

1.5. Role of the primary visual cortex

The primary visual cortex received a significant amount of attention in research on VMI and VVMI. Because of its topographical organization, the early visual cortex is a key area to identify the representational organization of VMI in the brain. Since the early visual areas both send and receive projections from high-level areas (Pearson et al., 2015), the research of those areas is expected to significantly contribute to a better understanding of VMI. For example, decoding the underlying mechanisms of VMI could help to get a better understanding of how experiences, expectations and beliefs could alter our perception, even at such an early stage of processing (S. M. Kosslyn et al., 2001a). The results of Goebel et al. (1998) suggest that imagery related activation is present in V1 (i.e. Brodmann area 17), but it is not as pronounced as in V2 (i.e. Brodmann area 18) and V3a (i.e. part of Brodmann area 19). The role of primary visual cortex seems to significantly differ between individuals. Bergmann et al. (2016) found a negative relationship between the size of V1-surface area and imagery strength, and a positive relationship between V1-surface area and imagery precision. They additionally found that “subjective vividness of imagery was positively related to prefrontal cortex volume, but unrelated to V1 anatomy” (Bergmann et al., 2016, p. 3838).

1.6. Visual Mental Imagery as a Visual Working Memory Strategy

When memories for visual information are retained or manipulated over short term, then they are part of the Visual Working Memory (VWM) (Keogh et al., 2021; Schurgin, 2018). The results of Keogh et al. (2021) suggest that visual imagery might be one of multiple tools that can be used to solve a visual working memory task. Potentially the most influential model of VWM is Baddeley's multicomponent model (A. Baddeley, 1992; A. D. Baddeley & Hitch, 1974). The model consists of three components, namely the central executive, the visuospatial sketchpad, and the phonological loop. The central executive is thought to control attention (limited capacity). The visuospatial sketchpad and the phonological loop are seen as subsidiary slave systems, which help maintain and manipulate specific sensory information. The visuospatial sketchpad is involved in visual imagery and processes visual information, while the phonological loop processes auditory and verbal information (A. D. Baddeley & Andrade, 2000). Baddeley (2000) suggested the episodic buffer to be a third subsidiary slave system, which is thought to bind information from the visuospatial sketchpad, the phonological loop, and the long-term memory together. According to the model, the episodic buffer is able to hold multimodal information for a limited time (A. Baddeley, 2000). Newer research suggests that the visuospatial sketchpad can be functionally separated into the visual cache and the visual buffer (Cocchini et al., 2002). It is suggested that the visual cache can mediate the short-term retention of visual representations generated by both, through visual input and from information stored in the long-term memory (G. Borst et al., 2012; Pearson & Keogh, 2019). The visual buffer is thought to form and shortly maintain low-level visual representations, while those representations are being easily disrupted by incoming visual information, even if it is irrelevant (G. Borst et al., 2012). The visual cache is associated with the posterior parietal cortex while the visual buffer relies on the primary visual cortex (Pearson & Keogh, 2019).

As already mentioned, VMI could be used as a VWM strategy (Keogh et al., 2021; Pearson & Keogh, 2019). For example, in a cued imagery task, where participants first see a visual stimulus and then imagine the same visual stimulus, participants could hold the stimulus in VWM rather than recreating the imagery of the stimulus. Positive correlations were found between VMI strength and VWM performance, but not between VMI strength and iconic or numerical working memory (Keogh & Pearson, 2011, 2014). When conducting a study on VMI it therefore can be necessary to be able to differentiate if participants relied on VMI or VWM.

1.7. Role of Stimulation

Different stimuli, for example faces and artworks, evoke different patterns of stimulation (Leder et al., 2016; Marković, 2014; Schulz & Hayn-Leichsenring, 2017). The ratings of attractiveness and (artistic) beauty of art portraits are correlated (Hayn-Leichsenring et al., 2013). The results of Schulz & Hayn-Leichsenring (2017) suggest that the processing of attractiveness is predominantly perceptually driven, while the appreciation of artistic beauty is at least partly modulated by cognition. Marković (2014) investigated the structure of the experience of beauty and whether it is domain-specific or domain-general. The results of Marković (2014) suggest that the experience of beauty was partially domain-specific. Specifically, they found that the experience of beauty was associated more with pleasure in environmental objects and artworks while it was associated more with harmony in human faces and bodies and abstract forms. Further, stimuli properties like complexity and symmetry seem to be important factors to predict aesthetic judgments (Jacobsen, 2004; Jacobsen et al., 2006). The results of Leder et al. (2016) suggest, that beauty ratings of abstract artworks have more inter-individual variability than beauty ratings of faces.

1.7.1. The role of complexity

When it comes to Visual Mental Imagery, Sunday et al. (2017, p. 733) found that "domain-specific imagery relates most strongly to general imagery vividness and less strongly to self-reported expertise, while it does not relate to perceptual or semantic expertise". Concerning stimulus properties, one aspect seems to play an important role in imagery vividness, namely the complexity of the stimulus. Dijkstra et al. (2017) found that letters and fruits are experienced more vivid than faces. Average trial-by-trial vividness ratings were significantly higher for the imagery of letters ($p < .01$) and fruits ($p < .05$) in comparison to faces (Dijkstra et al., 2017). Those three categories each had different levels of Kolmogorov complexity, with faces having the highest complexity.

1.8. Aesthetic Experiences

Not only VMI can elicit emotions in multiple ways (Holmes & Mathews, 2010), also visual stimuli, for example in form of an artwork, can elicit emotions (Belfi et al., 2019). Aesthetic experiences are not always (uniformly) defined (Pearce et al., 2016). Wassiliwizky & Menninghaus (2021) suggest an aesthetic experience to be emotionally and hedonically engaging. With the aesthetic triad, Chatterjee & Vartanian (2014) came up with a model that aims to explain how certain neural systems influence the emergence of aesthetic experiences.

The three neural system are “sensory-motor”, “knowledge-meaning”, and emotion-valuation”. In short, aesthetics experiences rely on sensation, perception, motor-system, expertise, context, culture, reward, emotion, wanting/liking. Aesthetic experiences can be measured with the Aesthetic Experience Scale (AES) (Silvia & Nusbaum, 2011). The AES is a self-report scale consisting of 10-items, which assesses the ability of an individual to experience aesthetic experiences. Responses to the AES are measured on a 7-point Likert-type scale ranging from 1 (“never”) to 7 (“nearly always”).

It is suggested that beauty plays a fundamental role in aesthetic experiences (Pearce et al., 2016; Wassiliwizky & Menninghaus, 2021). It is not easy to define beauty (Pearce et al., 2016; Schulz & Hayn-Leichsenring, 2017; Xenakis & Arnellos, 2022) since there are many different principles of aesthetics that might not always be compatible with each other (Horng & Hsu, 2020; Hu et al., 2016). A common approach is to define the experience of beauty as a pleasurable aesthetic experience that is the outcome of the multi-stage processing of an aesthetic object (Hu et al., 2016; Leder et al., 2004b; Leder & Nadal, 2014). The experience of beauty seems to be partially dependent on the domain (Marković, 2014) (see chapter 1.7.), and it seems to be more objective for faces than for abstract art (Leder et al., 2016).

While aesthetic experiences can relate to beauty, there is more to it than beauty alone (Pearce et al., 2016; Wassiliwizky & Menninghaus, 2021). Pleasure can be seen as motivator for individuals to pursue rewards (Berridge & Kringelbach, 2015). Berridge et al. (2009) describe three dissociable psychological components of reward, namely “liking”, “wanting”, and “learning”. Chatterjee (2014) calls the state of liking without wanting a “pleasurable aesthetic emotion” and links aesthetic experiences to pleasure in general. Previous studies suggest aesthetic experience and pleasure are linked by considering aesthetic experiences to be rewarding processes (Leder et al., 2004a; Mastandrea et al., 2019; Silvia, 2005).

In an aesthetic context, the feeling of being *(aesthetically) moved* are typically accompanied by pleasure, independently of the emotional valence of the stimulus (Belfi et al., 2019; Menninghaus et al., 2015; Menninghaus et al., 2017). The concept of *aesthetically moving* is not always well defined and further is not always well understood (Menninghaus et al., 2015). Menninghaus et al. (2015) sketch the psychological construct of being moved. Being moved can be, among others, associated with the experience of emotions (positive and negative) and potential physiological reactions like chills (goose bumps and/or shivers down the spine) (Menninghaus et al., 2015).

1.8.1. Neuronal correlates of Aesthetic Experiences

Generally, aesthetic experiences might be connected to two different neural systems, one consisting among of others of reward-related regions (Berridge & Kringelbach, 2008), and the other one consisting among others of parts of the default mode network, more specifically of anterior medial prefrontal cortex, posterior cingulate cortex and hippocampus (Vessel et al., 2012). While the first system is associated with aesthetic appreciation, most moving artworks led to a selective activation of central nodes of the second system (Vessel et al., 2012).

For the experience of beauty the medial orbitofrontal cortex seems to play an important role (Belfi et al., 2019; Blood & Zatorre, 2001; Ishizu & Zeki, 2011; Kawabata & Zeki, 2004). Concerning artworks, the experience of beauty is associated with the motion area V5/MT+ (Cattaneo, 2020; Thakral et al., 2012) and the anterior prefrontal cortex (Thakral et al., 2012). Another important brain structure for the experience of beauty seems to be the insula. The results of Di Dio et al. (2007) suggest that the joint activation of neurons responding to the physical properties of a stimulus and neurons located in the insula might be an indicator of a more beautiful perception of that stimulus. For the perception of facial attractiveness, the dorsolateral prefrontal cortex might play a role (Cattaneo, 2020; Ferrari et al., 2015), as well as the fusiform face area and part of the ventral striatum (Chatterjee et al., 2009; Chatterjee & Vartanian, 2016). Individual differences in facial attractiveness seem to be connected to activation in middle temporal gyrus (Vartanian et al., 2013).

Insula is not solely associated with beauty but also with pleasure. The results of previous studies on different topics concerning pleasure, like pleasure in sexuality (Cacioppo et al., 2012; Georgiadis et al., 2012), parent-infant relationship (Parsons et al., 2010), anticipation and experience of peak emotion to music (Salimpoor et al., 2011), viewing paintings (Vartanian & Skov, 2014), and in viewing faces of opposite- and same-sex romantic partners (Zeki & Romaya, 2010), suggest the existence of a reward network including parts of the prefrontal, orbitofrontal, and anterior cingulate cortex, parts of insula, as well as nucleus accumbens, ventral palldium, and amygdala (Berridge & Kringelbach, 2015). Further, activity in default mode network was greater for pleasing images (in the 5 seconds after imagery onset) (Belfi et al., 2019). Usually, the default mode network is active while self-centered tasks or at rest (Raichle, 2015).

The anterior prefrontal cortex is not only associated with beauty in respect to artworks, but also with the experience of being aesthetically moved (Vessel et al., 2012). More specifically, the results of Vessel et al. (2012) suggest, that parts of the default mode network, namely the anterior medial prefrontal cortex, posterior cingulate cortex and hippocampus, are engaged in the perception of (highly) aesthetically moving artworks. The results of Belfi et al. (2019) suggest that nucleus accumbens and nucleus caudate only correspond to aesthetic appreciation during longer trial durations, specifically durations of 5 and 15 seconds. If that is true, trials need to be presented at least 5 to 15 seconds long, so that activity caused by aesthetic appreciation could be measured in those brain areas.

1.9. Relationship between Aesthetic Experiences and Visual Mental Imagery

Previous research has shown that visual imagery ability as measured with the VVIQ predicts the aesthetic appeal of sophisticated art forms such as haiku (Hitsuwari & Nomura, 2022). Also, the experienced vividness predicts haiku's aesthetic appeal (Belfi et al., 2018; Hitsuwari & Nomura, 2022). In both studies, aesthetic appeal ("How enjoyable or aesthetically appealing did you find this poem?") was rated on a continues scale from 0 to 100 (Belfi et al., 2018). Aesthetic features seem to be connected to the visual memorability, Wallraven & Freese (2015) found a weak relationship between aesthetics and memorability for art and photos of everyday scenes. Furthermore, facial attractiveness is suggested to modulate face processing, independently from facial expression (Marzi & Viggiano, 2010). Generally, the research of the relationship between vividness of visual mental imagery and aesthetic experiences is scarce.

2 Current study

2.1 Context of the study

This work is part of a larger project, which investigates underlying neuronal correlates of visual perception and visual mental imagery to find out whether aesthetic experiences require sensory perception. In this larger project, properties of network connectivity of the medio orbitofrontal cortex, the dorsolateral prefrontal cortex, and subcortical regions including caudate nucleus and the nucleus accumbens will be compared between visual perception and visual mental imagery by using functional magnetic resonance imaging (fMRI). Additionally, the relationship of ratings of aesthetic experiences during visual perception and visual mental imagery of aesthetic stimuli will be analyzed, as well as the relationship between ratings of the aesthetic experience and connectivity of the underlying network for perception and imagery.

In this study, when we talk about aesthetic experiences, we refer to three different concepts, namely beauty, aesthetically moving, and pleasure. We included these three concepts for several reasons. We included the concept *aesthetically moving* since we are convinced that it resembles aesthetic experiences the best. Though *aesthetically moving* can be defined, it often is not defined. We believe that the concept of *aesthetically moving* is not uniformly understood without prior definition, which might limit the comparability to other studies. We think that *beauty* does not resemble aesthetic experiences as precise as *aesthetically moving* does. Though *beauty* is ill defined, it is used in numerous studies, so we included it in our study as well. *Pleasure* is a rather superficial measure for aesthetic experiences. We included *pleasure* anyway because it is well defined.

We use two categories of stimuli, namely faces and artworks. Beauty ratings of abstract artworks seem to have more inter-individual variability than beauty ratings of faces (Leder et al., 2016). Further, the experience of beauty seems to be partially domain-specific with it closer being associated with pleasure in artworks and closer associated with harmony in human faces (Marković, 2014). Consequently, by combining both categories of stimuli we can draw more general conclusions about aesthetic experiences. Importantly, artworks and faces can both elicit aesthetic experiences (Leder et al., 2016; Pelowski et al., 2017).

2.2 Goals of the study

Before we can actually address the main question (is sensory perception necessary for an aesthetic experience?), it is important to clarify some intermediate steps. First, we need to replicate previous findings identifying the specific role of brain areas in mental imagery. In case of a successful replication, this thesis provides a more solid empirical ground for the larger project. Previous research connecting VMI, VVMI and aesthetic experiences is scarce. To provide crucial information about the relationship of the variables used in the larger project, the current study also explores the role of vividness of visual mental imagery, especially how it is affected by different stimuli, and how it affects not just mental imagery in general but the aesthetic experience specifically. This is the focus of the present thesis.

In detail, previous findings by Dijkstra et al. (2017) are meant to be replicated. Generally, replication studies make an important contribution to the validation of knowledge. Especially when researching latent concepts, replication studies can function as a supporting pillar to validate the results of a study. Furthermore, the importance of replication studies became especially evident, when it became public that some researchers fabricated data on a large scale. The resulting "crisis of confidence" (Pashler & Wagenmakers, 2012) led to the conclusion that "replications are considered a powerful weapon in science's armor for the protection against fraud" (Stroebe et al., 2012, p. 679). The reasons for the crisis of confidence are not limited to fraud, p-hacking (Simonsohn et al., 2015), file drawering of negative or inconclusive results (Rosenthal, 1979), problematic measurement (Lilienfeld & Strother, 2020), and other questionable research practices (Fiedler & Schwarz, 2016; John et al., 2012) – a lack of sufficient definitions of latent concepts might have also contributed to the crisis. On the other hand, replication studies are essential to validate the results of preceding studies. Every study takes place at a certain place at a certain time. While the results of a study without doubt are influenced by the sample, the sample in turn is influenced by several context factors. Influencing context factor are for example, the country and culture the participants grew up in, the current season, the weekday, and the current mood of the participants. A sufficient sample size is thought to eliminate unwanted distortions. However, calculating the sufficient sample size can be tricky and might lead to errors (Anderson & Maxwell, 2017). Replications of findings with differences in the sample composition and other relevant factors helps to validate those findings. In this case, the study design of this study differed from Dijikstra et al. (2017). While Dijikstra et al. (2017) also implemented a within-subject design using the same stimulus multiple times with each participant, the current study only used every stimulus once per participant. Also, Dijikstra et al. (2017) used an adapted retro-cue working memory paradigm, where each of their six stimuli was perceived 60 times and imagined 30 times. We used a within-subject block-design to compare two conditions, namely visual perception, and Visual Mental Imagery and our 40 stimuli were each perceived once and imagined once. Our sample (21 females, 12 males, and 1 divers; mean age: 23,48 years, SD = 4.01, range = 18-34) was similar to the sample of Dijikstra et al. (2017) (18 females, 8 males; mean age: 24.31, SD = 3.05). With approximately 1 hour scanner time per participant our experiment was 30 minutes longer than the one from Dijikstra et al. (2017).

Before novel conclusions can be drawn from the data of this study, it is necessary for the findings to be replicated. Further hypotheses then will stand on a more solid empirical ground.

2.3 Hypotheses

To reach these above specified goals, the current study addresses three hypotheses.

1. *Does Visual Mental Imagery lead to stronger activity in insula, left dorsal lateral prefrontal cortex, and medial frontal cortex and weaker activity in the whole ventral visual stream compared to visual perception?*

Brain regions in insula and medial frontal lobes seem to be activated more strongly during VMI in high imaginers than low imaginers as measured with the Vividness of Visual Mental Imagery Questionnaire (VVIQ) (Fulford et al., 2018a). Medial frontal cortex, more specifically the mesial superior frontal gyrus (SFG), seems to be associated with imagery performance (Aline W. de Borst et al., 2012) and attentional demand of the task (Trojano et al., 2000). Further, mesial SFG seems to have an integrative role, as they "are suggested to drawn on remote parietal regions for retrieval and representation of the spatial content of the scene and occipital–temporal regions for detailed visual representation of the objects" (Aline W. de Borst et al., 2012). Right parietal cortex has been associated with percept stabilization (Zaretskaya et al., 2010) and spatial comparison (Aline W. de Borst et al., 2012; Sack et al., 2005). Dijkstra et al. (2017) found that both visual perception and Visual Mental Imagery (VMI) activate large parts of the visual cortex. In detail, their results suggest that VMI leads to stronger activity in insula, left dorsal lateral prefrontal cortex, and medial frontal cortex and weaker activity in the whole ventral visual stream compared to visual perception. These findings of Dijkstra et al. (2017) are meant to be replicated.

2. *Behavioral: Does experienced vividness of Visual Mental Imagery positively affect the similarity of aesthetic ratings and pleasure ratings between Visual Mental Imagery and visual perception?*

Previous research has shown that vividness of visual mental imagery can predict aesthetic appeal ($ß = 0.36$, $SE = 0.02$, $t = 15.82$, $p < .001$) in poems, with aesthetic appeal ("How enjoyable or aesthetically appealing did you find this poem?") being rated on a continues scale from 0 to 100 (Belfi et al., 2018). Generally, the research of the relationship between vividness of visual mental imagery and aesthetic experiences is scarce. In this study, the relationship of ratings in beauty, aesthetically moving and pleasure between visual perception and visual mental imagery are meant to be explored. Similarity of aesthetic ratings is operationalized as the difference between the ratings of the same stimuli during perception and during imagery. Previous studies found similarities between VMI and visual perception in the spatial correspondence between fixation positions during perception and visual imagery (G. Borst & Kosslyn, 2008; Gurtner et al., 2021, p. 1; Johansson et al., 2012; Richardson & Spivey, 2000; Wynn et al., 2018), indicating a depictive "perception-like" representation of

VMI. Under this assumption, we suggest that the more vivid VMI is experienced, the more similar the perceived stimulus and the corresponding visualized image should be. This should then be reflected in more similar ratings. Thus, when addressing the question whether sensory input is necessary for an aesthetic experience, it is crucial to control for the ability to imagine the experience that is rated.

3. a) *Behavioral: Are there effects of stimulus category on the experienced vividness of Visual Mental Imagery?*
   b) *Behavioral: If there would be an effect, does stimulus category moderate the effect of experienced vividness of Visual Mental Imagery on the similarity of aesthetic ratings and pleasure ratings between Visual Mental Imagery and visual perception*
   c) *Behavioral: Are there main effects of the experienced vividness of Visual Mental Imagery and stimulus category on the similarity of aesthetic ratings and pleasure ratings between Visual Mental Imagery and visual perception?*

Complex stimuli are experienced less vivid as tested in a retro-cue working memory paradigm (Dijkstra et al., 2017). More specifically, they found that letters and fruits are experienced more vivid than faces. Average trial-by-trial vividness ratings were significantly higher for the imagery of letters ($p < 0.01$) and fruits ($p < 0.05$) in comparison to faces (Dijkstra et al., 2017). Those three categories each had different levels of Kolmogorov complexity, with faces having the highest complexity. Since we do not find it very convincing that there is a large systematical difference in complexity between our selection of artworks and faces, we do not expect any effects of stimulus category on the experienced vividness. However, Sunday et al., (2017) associated better imagery vividness in a specific domain with more self-reported experience with and interest in the given domain, but this was independent of the actual quality, the perceptual skills or knowledge in that domain. Thus, there may be other effects of the stimulus category on vividness (see hypothesis 3a).

If there is indeed an effect of stimulus category on vividness in our data, it is also necessary to investigate whether the effect of vividness on the similarity is moderated by different stimulus categories (see hypothesis 3b).

The results of Marković (2014) suggest that the experience of beauty was partially domain specific. Specifically, they found that the experience of beauty was associated more with pleasure in environmental objects and artworks while it was associated more with harmony in human faces and bodies and abstract forms. Since stimulus category seems to influence aesthetic ratings and, depending on self-reported experience with and interest in a stimulus domain, also imagery vividness, we will again analyze the relationship without the interaction term to get a better understanding of the effects of the experienced vividness and stimulus category on the similarity of aesthetic ratings. In other words, we exploratively investigate the main effects of the experienced vividness of Visual Mental Imagery and stimulus category on the similarity of aesthetic ratings and pleasure ratings between Visual Mental Imagery and visual perception (see hypothesis 3c).

2.4 Relevance of the current study

This study aims at disentangling the mysteries of Visual Mental Imagery (VMI) one step further. VMI has the ability to be advantageous or even clinically relevant (Pearson, 2019b). There are several reasons why research on VMI and VVMI has a strong practical relevance. In visual perception feedforward and feedback signals are involved while VMI can function without bottom-up feedforward signals. For that reason, to understand the mechanisms of visual perception, research on VMI can be a key factor (Pearson, 2019b). Furthermore, in more clinical contexts, VMI might have great potential in reducing psychological strain. For example, VMI could help people in vegetative state to communicate (Owen et al., 2006). Here, a patient with severe traumatic brain injury, who fulfilled all criteria for a diagnosis of vegetative state according to international guidelines, was able to voluntarily imagine playing tennis and visit all the rooms in her house as measured with fMRI. Ongoing research can also help to find more effective treatments for neurological, psychological, and psychiatric disorders VMI is connected to, especially involuntary VMI. A psychosis or a hallucination can occur when the line between VMI and visual perception blurs (Amedi et al., 2005). Better treatments could help to reduce the intensity of involuntary imagery in form of flashbacks in people with post-traumatic stress disorder, craving inducing imagery in people with substance dependencies, and anxiety evoking imagery in persons with phobias, to name just a few examples (Holmes & Mathews, 2010; Pearson et al., 2015). On top of that, the quality of eyewitness testimonies could be improved (Dobson & Markham, 1993). Interestingly, Dobson & Markham (1993) found high imagery to be poorer at discrimination the source of items based on a written description than low visualizers.

In summary, research on VMI and VVMI not only can be crucial to understand visual perception but can also contribute to improve treatments for a variety of disorders and might improve eyewitness testimonies.

3 Pre-study

The study consists of two stages, a pre-study, and the main fMRI-study. The pre-study was designed to obtain ratings for stimuli, according to which the stimuli used for the main study could be selected. The pre-study was conducted online.

The pre-study was designed to obtain ratings for face-stimuli, which needed to be comparable to the ratings for the artworks. For comparability reasons the pre-study was set up analogous to the study introducing the Vienna Art Picture System (VAPS) (Schäfer, 2015). In the pre-study, 56 preselected face images were rated according to beauty, pleasure, aesthetically moving, interest, valence, and emotional expressiveness.

3.1 Methods and Materials

3.1.1 Participants

17 participants absolved the pre-study, all of which were recruited through the Laboratory Administration for Behavioral Science System (LABS-System) of the University of Vienna. The LABS-System is a database for the administration of study participants and associated studies. Throughout the study of psychology, students are obligated to earn LABS-credits to finish certain seminars. The way to earn LABS-Credits is to participate in studies. The pre-study took about 50 minutes, for which 4 LABS-Credits were earned. According to a power analysis in G*Power, a sample size of at least 8 was necessary to have a power above 0.8. For the power we calculated a one-tailed and one sample t-test against 50 for the mean of the beauty rating overall. This indicated us, that the stimuli elicited aesthetic experiences (effect size d: 1.017, alpha = 0.05, Actual Power: 0826). As there were different sets of example stimuli, while every face was rated in general, not every participant rated every face. Consequently, the number of the participants is not the crucial measure for the estimation of the power, but the number of the ratings per face, in this case specifically of the beauty ratings, is. Importantly, every single face was rated by at least 8 different participants.

Our sample consisted of 17 participants, 7 of which were female (41.2 %). The age ranged from 16 to 49 years (mean = 29.7, SD = 11.3).

N	17
Woman, n (%)	7 (41,2)
Age in years	
Mean	27,9
SD	11,3
Range	16 - 59
Sexual Orientation	
Heterosexual (of which woman)	11 (5)
Homosexual (of which woman)	1 (0)
Bisexual (of which woman)	5 (2)

Table 1
Sample description
Demographic information about the sample of the pre-study

3.1.2.1 Exclusion

We excluded one participant who rated significantly lower than the others and who was classified as an outlier. Three additional participants were excluded, because they felt inhibited to rate someone as not beautiful. One participant had left the full screen, but since the ratings seemed reasonable based on a visual inspection, the participant was not excluded.

3.1.2 Study Design

The pre-study was organized in three sections.

In the first section, participants were informed about the procedure, risks, the intention of the study, data recording and data protection, benefits and costs of the study, and their right to leave the study at any time without specification and without any disadvantages. After that, they had to give informed consent. To check for confounding variables, we assessed participants' age, gender identity, sexual orientation, and county of origin. Additionally, we assessed participants' level of German. To be included in the study, participants needed to be fluent in German, both written and spoken. Furthermore, a translated version of the Aesthetic Experience Scale (AES) (Silvia & Nusbaum, 2011) was included. With the AES we assessed participants frequency of experiencing aesthetic experiences (see chapter 3.1.3.2). Preceding

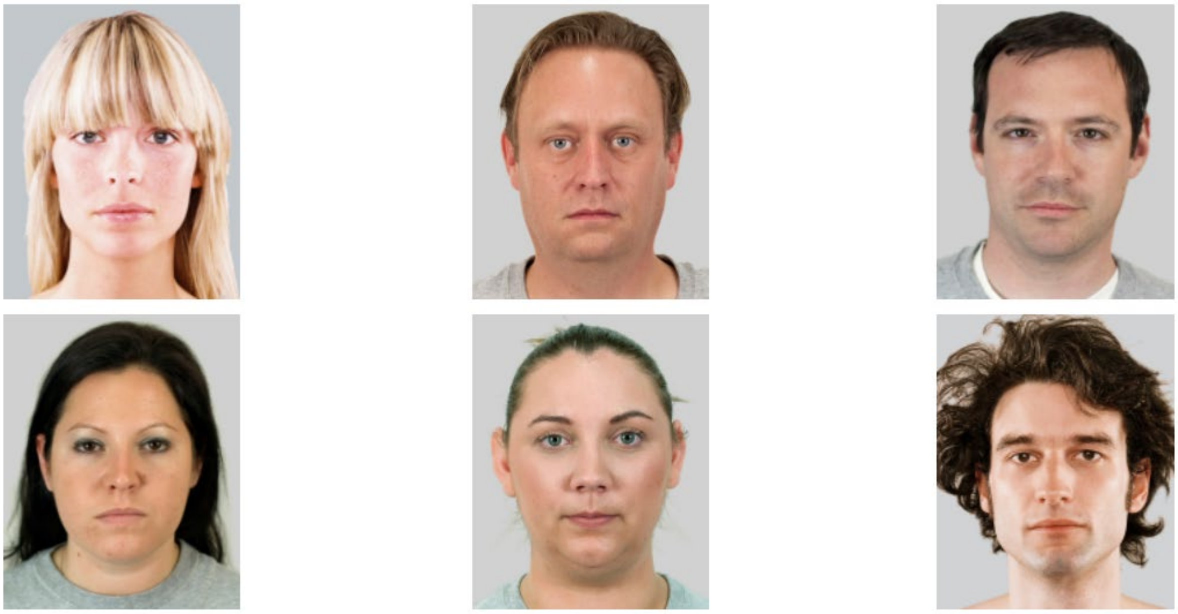

Figure 1
Example stimuli
One out of eleven different templates of example stimuli shown before the rating

the AES, two questions were asked. First, we asked for the domain of art that elicits the most frequent and the strongest emotions respectively the highest aesthetic experience. Second, we asked participants how often they are confronted with that domain. Importantly, we asked the participants to complete the AES with the chosen domain in mind.

In the second section, preselected male and female face-stimuli were rated across six different questions. To avoid order effects, the order of the trials and the order of the questions were pseudo-randomized between participants. Note that the order of the questions within participants did not change to avoid unnecessary cognitive load. Before the rating we showed 6 example stimuli. Importantly, the example stimuli were a subset of the 56 preselected stimuli. To still obtain ratings for every stimulus, we created 11 templates of example stimuli with every high-rated and every neutral-rated stimulus serving as example stimulus only once and low-rated stimuli servng as example stimuli twice at maximum. The example stimuli were intended to serve as indicator for the range of beauty that can be expected. Every participant saw one example-stimuli set (see Figure 1), and the stimuli from that template then did not show up during the rating for that participant. The templates were shown chronologically, with the first partcipant seeing the first template, the 11th participant seeing the 11th template, and the 12th participant seeing the first template again. To get valid data, we pointed out in the beginning that it is utmost important to answer brutally honest ("*schonungslos ehrlich*") and free of social norms. In the same sentence we reminded of the anonymity of the data.

For the rating, a slider was used. The slider started in the middle of the scale, to weaken or prevent unwanted artificial rating tendencies in one direction of the scale. For engagement reasons, we included an indicator of the progress. After around half of the rated faces, we included a short calculation task, and after two thirds of the rated faces, we included an attention task. Both tasks were easily solvable and were meant to raise the engagement of participants in the otherwise rather monotonous rating study. Additionally, wrong answers in both tasks served as indices of unwariness. Participants rated the stimuli in terms of beauty, interest, aesthetically moving, liking, arousal, and valence. Specifically, the following questions were rated on a scale from 1 (not at all; "überhaupt nicht") to 100 (extremely; "äußerst"): "How beautiful do you find the face?" ("*Wie schön finden Sie das Gesicht?*"), "How interesting do you find the face?" ("*Wie interessant finden Sie das Gesicht?*"), "How aesthetically moving do you find the face?" ("*Wie ästhetisch bewegend finden Sie das Gesicht?*"), and "How do you personally like the face?" ("*Wie sehr gefällt Ihnen das Gesicht persönlich?*"). The remaining two questions both started with "When I see this face, I feel .." ("*Wenn ich dieses Gesicht betrachte, fühle ich mich ..*"), and one was rated from 1 (very calm) to 100 (very activated), and the other one from 1 (very negative) to 100 (very positive). To ensure comparability, both, questions and scale, were adapted to be the same as in VAPS. For an example of a trial see Figure 2.

Figure 2
Example of a trial in the pre-study

The third section consisted of two questions. Importantly, the VAPS-study lacked a definition of the concept *aesthetically moving* and did not include a question about how the participants interpreted the concept. To ensure comparability, we also did not include any further information or instructions on the concept *aesthetically moving.* However, since we were under the assumption, that the concept of *aesthetically moving* is not uniformly understood, so we included an open format question at the end, asking how participants interpreted the concept of *aesthetically moving*. We intentionally placed the question after the ratings to still obtain comparable results to the VAPS-study. Also, at the end of the pre-study, we asked if participants felt inhibited to rate a face as ugly, even though they felt that way. We included this question because this inhibition might distort the ratings. Since we needed honest and preferably undistorted ratings, we needed to identify this systematic distortion to be able to exclude the participant.

Importantly, the gathered data was anonymized and only the principal investigator and staff had access to the data.

3.1.3 Materials

3.1.3.1 Stimuli

We used face stimuli derived from three different databases, namely the "Chicago Face Database" (Ma et al., 2015), the "Face Research Lab London Set" (DeBruine & Jones, 2017). , and an imagery Database used by (Schacht et al., 2008). For the main study we needed highly beautiful face-stimuli, as well as neutral-rated and low-rated face-stimuli in terms of beauty. The three mentioned databases individually lacked enough highly beautiful faces according to ratings, if ratings were existent, otherwise according to our subjective assessment. Consequently, we preselected 56 faces in terms of beauty based on our subjective ratings. Our preselection consisted of 28 female faces and 28 male faces. For every stimulus-sex, we selected the 11 faces we rated the highest, 11 faces we rated neutral, and the 6 faces we rated lowest according to beauty. Since out target group would mostly consist of Caucasians, we only used Caucasian faces to avoid race effects. Another reason we only used Caucasian faces was the lack of enough suitable non-Caucasian faces.

Since we used stimuli from three different databases, they were not standardized in terms of the background color and the image format, so we standardized the background manually with the editing software Adobe Photoshop. Furthermore, some faces contained rather unnatural color gradings, especially gradings of yellow and red. We corrected the color gradings of the faces to make them look more natural.

In summary, 56 faces varying in beauty (11 high-rated female, 11 high-rated male, 11 neutral-rated female, 11 neutral-rated male, 6 low-rated female, 6 low-rated male) and derived from three different databases were used as stimuli in the pre-study.

3.1.3.2 Aesthetic Experience Scale

A translated version of the Aesthetic Experience Scale by (Silvia & Nusbaum, 2011) was used. The AES is a self-report scale consisting of 10-items, which assesses the ability of the potential participant to experience aesthetic experiences. Responses to the AES are measured on a 7-point Likert-type scale ranging from 1 (“never”) to 7 (“nearly always”).

Previous studies reported a good reliability with a Cronbach’s alpha of .85 (Nusbaum & Silvia, 2011) and .88 (Harrison & Clark, 2016).

Preceding the AES, two questions were asked. First, we asked for the domain of art that elicits the most frequent and strongest emotions respectively the highest aesthetic experience. Here, participants chose the domain from a list. In case no domain from the list fitted, we added an “other” option to select. Second, we asked participants how often they are confronted with that domain. Answer options ranged from “daily” to “less than once or twice a year”.

Three native German speakers translated the English AES scale to German followed by three English speakers translating the German version back to English. The different versions were then compared and the translations which were judged as the most similar were chosen. See appendix for more information on the AES.

3.1.4 Analysis

First, we organized the raw data in easily accessible data frames. For this we used the R packages *tidyverse* (Wickham et al., 2019) and *plyr* (Wickham, 2011). In a next step, we summarized demographic data, the results of the attention task and distraction task as well as the two final questions, one question being targeted at the interpretation of the concept *aesthetically moving* and the other one exploring participants’ inhibition to rate faces they thought were ugly, even though they felt that way.

The main goal of the analysis was the selection of stimuli for the main study. Since we selected the stimuli according to their beauty ratings, we visually examined the effects and of variables concerning gender and sexual orientation on beauty ratings. Further, we tested for outliers using the R package *outliers* (Komsta, L., & Komsta, M. L., 2011). For the final selection, we selected the 20 faces with the most beauty ratings above 89. If there were an identical number of values above 89, we took the ones with more values above 94. We chose this method to maximize the possibility for very high ratings in the main study. We excluded faces with many outliers downwards because we did not want the stimuli to elicit negative aesthetic emotions.

We calculated the effect size to estimate the number of participants we needed. For that, we used the R package *effsize* (Torchiano, M., & Torchiano, M. M., 2020) and *Rcpp* (Eddelbuettel, 2013).

To analyze the data for the pre-study, RStudio (2021.09.0+351 "Ghost Orchid" Release (077589bcad3467ae79f318afe8641a1899a51606, 2021-09-20)) for Windows (Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) QtWebEngine/5.12.8 Chrome/69.0.3497.128 Safari/537.36) was used.

3.2 Results

The demographic data is summarized in chapter 3.1.2 (see *table 1*). Visually inspecting the results of the attention task and distraction task, we could not find any indication of unconcentrated completion of the study.

In a further step, we visually checked for interactions of sexual orientation and the sex of the participants on the beauty ratings. We did not find any pattern indicating an interaction of either sexual orientation or sex of the participants on the beauty ratings.

Following our selection method, we identified the 21 stimuli with the highest beauty ratings. Among those 21 stimuli, two stimuli shared the place with the lowest ratings, one male face and one female face. We took the stimulus with the male face, since there were fewer male faces than female faces at this point. The final selection of stimuli consisted of the 20 faces, 12 female and 8 male faces. We only took the faces with the highest ratings since some of those already were rated neutral (see Figure 3).

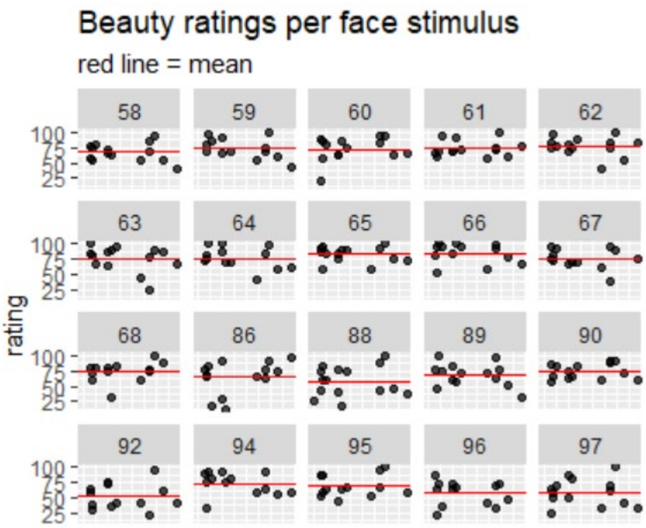

Figure 3
Scatterplots of beauty ratings per face stimulus

The concept *aesthetically moving* was interpreted in various ways. Mostly it was interpreted in terms of either *beauty*, *interest*, or *emotional expressiveness* (see table 2). As a result, we believe that it can be advantageous to define the concept *aesthetically moving* prior to its use in experiments.

German (original)	English (translation)
„Dass mir etwas so gut gefällt/mich so sehr anspricht, dass es in mir ein Gefühl auslöst“	“That I like something so much/it appeals to me so much that it triggers a feeling in me”
„Dass eine Emotion durch den Stimulus ausgelöst wird. Ob diese Emotion positiv oder negativ ist, bleibt dabei offen“	“That an emotion is triggered by the stimulus. Whether this emotion is positive or negative remains open”
„aufwühlend, angenehm oder unangenehm, einzigartig“	“upsetting, pleasant or unpleasant, unique”
“löst eine Emotion aus”	“triggers an emotion”
„eine Art von Gefühlsregung, innere Bewegung auslösend“	“a kind of emotion, triggering inner movement”
“stimmt mich positive”	“puts me in a positive mood”
„emotional bewegend. Im Falle von Gesichtern aber auch vor allem Symmetrie usw.“	“emotionally moving. In the case of faces, but also especially symmetry, etc.”
„ehrlich gesagt keine Ahnung. Vielleicht so etwas wie symmetrisch oder allgemein schön“	“honestly no idea. Maybe something like symmetrical or generally beautiful”
„ob mich eine Person auf der Schönheitsebene (falls es das gibt), bewegt“	“whether a person moves me on the beauty level (if there is one)”
„wenn man etwas subjektiv als schön einschätzt“	“when you subjectively judge something to be beautiful”
„wenn ich etwas persönlich als schön empfinde und ich es gerne lange betrachte“	“when I personally find something beautiful and I like to look at it for a long time”
„Wenn ich mir vorstellen kann, dass etwas als ein Kunstobjekt (Gemälde), verwendet werden kann“	“If I can imagine that something can be used as an art object (painting).”
„ausdrucksstark, auslösend“	„expressive, triggering“
„Ähnlich wie interessant, Gesichter mit Auffälligkeiten“	“Similar to interesting, faces with features”
„Wenn etwas entweder in klassischer oder unkonventioneller Art meinen Ästhetischen Sinn anregt“	“When something stimulates my aesthetic sense, either in a classic or unconventional way”
„vermittelt Gefühle bzw. löst Gedanken über Gefühle aus“	“conveys feelings or triggers thoughts about feelings”
„Dass eine Emotion durch den Stimulus ausgelöst wird. Ob diese Emotion positiv oder negativ ist, bleibt dabei offen“	“That an emotion is triggered by the stimulus. Whether this emotion is positive or negative remains open”
„aufwühlend, angenehm oder unangenehm, einzigartig“	“upsetting, pleasant or unpleasant, unique”
“löst eine Emotion aus”	“triggers an emotion”
„eine Art von Gefühlsregung, innere Bewegung auslösend“	“a kind of emotion, triggering inner movement”
“stimmt mich positive”	“puts me in a positive mood”
„emotional bewegend. Im Falle von Gesichtern aber auch vor allem Symmetrie usw.“	“emotionally moving. In the case of faces, but also especially symmetry, etc.”
„ehrlich gesagt keine Ahnung. Vielleicht so etwas wie symmetrisch oder allgemein schön“	“honestly no idea. Maybe something like symmetrical or generally beautiful”
„ob mich eine Person auf der Schönheitsebene (falls es das gibt), bewegt“	“whether a person moves me on the beauty level (if there is one)”
„wenn man etwas subjektiv als schön einschätzt“	“when you subjectively judge something to be beautiful”
„wenn ich etwas persönlich als schön empfinde und ich es gerne lange betrachte“	“when I personally find something beautiful and I like to look at it for a long time”
„Wenn ich mir vorstellen kann, dass etwas als ein Kunstobjekt (Gemälde), verwendet werden kann“	“If I can imagine that something can be used as an art object (painting).”
„ausdrucksstark, auslösend“	„expressive, triggering“
„Ähnlich wie interessant, Gesichter mit Auffälligkeiten“	“Similar to interesting, faces with features”
„Wenn etwas entweder in klassischer oder unkonventioneller Art meinen Ästhetischen Sinn anregt“	“When something stimulates my aesthetic sense, either in a classic or unconventional way”
„vermittelt Gefühle bzw. löst Gedanken über Gefühle aus“	“conveys feelings or triggers thoughts about feelings”

Table 2
Interpretations of the concept “aesthetically moving”
Interpretations according to our subjects in the pre-study

4 Main study

A 2x2 within subject design was used, with the factor's beauty (high/neutral), and stimulus category (artwork/face), for which visual perception and visual mental imagery was contrasted.

4.1 Methods and Materials

4.1.3 Participants

4.1.3.1 Recruitment

We hung up invitation flyers in and near the University of Vienna (Universitätsstraße 7, 1010 Wien) to recruit participants. After interested persons contacted us via mail, we invited them via link to our pre-screening. The pre-screening was conducted online in labvanced, a web-based solution for experiments (Finger et al., 2017). The pre-screening consisted of demographic questions, questions about the suitability for our study, questions about the general MRI-suitability and 2 self-assessments, namely the Vividness of Visual Mental Imagery Questionnaire (VVIQ) and the Aesthetic Experience Scale (AES). Because of the high internal consistency reliability and for efficiency reasons, we only used 8 out of 16 items of the VVIQ. Also, VVIQ and AES were modified and translated to German (for more information about the modification and translation of VVIQ see chapter 3.3.4.2 and of AES see chapter 3.1.3.2). The completion of the pre-screening took about 10 minutes.

In the next step, we summed up the individual scores for the VVIQ and AES per person.

4.1.3.2 Exclusion criteria

To ensure that participants at least possessed an average frequency of aesthetic experiences and an average ability in VMI, we excluded everyone who scored <35 out of 70 points of AES and/or <25 out of 40 points of VVIQ. To minimize the possibility of having issues concerning the lateralization of neural functioning, we excluded everyone who was non-righthanded. Participants under current medication were excluded, if the effects of the medication were associated with affecting pleasure. If participants were diagnosed with a psychological disorder associated with pleasure and/or mood or any psychiatric or neurological disorder, they also were excluded. Additionally, participants needed to have normal or corrected to normal vision to be included. Furthermore, we excluded participants who were not suitable to be scanned with fMRI.

4.1.3.3 Sample

The final sample consisted of 34 (21 females, 12 males, and 1 divers) participants. This number results from a calculation with G*Power with an alpha of 0.05, a power of .80, and an effect size of 0.25. On average, participants were 23,48 years old (SD = 4.01; range = 18-34). 32 participants spoke German as native language, the remaining 2 participants spoke very good German. 22 participants were heterosexual, 7 were bisexual, 4 were homosexual, and 1 participant could not be classified. Every participant got financially compensated with 20 Euros. One participant was excluded after invitation because of mood-affecting medication and one participant was excluded because the fMRI scanning was terminated early.

4.1.3.4 Ethical considerations

The study was approved by the local ethics committee of the University of Vienna (Reference Number: 00636).

4.1.4 Study design

A within-subject block-design was used to compare two conditions, namely visual perception, and Visual Mental Imagery (VMI). The study consisted of 4 runs, each 13 to 14 minutes long. Two categories of stimuli were presented, namely faces and artworks. In each trial, participants performed a cued imagery task. First, a fixation cross was presented jittered over 3 to 5 seconds. Then, a stimulus was presented for 15 seconds, after which participants rated the stimulus according to beauty, the induced pleasure, and how aesthetically moving they found it. For each rating participants had 6 seconds, resulting in 18 seconds of rating. No answer means a missing value. The ratings between the visual perception and the VMI of a stimulus had the positive side benefit to hinder participants holding the stimulus in VWM rather than recreating the imagery of the stimulus. After the rating, the information "Imagine, close your eyes" ("Vorstellen, Augen schließen") was shown for 5 seconds, then an auditive cue indicated the participants, that they already should have a clear image in front of their minds eye. 15 seconds after that, a second auditive cue indicated that the participant should

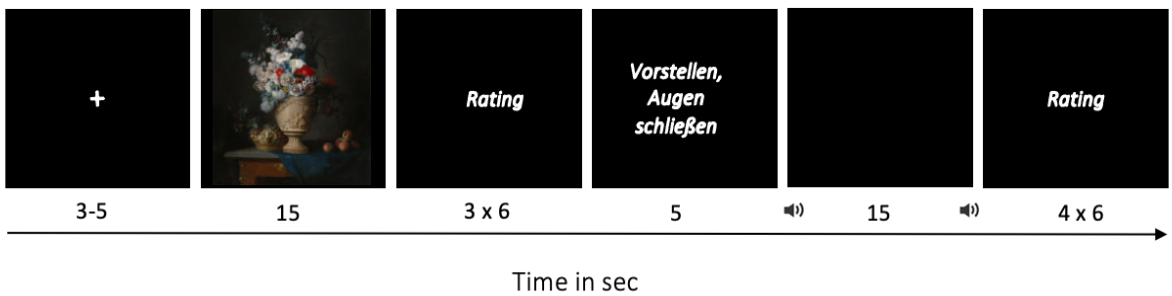

Figure 4
Study design

open their eyes again. 24 seconds of rating followed, again 6 seconds per question. The first question after the imagery task always asked about how vivid the imagery was. Afterwards, the same three questions were asked as before. Except for the fixed position of the question about vividness, to avoid order effects and to make the rating more engaging, all questions were randomized between trials. As mentioned, stimulus presentation for the perception task and the VMI task was each set to 15 seconds. This duration was chosen because the results of (Belfi et al., 2019) suggest, that some brain areas, like nucleus accumbens and nucleus caudate, only correspond to aesthetic appreciation during longer trial durations, specifically durations of 5 and 15 seconds.

The study consisted of 40 trials. In 20 trials, artworks served as stimuli, and in the other 20 trials, faces were shown. To prevent order effects, we used a block-design randomization of stimulus presentation, namely an epoch-design.

Participants rated the following questions on a scale from 1 (not at all; "überhaupt nicht") to 7 (extremely; "äußerst"): "How beautiful did you find the image?" ("*Wie schön fanden Sie das Image?"),* "How pleasurable did you find the image?" ("*Wie viel Vergnügen bereitete Ihnen das Image*?") and "How aesthetically moving did you find the image?" ("*Wie ästhetisch bewegend fanden Sie das Image*?"). The additional question shown after the imagery task was: "How vivid was your imagery?" ("*Wie anschaulich war Ihre Vorstellung*?").

4.1.5 Procedure

The study took place in the University Dental Clinic Vienna in Sensengasse 2a, 1090 Vienna. As a first step, participants read and filled out three different documents (one about participant information, one about MRI-safety, and one for the expense allowance). Next, participants were given a laptop with instructions about the study. They were asked to click through the instructions while reading carefully, as questions about this information will be asked afterwards. With the instructions we wanted to make sure that every participant understood the procedure, as well as our interpretation of the constructs we were using. The instructions included information about the procedure of the study and information about how to behave in the scanner. Crucially, we also explained the scales for every question, and we gave a definition of the construct *aesthetically moving*, since it is not uniformly understood as the results of the pre-study suggest. We defined it as follows (translated from German): "*Aesthetically moving* means that the image moves or touches you emotionally or physiologically. This is expressed by experiencing intense emotions (of all kinds), possibly also physical changes: such as palpitations, goosebumps, change in breathing rate, a chill, running down your back, and so on. So-called “chills" often occur in those states. Chills are expressed, for example, by a cold shiver running down your back or you get goose bumps. Many people experience chills when they listen to emotional music or watch an emotional movie, but everyone feels chills differently, some don't feel any physical reactions at all." (original: „"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 emotionalen Film schauen. Jeder Mensch empfindet Chills aber anders, manche empfinden gar keine körperlichen Reaktionen."). See appendix for more information on the instructions.

When participants were not able to answer a question, the relevant information was given again at that point to make sure that every participant starts with the same information. In a next step, the MRI-safety-check was performed with the participants. If necessary, vision correcting glasses were given. At every point, participants had the ability to ask questions.

After the MRI-safety-check, participants were guided into the scanner room. They were given in-ear headphones, which also were designed to function as ear protection against the noises in the scanner. A button box was placed on the right thigh of the participant, so that they could reach every button without problem. The button box was used to navigate through the ratings. Additionally, a small balloon was taped on the chest of participants. In case of an emergency, participants could press it to activate the alarm. The whole experiment was presented on a MRI-compatible monitor using the Software *PsychoPy* (Peirce, 2007). A mirror was mounted before the participants eyes, so that they were able to see the screen behind the scanner.

Before the experiment started, a test-trial was absolved. This way, participants were able to try out the usage of the button box. Additionally, the volume of the auditive cues were checked and adapted, if necessary. After the first subject, who completed the experiment in one run, suggested having a break during the experiment for motivational purposes, we implemented one break in the middle of the experiment for the second subject. The division of the experiment also led to a safer data acquisition since potential data loss only affected the current run. Because of both reasons, starting with subject three, the experiment was again divided, this time into four separate runs. Every run was 13 to 14 minutes long. After every run, participants had the opportunity to talk to us via the intercom.

Note that for the first 11 participants a run only consisted of 19 instead of 20 trials due to an error with the randomization. This error led to one missing trial per run, with the trial being missing at random.

After the experiment, participants were debriefed, and their questions were answered. At last, they were asked if they would like to take part in more studies.

4.1.6 Materials

4.1.6.1 Stimuli

Two categories of stimuli were used in the main study, namely faces and artworks. We used 20 face stimuli (12 female and 8 male). Additionally, we used 20 artworks of different art styles. Half of the stimuli were chosen to evoke maximal aesthetic experiences, and the other half was chosen to be neutral in terms of evoking aesthetic experiences.

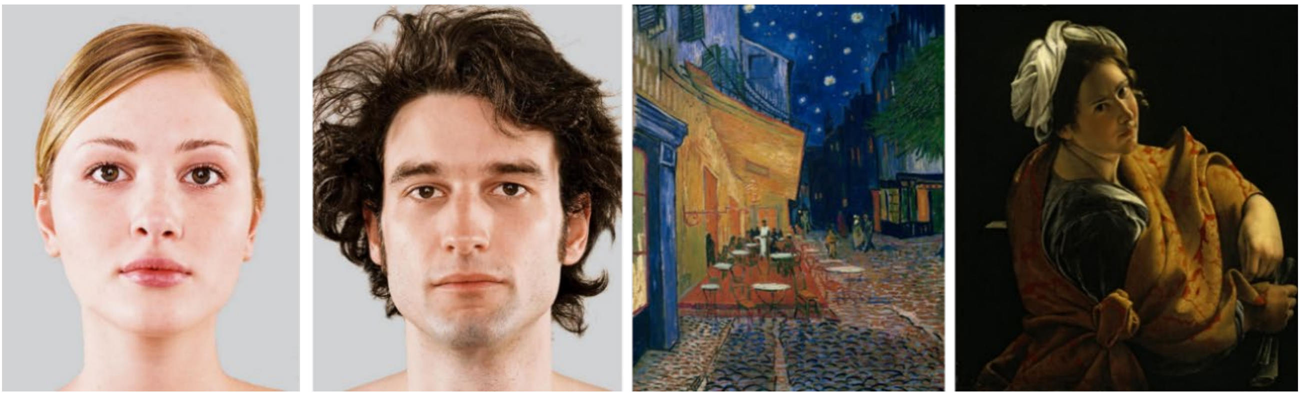

Figure 5
Examples of the used stimuli

We selected the artworks from the VAPS-study (Schäfer, 2015) to maximize participants' likelihood of being strongly moved (and/or experiencing chills) by the artwork. The criteria for artwork selection were a general high mean rating of beauty, and preferably many values above 90 (out of 100). Analogous to the selection of the faces, we used this method to maximize the possibility for very high beauty ratings. For more information on the selection of faces see chapter 3.1.4.

We selected faces and artworks according to ratings in terms of *beauty* and not in terms of *aesthetically moving,* because for *aesthetically moving* there was no explanation of

Figure 6

Mean values and variance of the artworks

Values for "liking", "beauty", "interest", and "aesthetically moving" as rated in the VAPS

what it means given to participants prior to the study, which is why we deemed the likelihood of participants to not uniformly understand the concept behind it as very high. Also, the aesthetically moving ratings had a higher variance than the beauty ratings (see Figure 6). To maximize the possibility for very high beauty ratings, we preferred high ratings with low variance.

In sum, we selected both categories of stimuli, namely faces and artworks, according to the ratings in *beauty*.

4.1.6.2 Vividness of Visual Mental Imagery Questionnaire

An adapted, shortened and translated version of the Vividness of Visual Mental Imagery Questionnaire (VVIQ) (Marks, 1973) was used. The VVIQ is a self-report questionnaire consisting of 16 items, measuring the ability to create clear mental images in front of the mind's eye. All 16 items are completed twice, once with the eyes open and once with the eyes shut.

We adapted the VVIQ for two reasons, first to match the gender policy of the University of Vienna, and second to improve the comprehensibility. For example, we changed "Then rate the following aspects" to "Then rate the following aspects based on how clearly you saw them in your mind's eye". Again, we only used 8 out of 16 items of the VVIQ because of the high internal consistency reliability and for efficiency reasons. The translation from English to German was accomplished with the help of an English teacher, so that the meaning of the items remained identical (Schneider, 2020). For more information on the VVIQ see appendix.

Using the split-half method, (Rossi, 1977) found the VVIQ to have an internal consistency reliability of 0.96. Cronbach's α is suggested to be around 0.88 (Campos et al., 2002), 0.91 (Campos, 2011), and 0.95 (Burton, L. J., & Fogarty, G. J., 2003).

4.1.7 fMRI

4.1.7.1 fMRI acquisition

A Siemens MAGNETOM Skyra 3 Tesla MRI scanner with a 32-channel head coil was used. Subjects were not acclimated to the scanner environment with the use of an MRI simulator and every subject interacted with at least two experimenters.

For the functional acquisitions, the Echo Time (TE) was set to 34 ms and the Repetition Time (TR) to 915 ms. The Flip Angle (FA) was set to 55 degrees. The Field of View (FoV) read was set to 210 mm with the FoV phase being at 100%. Slice thickness was set to 2.2 mm. We set the multi-band acceleration factor to 4. For the structural acquisitions the TE was set to 2.29 ms and the TR to 2300 ms. The FA was set to 8 degrees. The Inversion Time (TI) was set to 900 ms. The FoV read was set to 240 mm with the FoV phase being at 100%. Slice thickness was set to 0.94 mm. Slice acquisition timing was set to sequential increasing and phase encoding direction was set as A/P.

4.1.7.2 fMRI data preprocessing

Generally, FSL (version number 5.0) was used for the fMRI data preprocessing. First, raw data was converted to NIFTI-format. The anatomical files then were brain extracted using FSL optiBET with a default fraction parameter of 0.07. As a preliminary quality control, the results were visually inspected. The fraction parameter was changed if it seemed to fit better according to a visual inspection. No manual editing was applied to the brain masks. In a next step, motion was checked. Exclusion criteria were either a mean framewise displacement greater than 0.25 mm, more than 20% framewise displacement above 0.2 mm, and/or any framewise displacement greater than 5 mm (Parkes et al., 2018). One subject was excluded because of too much motion. To determine the root-mean-squared volume-to-volume displacement we used the method from (Jenkinson et al., 2002). We used FSL FAST for segmentation of the structural images. FSL McFlirt was used for motion correction. The middle volume was used as an initial template image. All optimizations use trilinear interpolation. No slice time correction was used due to multiband acquisition. Gradient distortion correction was performed with fieldmap correction in FEAT. For intra-subject function-structure coregistration we used FSL FEAT FLIRT. We ran subjects with a cost function of Correlation Ratio in FLIRT and for those who did not turn out well, we varied the cost functions and warp resolution to then select the best one. For intersubject registration to standard space with a warp-resolution of 10mm we used FSL FLIRT and FNIRT. The T1-weighted image was registered to the MNI template (MNI152_T1_1mm_brain.nii.gz). T2* image was the mean image and T1 was bias field corrected. We used FSL for intensity correction. Spatial smoothing was performed in native volume using FSL SUSAN in FEAT. The size of the smoothing kernel was 6 mm and we used FWHM as a filter. We did not perform any intensity correction or volume censoring and we did not create any summary measure. We performed a non-aggressive denoising using ICA-AROMA and then applied temporal filtering with the fslmath command and the -bptf flag.

4.1.7.3 fMRI data analysis

For hypothesis 1 we ran a univariate GLM in which we modeled the different regressors separately for each fMRI run, analogues to (Dijkstra et al., 2017). For the whole data analysis FSL was used. Perception events and imagery events were modeled each in a separate regressor. For functional reasons, the rating events were modeled as a separate regressor, even though we were not interested in the results. As a baseline served everything but perception events, imagery events, and rating events. Generally, we used a full brain cluster-based approach.

In a first level, we calculated the parameter estimated for every event (i.e., perception events, imagery events, and rating events) versus baseline. In a second level, we averaged together the parameter estimates and contrast estimates from the first-level analysis across all runs for each subject. In a third level, we ran a group-level analysis. Here, we contrasted perception versus imagery and imagery versus perception.

The timing sheets for the fMRI analysis were created using the software R (version 4.1.1 (2021-08-10) -- "Kick Things", Copyright (C) 2021 The R Foundation for Statistical

Computing; Platform: x86_64-w64-mingw32/x64 (64-bit)). For that, the following packages were used: stringr (Wickham, H., & Wickham, M. H., 2019), tidyverse (Wickham et al., 2019).

4.1.8 Behavioral analysis

To operationalize the similarity of the aesthetic ratings between visual mental imagery and visual perception, we subtracted the aesthetic rating of imagery condition from the aesthetic ratings from the perception ratings. This way we end up with a scale from -6 (highest asymmetry with high imagery ratings), over 0 (perfect symmetry), to 6 (highest asymmetry with high perception ratings).

As a first step, we visually inspected the linearity and further tested the normality and homoscedasticity of the data. The data of none of the ratings seemed to be linear. Further, according to Shapiro-Wilk Normality test, none of the residuals were normally distributed (beauty ratings: $W = 0.95771$, $p < 0.001$; pleasure ratings: $W = 0.95171$, $p < 0.001$; aesthetically moving ratings: $W = 0.95472$, $p < 0.001$). According to the ncvTest (R package *car* by (John Fox et al.), data for *beauty ratings* and *pleasure ratings* were homoscedastic (beauty ratings: $p = 0.31296$; pleasure ratings: $p = 0.12$)., while *aesthetically moving ratings* were heteroscedastic ($p < 0.01$). Further, we calculated the response rate across participants.

For hypothesis 2 we wanted to perform a linear regression between the vividness ratings and the similarity-measure, separately for *beauty ratings*, *aesthetically moving ratings*, and *pleasure ratings*. Since none of the ratings met the assumptions for a linear regression, we performed an ordered logistic regression with bootstrap confidence intervals instead.

For hypothesis 3.a we were interested if stimulus category influenced the experienced vividness. To test that, we performed a paired sample t-test between the experienced vividness ratings of artworks and the experienced vividness ratings of faces using the R package *stats* (R Core Team, 2013).

For hypothesis 3.b we investigated if stimulus category moderates the effect of experienced vividness on similarity. We performed a moderator analysis with the experienced vividness as metric independent variable, the similarity of aesthetic ratings as dependent metric variable, and the stimulus category as categorial moderator using the PROCESS macro for R (Hayes, 2017). We mean centered the experienced vividness to simplify the interpretation of the results.

For hypothesis 3.c we tested the effects of vividness and stimulus category on the similarity of the ratings. For that, we performed an ordered logistic regression with bootstrap confidence intervals.

For plots we generally used the R package *ggplot2* (Wickham et al., 2016). For the preparation of the ordered logistic regressions and for the bootstrap confidence intervals, we used the packages *boot* (Canty, 2002) and *stats* (R Core Team, 2013). The ordered logistic regressions were performed using the *polr* function which is part of the *MASS* package (Ripley et al., 2013) in R. We performed the default regression of that function, which is a proportional odds logistic regression. For all ordered logistic regressions with bootstrap confidence intervals, the seed was set to "12345" and the repetitions to "10000". The whole analysis was performed using the software R (version 4.1.1 (2021-08-10) -- "Kick Things", Copyright (C) 2021 The R Foundation for Statistical Computing; Platform: x86_64-w64-mingw32/x64 (64-bit)).

4.2 Results

4.2.1 fMRI

4.2.1.1 Hypothesis 1

The results of our fMRI analysis were in line with the findings of (Dijkstra et al., 2017). Like them, we observed stronger activity during visual perception than visual mental imagery in the whole ventral visual stream. Unlike Dijkstra et al. (2017), we also found stronger activity during visual perception in relation to visual mental imagery in parts of the orbitofrontal cortex and the amygdalae. Like (Dijkstra et al., 2017), we observed stronger activity during imagery in insula, dorsolateral prefrontal cortex, and medial frontal cortex (see Figure 7)

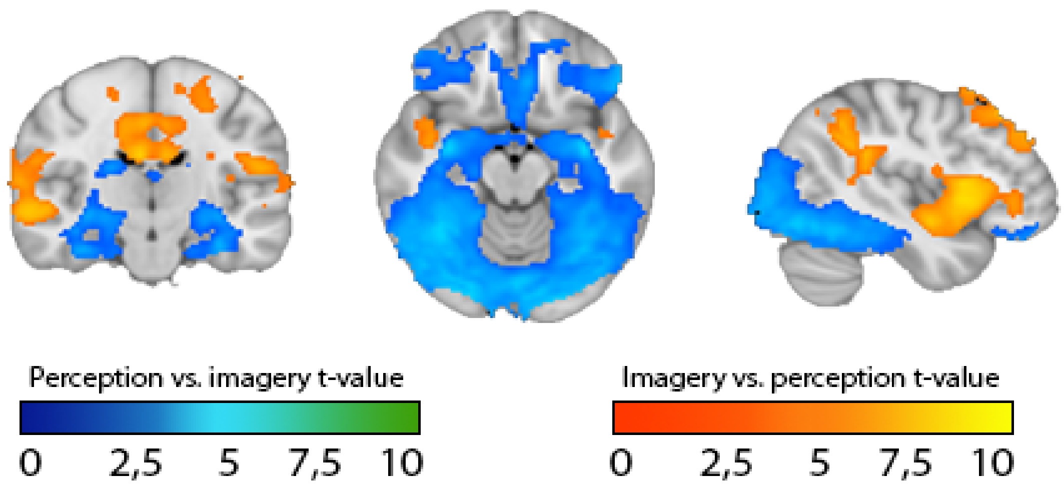

Figure 7
Visual perception versus Visual Mental Imagery
The colors blue to green represent t-values for perception versus imagery and red to yellow colors represent t-values for imagery versus perception. The shown t-values were significant on the group level.

4.2.2 Behavioral

The response rate of the behavioral ratings was 91,47% (SD = 12,48).

4.2.2.1 Hypothesis 2

Three ordered logistic regressions with bootstrap confidence intervals were performed to investigate the effects of the experienced Vividness of Visual Mental Imagery on the similarity of aesthetic ratings, more specifically *beauty ratings*, *pleasure ratings*, and *aesthetically moving ratings*, between Visual Mental Imagery and visual perception. All three ordered logistic regression were significant (*beauty*: $p <.001$; *pleasure,* and *aesthetically moving*: both, $p <.05$). For every one unit increase in vividness, the odds of aesthetic ratings being more similar are getting higher (*beauty:* OR = 0.86, 95% CI [0.79, 0.93]; *pleasure*: OR = 0.91, 95% CI [0.85, .99]; *aesthetically moving*: OR = 0.92, 95% CI [0.85, 0.99]). In other words: The higher the experienced vividness is rated, the more likely we expect similar aesthetic ratings.

Rating	Odds Ratio	CI 2,5 %	CI 97,5 %	t value	Nagelkerke R2	AIC	edf	p value
beauty	0.858	0.794	0.927	-3.881	0.016	2722.31	6	**<.001**
pleasure	0.913	0.846	0.986	-2.315	0.005	2724.55	6	**<.05**
aesthetically moving	0.92	0.851	0.994	-2.103	0.005	2753.3	6	**<.05**

Table 3
Model summary of three ordered logistic ordered logistic regressions
Summary with bootstrap confidence intervals

4.2.2.2 Hypothesis 3

Hypothesis 3.a). We found an effect of stimulus category on the experienced vividness. The results of the paired sample t-test indicate a significant difference between the experienced vividness rating for artworks (M = 4.79; SD = 1.41) and faces (M = 4.57; SD = 1.37) [t(3.15) = 611, p < .01].

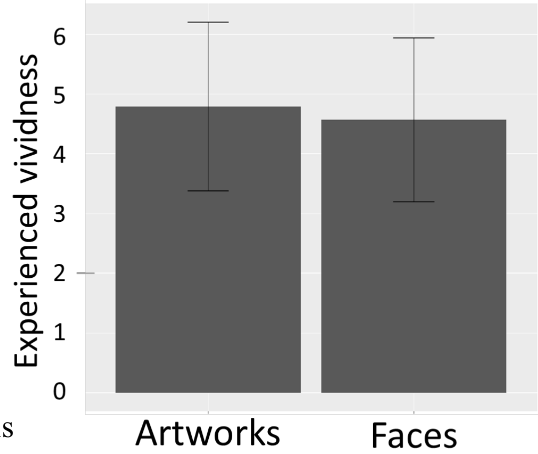

Figure 8
Mean and variance of vividness ratings for artworks and faces

Hypothesis 3.b). The results of the moderation analysis using PROCESS macro show that stimulus category did not significantly moderate the effect between vividness and similarity between ratings, $\Delta R^2 = 0.03$ %, $F(1, 3583) = 98.85$, $p = .320$, 95% CI[-0.0265, -0.0758].

Model	coeff	se	t value	df1	df2	p value
constant	0.4045	0.0249	16.2333	0.3556	0.4534	**<.001**
vividness	-0.1542	0.0176	-8.7677	-0.1887	-0.1197	**<.001**
type_face	-0.15	0.0352	-4.2627	-0.2189	-0.0810	**<.001**
vividness x type_face	0.0251	0.0252	0.9942	-0.0244	0.0745	**=.32**

Table 4
Model summary of the moderation analysis

Hypothesis 3.c). The results of the ordered logistic regression with bootstrap confidence intervals show that the higher the experienced vividness is rated, the more likely we expect similar aesthetic ratings ($p < .001$; OR = 0.89, 95% CI [0.86, 0.94]. Further, stimulus category seems to have no significant influence on the similarity of aesthetics ratings between visual perception and visual imagery ($p = .109$; OR = 0.90, 95% CI [0.80, 1.02].

Variable	Odds Ratio	CI 2,5 %	CI 97,5 %	t value	p value
vividness	0.894	0.855	0.935	-4.881	**<.001**
stimulus category (face)	0.903	0.797	1.023	-1.601	**=.109**

Table 5
Model summary of the ordered logistic ordered logistic regressions
Summary with bootstrap confidence intervals

5 Discussion

34 healthy participants (21 females, 12 males, and 1 divers), who were on average 23,48 years old (SD = 4.01; range = 18-34), and who scored ≥35 out of 70 points of AES and ≥25 out of 40 points of VVIQ, undertook an fMRI experiment in which visual perception and visual mental imagery was contrasted.

The first goal of this study was the partial replication of the findings by Dijkstra et al. (2017). We ran a univariate GLM in which we modeled the different regressors separately for each fMRI run, analogues to Dijkstra et al. (2017). The results of Dijkstra et al. (2017) suggest that VMI leads to stronger activity in insula, left dorsal lateral prefrontal cortex, and medial frontal cortex and weaker activity in the whole ventral visual stream compared to visual perception. We successfully replicated these results. Like Dijkstra et al. (2017), we observed stronger activity during visual perception than visual mental imagery in the whole ventral visual stream and stronger activity during visual mental imagery in insula, dorsolateral prefrontal cortex, and medial frontal cortex. A possible explanation for the activation in insula and medial frontal cortex is that we selected individuals with preferably high VVIQ-scores and excluded everyone with <25 out of 40 points of VVIQ, since activation during VMI of parts in insula and medial frontal lobes are associated with high imaginers as measured with the Vividness of Visual Mental Imagery Questionnaire (VVIQ) (Fulford et al., 2018a). Further, medial frontal cortex, more specifically the mesial superior frontal gyrus (SFG), seems to be associated with imagery performance (Aline W. de Borst et al., 2012). Therefore, we expected activation in medial frontal cortex. Activation in dorsolateral prefrontal cortex is associated with imagery, more specifically with low reported imagery ability (Kleider-Offutt et al., 2019). Summarized, this would explain why we found stronger activation in insula and dorsolateral prefrontal cortex, and medial frontal cortex in VMI compared to visual perception. We also found stronger activity during visual perception in relation to VMI in parts of the orbitofrontal cortex and the amygdalae. Activation in orbitofrontal cortex is associated with the response to novel visual stimuli (Rolls et al. 2005). Further studies might investigate the role of amygdala in visual perception. With this replication we validated the findings of Dijkstra et al. (2017).

The second goal was to investigate the effects of experienced vividness on the similarity of aesthetic ratings and pleasure ratings between VMI and visual perception. We expected experienced vividness to positively affect the similarity of aesthetic ratings and pleasure ratings between VMI and visual perception. To test that, we performed three ordered logistic regressions with bootstrap confidence intervals, separately for *beauty ratings*, *pleasure ratings*, and *aesthetically moving ratings*, which were all significant (*beauty*: $p < .001$; *pleasure* and *aesthetically moving*: both, $p < .05$). Our results suggest that the higher the experienced vividness is rated, the more likely similar aesthetic ratings can be expected. This is in line with our expectations, as previous research indicates significant similarities between VMI and visual perception (G. Borst & Kosslyn, 2008; Gurtner et al., 2021, p. 1; Johansson et al., 2012; Richardson & Spivey, 2000; Wynn et al., 2018), indicating a "perception-like" representation of VMI. Our results emphasize the similarity between VMI and visual perception and further pointing out the important role of experienced VVMI on given similarity of aesthetic ratings. This may imply that the vividness of the mental imagery or the ability for mental imagery increases the aesthetic experience to a level that is very similar to the aesthetic experience you have while actually perceiving the sensory input. The broader relationship between VVMI and aesthetic ratings, specifically the similarity of aesthetic ratings between VMI and visual perception, needs to be topic of future studies.

Our third goal was to examine the effects of stimulus category in several ways. First, we investigated the effects of stimulus category on the experienced vividness. Complex stimuli are experienced less vivid as tested in a retro-cue working memory paradigm (Dijkstra et al., 2017). Since we did not find it very convincing that our selection of artworks and faces differed systematically in complexity, we did not expect effects of complexity of stimulus category on the experienced vividness. The results of the paired sample t-test indicate a significant difference between the experienced vividness rating for artworks compared to faces. Artworks were significantly experienced more vivid as faces. One possible explanation is that the assumption, that our selection of stimuli did not systematically differ in complexity, was wrong. If a difference in complexity was the reason for our results, and complex stimuli are experienced more vivid (Dijkstra et al., 2017), that would indicate that our selection of artworks was less complex as our selection of faces. However, more complex stimuli (i.e. more individual elements that composed that stimulus) are considered more beautiful than simple stimuli (Jacobsen, 2004; Tinio & Leder, 2009). Our selection of artworks was rated higher in aesthetic experience (see Figure 9), and higher in beauty separately, both for perception (mean: 4.79, SD: 1.56) and imagery (mean: 4.43, SD: 1.54) than our selection of faces (perception: mean: 4.21, SD: 1.52; imagery: mean: 3.92 SD: 1.5), although not significantly (see results of hypothesis 3.c). This could be an indication that complexity at least might not be the only reason for higher experienced vividness in artworks. Reisberg et al. (2003) speculate that variables like the degree of elaboration of a stimulus and the attention paid to a stimulus might influence vividness ratings. Similarly, Sunday et al. (2017) associated better vividness with more self-reported experience and interest in the given domain. If that would be true, that might explain our results. Future research is needed to investigate the difference in experienced vividness between artworks and faces. For that, it

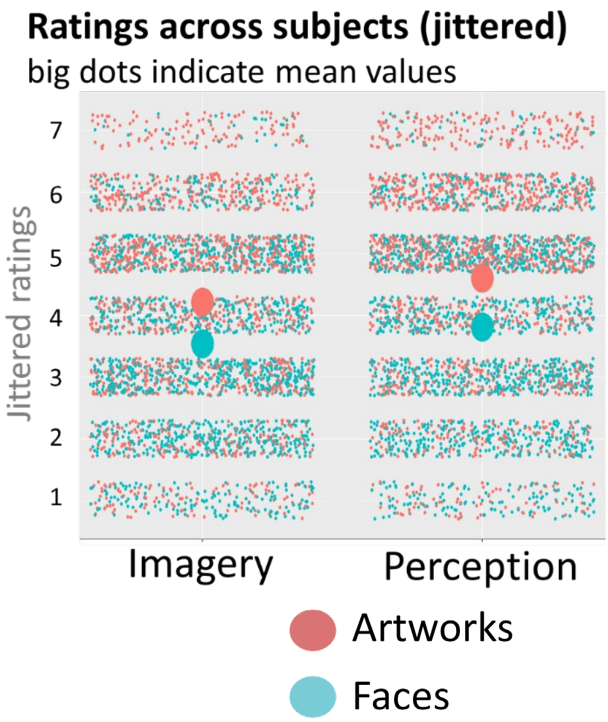

Figure 9
Jittered aesthetic ratings
Ratings of beauty, pleasure, and aesthetically moving for artworks and faces, separately for imagery and perception

would be interesting to examine the differences in complexity between artworks and faces, and how those differences relate to the experienced vividness.

Second, we investigated if stimulus category moderates the effect of experienced vividness of Visual Mental Imagery on the similarity of aesthetic ratings and pleasure ratings between Visual Mental Imagery and visual perception. To test that we performed a moderator analysis. The results show that stimulus category did not significantly moderate the effect of vividness on the similarity between ratings.

Third, stimulus category seems to influence aesthetic ratings (Marković, 2014) and depending on self-reported experience with and interest in a stimulus domain, also vividness (Sunday et al., 2017). Therefore, we further explored the effects of the experienced vividness and stimulus category on the similarity of aesthetic ratings and pleasure ratings between VMI and visual perception. For that, we analyzed the model without the interaction term. The results show that the higher the experienced vividness is rated, the more likely we expect similar aesthetic ratings ($p < .001$; OR = 0.89, 95% CI [0.86, 0.94]. This is in line with our findings for our second hypothesis. Further, our results indicate that stimulus category does not have a significant influence on the similarity of aesthetics ratings between visual perception and VMI ($p = .109$; OR = 0.90, 95% CI [0.80, 1.02], when the experienced vividness is held constant. Future studies might identify other influencing aspects on the similarity of aesthetics ratings between visual perception and VMI besides the experienced vividness.

5.1 Limitations and future research

This study has certain limitation that shall be addressed here.

Importantly, the results of our pre-study indicate that the concept *aesthetically moving* is not uniformly understood, at least not intuitively. Future research should take that into account and provide a definition of the concept *aesthetically moving* prior to the experiment which we did implement in this study. This brings us to a more general problem. Some concepts in aesthetic research, for example *aesthetically moving, beauty* and *aesthetic experiences*, are not always well defined, which might compromise comparability between studies. Future studies might include definitions of the concepts used.

In the fMRI analysis, artworks and faces were not analyzed separately. To disentangle potentially different effects of brain activation during VMI and visual perception between artworks and faces, future studies might analyze both stimulus categories separately.

We asked participants in the pre-study to choose the domain of art, that most frequently elicits strong aesthetic experiences. The AES then was absolved with that domain in mind. If participants did not choose a visual domain, we had no information about their ability to form aesthetic emotions based on visual stimuli, which we used. Additionally, the selection process of the stimuli categories slightly differed, so a fair comparison between our selection of artworks and faces might be compromised.

We did not categorize our stimuli according to complexity. Since the complexity of stimuli is associated the experienced vividness (Dijkstra et al., 2017), future studies could investigate the effects of stimulus category (artworks vs faces) on the experienced vividness and include complexity measures for the stimuli. This might be the Kolmogorov complexity or might be even measured with electroencephalography (EEG) (Kontson et al., 2015).

Note that for the first 11 participants a run only consisted of 19 instead of 20 trials due to an error with the randomization. This error led to one missing trial per run, with one trial per run being missing at random. Having said that, since those trials were missing at random, we did not expect unwanted distortions. However, the power of the study might be impaired.

We only replicated a part of the analysis of Dijkstra et al. (2017). Specifically, we only replicated the part connected to the univariate GLM and we left out the rest of the analysis in which a searchlight method is used (Dijkstra et al., 2017). We did this because replicating the rest of the analysis would have exceeded the scope of a master's thesis. It would be interesting if the rest of the results can also be replicated, which might be achieved by future studies.

6 Conclusion

The goal of this master's thesis was to further link research on Visual Mental Imagery (VMI) and aesthetics by investigating the influence of experienced Vividness of Visual Mental Imagery (VVMI) on aesthetic ratings. Our successful replication of previous results from (Dijkstra et al., 2017) validated the important role of activity in insula, dorsolateral prefrontal cortex, and medial frontal cortex for VMI using functional magnetic resonance imaging (fMRI). Our results further suggest that orbitofrontal cortex and the amygdalae are more active during visual perception in relation to VMI, while the investigation of the specific role of both areas in VMI of aesthetic stimuli is up to future research. Our behavioral results suggest that the higher experienced vividness rated, the more similar aesthetic ratings between visual perception and VMI can be expected. This finding indicates the degree of VVMI to play an important role in the similarity between VMI and visual perception. We also found a significant effect of stimulus category on the experienced VVMI, with artworks being experienced more vivid than faces. Here, more research is needed to explain this difference. According to our results, stimulus category did not significantly moderate the effect of VVMI on the similarity of aesthetic ratings between visual perception and VMI and had no significant effect on the similarity of aesthetic ratings between visual perception and VMI directly. Future studies might contrast stimuli with different levels of stimulus complexity to gain further insights in the relationship between stimulus complexity on aesthetic ratings in VMI. By further disentangling the relationship of VVMI and aesthetic experiences, this work not only provides the foundation for the main research question of this project, but also contributes to the improvement of treatments for a variety of disorders connected to VMI, VVMI, and aesthetics.

References

Albers, A. M., Kok, P., Toni, I., Dijkerman, H. C., & Lange, F. P. de (2013). Shared representations for working memory and mental imagery in early visual cortex. *Current Biology : CB*, *23*(15), 1427–1431. https://doi.org/10.1016/j.cub.2013.05.065

Amedi, A., Malach, R., & Pascual-Leone, A [Alvaro] (2005). Negative BOLD differentiates visual imagery and perception. *Neuron*, *48*(5), 859–872. https://doi.org/10.1016/j.neuron.2005.10.032

Anderson, S. F., & Maxwell, S. E. (2017). Addressing the "Replication Crisis": Using Original Studies to Design Replication Studies with Appropriate Statistical Power. *Multivariate Behavioral Research*, *52*(3), 305–324. https://doi.org/10.1080/00273171.2017.1289361

Baddeley, A. (1992). Working memory. *Science (New York, N.Y.)*, *255*(5044), 556–559. https://doi.org/10.1126/science.1736359

Baddeley, A. D., & Andrade, J. (2000). Working memory and the vividness of imagery. *Journal of Experimental Psychology. General*, *129*(1), 126–145. https://doi.org/10.1037//0096-3445.129.1.126

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences*, *4*(11), 417–423. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A. D., & Hitch, G. (1974). Working Memory. In *Psychology of Learning and Motivation* (Vol. 8, pp. 47–89). Elsevier. https://doi.org/10.1016/S0079-7421(08)60452-1

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2016). *Neuroscience: Exploring the brain* (Enhanced fourth edition). Jones & Bartlett. https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=6175387

Belfi, A. M., Vessel, E. A., Brielmann, A., Isik, A. I., Chatterjee, A., Leder, H., Pelli, D. G., & Starr, G. G. (2019). Dynamics of aesthetic experience are reflected in the default-mode network. *NeuroImage*, *188*, 584–597. https://doi.org/10.1016/j.neuroimage.2018.12.017

Belfi, A. M., Vessel, E. A., & Starr, G. G. (2018). Individual ratings of vividness predict aesthetic appeal in poetry. *Psychology of Aesthetics, Creativity, and the Arts*, *12*(3), 341–350. https://doi.org/10.1037/aca0000153

Bergmann, J., Genç, E., Kohler, A., Singer, W [Wolf], & Pearson, J. (2016). Smaller Primary Visual Cortex Is Associated with Stronger, but Less Precise Mental Imagery. *Cerebral*

Cortex (New York, N.Y. : 1991), *26*(9), 3838–3850. https://doi.org/10.1093/cercor/bhv186

Berridge, K. C., & Kringelbach, M. L. (2008). Affective neuroscience of pleasure: reward in humans and animals. Psychopharmacology, 199(3), 457-480.

Berridge, K. C., & Kringelbach, M. L [Morten L.] (2015). Pleasure systems in the brain. *Neuron*, *86*(3), 646–664. https://doi.org/10.1016/j.neuron.2015.02.018

Berridge, K. C., Robinson, T. E., & Aldridge, J. W. (2009). Dissecting components of reward: 'liking', 'wanting', and learning. *Current Opinion in Pharmacology*, *9*(1), 65–73. https://doi.org/10.1016/j.coph.2008.12.014

Blood, A. J., & Zatorre, R. J [R. J.] (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(20), 11818–11823. https://doi.org/10.1073/pnas.191355898

Borst, A. W. de [A. W.], & Gelder, B. de [B.] (2019). Mental Imagery Follows Similar Cortical Reorganization as Perception: Intra-Modal and Cross-Modal Plasticity in Congenitally Blind. *Cerebral Cortex (New York, N.Y. : 1991)*, *29*(7), 2859–2875. https://doi.org/10.1093/cercor/bhy151

Borst, A. W. de [Aline W.], Sack, A. T [Alexander T.], Jansma, B. M., Esposito, F., Martino, F. de, Valente, G., Roebroeck, A., Di Salle, F [Francesco], Goebel, R [Rainer], & Formisano, E [Elia] (2012). Integration of "what" and "where" in frontal cortex during visual imagery of scenes. *NeuroImage*, *60*(1), 47–58. https://doi.org/10.1016/j.neuroimage.2011.12.005

Borst, G., & Kosslyn, S. M [Stephen M.] (2008). Visual mental imagery and visual perception: Structural equivalence revealed by scanning processes. *Memory & Cognition*, *36*(4), 849–862. https://doi.org/10.3758/mc.36.4.849

Borst, G., Niven, E., & Logie, R. H. (2012). Visual mental image generation does not overlap with visual short-term memory: A dual-task interference study. *Memory & Cognition*, *40*(3), 360–372. https://doi.org/10.3758/s13421-011-0151-7

Cacioppo, S., Bianchi-Demicheli, F., Frum, C., Pfaus, J. G., & Lewis, J. W. (2012). The common neural bases between sexual desire and love: A multilevel kernel density fMRI analysis. *The Journal of Sexual Medicine*, *9*(4), 1048–1054. https://doi.org/10.1111/j.1743-6109.2012.02651.x

Campos, A. (2011). Internal consistency and construct validity of two versions of the Revised Vividness of Visual Imagery Questionnaire. *Perceptual and Motor Skills*, *113*(2), 454–460. https://doi.org/10.2466/04.22.PMS.113.5.454-460

Campos, A., Gonzalez, M. A., & Amor, A. (2002). The Spanish version of the Vividness of Visual Imagery Questionnaire: Factor structure and internal consistency reliability. *Psychological Reports*, *90*(2), 503–506. https://doi.org/10.2466/pr0.2002.90.2.503

Canty, A. J. (2002). Resampling methods in R: the boot package. The Newsletter of the R Project Volume, 2(3), 2-7.

Cattaneo, Z. (2020). Neural correlates of visual aesthetic appreciation: Insights from non-invasive brain stimulation. *Experimental Brain Research*, *238*(1), 1–16. https://doi.org/10.1007/s00221-019-05685-x

Chatterjee, A. (2014). Scientific aesthetics: Three steps forward. *British Journal of Psychology (London, England : 1953)*, *105*(4), 465–467. https://doi.org/10.1111/bjop.12086

Chatterjee, A., Thomas, A., Smith, S. E., & Aguirre, G. K. (2009). The neural response to facial attractiveness. *Neuropsychology*, *23*(2), 135–143. https://doi.org/10.1037/a0014430

Chatterjee, A., & Vartanian, O. (2014). Neuroaesthetics. *Trends in Cognitive Sciences*, *18*(7), 370–375. https://doi.org/10.1016/j.tics.2014.03.003

Chatterjee, A., & Vartanian, O. (2016). Neuroscience of aesthetics. *Annals of the New York Academy of Sciences*, *1369*(1), 172–194. https://doi.org/10.1111/nyas.13035

Cocchini, G., Logie, R. H., Della Sala, S., MacPherson, S. E., & Baddeley, A. D. (2002). Concurrent performance of two memory tasks: Evidence for domain-specific working memory systems. *Memory & Cognition*, *30*(7), 1086–1095. https://doi.org/10.3758/bf03194326

Cohen, M. S., Kosslyn, S. M [S. M.], Breiter, H. C., DiGirolamo, G. J., Thompson, W. L [W. L.], Anderson, A. K., Brookheimer, S. Y., Rosen, B. R., & Belliveau, J. W. (1996). Changes in cortical activity during mental rotation. A mapping study using functional MRI. *Brain : A Journal of Neurology*, *119 (Pt 1)*, 89–100. https://doi.org/10.1093/brain/119.1.89

Cui, X., Jeter, C. B., Yang, D., Montague, P. R., & Eagleman, D. M. (2007). Vividness of mental imagery: Individual variability can be measured objectively. *Vision Research*, *47*(4), 474–478. https://doi.org/10.1016/j.visres.2006.11.013

D'Argembeau, A., & van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition*, *15*(2), 342–350. https://doi.org/10.1016/j.concog.2005.09.001

Dawes, A. J., Keogh, R., Andrillon, T., & Pearson, J. (2020). A cognitive profile of multi-sensory imagery, memory and dreaming in aphantasia. *Scientific Reports*, *10*(1), 10022. https://doi.org/10.1038/s41598-020-65705-7

DeBruine, L., & Jones, B. (2017). *Face Research Lab London Set* [Data set]. figshare. https://doi.org/10.6084/M9.FIGSHARE.5047666.V3

Deckert, G. H. (1964). Pursuit eye movements in the absence of a moving visual stimulus. *Science*, *143*(3611), 1192–1193. https://doi.org/10.1126/science.143.3611.1192

Di Dio, C., Macaluso, E., & Rizzolatti, G. (2007). The golden beauty: Brain response to classical and renaissance sculptures. *PloS One*, *2*(11), e1201. https://doi.org/10.1371/journal.pone.0001201

Dijkstra, N., Bosch, S. E., & van Gerven, M. A. J. (2017). Vividness of Visual Imagery Depends on the Neural Overlap with Perception in Visual Areas. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *37*(5), 1367–1373. https://doi.org/10.1523/JNEUROSCI.3022-16.2016

Dobson, M., & Markham, R. (1993). Imagery ability and source monitoring: Implications for eyewitness memory. *British Journal of Psychology (London, England : 1953)*, *84 (Pt 1)*, 111–118. https://doi.org/10.1111/j.2044-8295.1993.tb02466.x

Eddelbuettel, D. (2013). *Seamless R and C++ integration with Rcpp*. *Use R! Vol. 64*. Springer.

Ferrari, C., Lega, C., Tamietto, M., Nadal, M., & Cattaneo, Z. (2015). I find you more attractive … after (prefrontal cortex) stimulation. *Neuropsychologia*, *72*, 87–93. https://doi.org/10.1016/j.neuropsychologia.2015.04.024

Fiedler, K., & Schwarz, N. (2016). Questionable Research Practices Revisited. *Social Psychological and Personality Science*, *7*(1), 45–52. https://doi.org/10.1177/1948550615612150

Finger, H., Goeke, C., Diekamp, D., Standvoß, K., & König, P. (2017). LabVanced: a unified JavaScript framework for online studies. In International conference on computational social science (cologne).

Fulford, J., Milton, F., Salas, D., Smith, A., Simler, A., Winlove, C., & Zeman, A. (2018a). The neural correlates of visual imagery vividness - An fMRI study and literature review. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *105*, 26–40. https://doi.org/10.1016/j.cortex.2017.09.014

Fulford, J., Milton, F., Salas, D., Smith, A., Simler, A., Winlove, C., & Zeman, A. (2018b). The neural correlates of visual imagery vividness - An fMRI study and literature review. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *105*, 26–40. https://doi.org/10.1016/j.cortex.2017.09.014

Galton, F. (1880). I.--Statistics of Mental Imagery. *Mind*, *os-V*(19), 301–318. https://doi.org/10.1093/mind/os-V.19.301

Ganis, G [Giorgio], Thompson, W. L [William L.], & Kosslyn, S. M [Stephen M.] (2004). Brain areas underlying visual mental imagery and visual perception: An fMRI study. *Brain Research. Cognitive Brain Research*, *20*(2), 226–241. https://doi.org/10.1016/j.cogbrainres.2004.02.012

Georgiadis, J. R., Kringelbach, M. L [Morten L.], & Pfaus, J. G. (2012). Sex for fun: A synthesis of human and animal neurobiology. *Nature Reviews. Urology*, *9*(9), 486–498. https://doi.org/10.1038/nrurol.2012.151

Goebel, R [R.], Khorram-Sefat, D., Muckli, L., Hacker, H., & Singer, W [W.] (1998). The constructive nature of vision: Direct evidence from functional magnetic resonance imaging studies of apparent motion and motion imagery. *The European Journal of Neuroscience*, *10*(5), 1563–1573. https://doi.org/10.1046/j.1460-9568.1998.00181.x

Greenberg, D. L., & Knowlton, B. J. (2014). The role of visual imagery in autobiographical memory. *Memory & Cognition*, *42*(6), 922–934. https://doi.org/10.3758/s13421-014-0402-5

Gurtner, L. M., Hartmann, M., & Mast, F. W. (2021). Eye movements during visual imagery and perception show spatial correspondence but have unique temporal signatures. *Cognition*, *210*, 104597. https://doi.org/10.1016/j.cognition.2021.104597

Harrison, N. R., & Clark, D. P. A. (2016). The Observing Facet of Trait Mindfulness Predicts Frequency of Aesthetic Experiences Evoked by the Arts. *Mindfulness*, *7*(4), 971–978. https://doi.org/10.1007/s12671-016-0536-6

Hayes, A. F. (2017). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. Guilford publications.

Hayn-Leichsenring, G. U., Kloth, N., Schweinberger, S. R., & Redies, C. (2013). Adaptation effects to attractiveness of face photographs and art portraits are domain-specific. *I-Perception*, *4*(5), 303–316. https://doi.org/10.1068/i0583

Hitsuwari, J., & Nomura, M. (2022). How Individual States and Traits Predict Aesthetic Appreciation of Haiku Poetry. *Empirical Studies of the Arts*, *40*(1), 81–99. https://doi.org/10.1177/0276237420986420

Holmes, E. A., & Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clinical Psychology Review*, *30*(3), 349–362. https://doi.org/10.1016/j.cpr.2010.01.001

Horikawa, T., Tamaki, M., Miyawaki, Y., & Kamitani, Y. (2013). Neural decoding of visual imagery during sleep. *Science (New York, N.Y.)*, *340*(6132), 639–642. https://doi.org/10.1126/science.1234330

Horng, J.-S., & Hsu, H. (2020). A holistic aesthetic experience model: Creating a harmonious dining environment to increase customers' perceived pleasure. *Journal of Hospitality and Tourism Management*, *45*, 520–534. https://doi.org/10.1016/j.jhtm.2020.10.006

Hsieh, P.-J., Vul, E., & Kanwisher, N. (2010). Recognition alters the spatial pattern of FMRI activation in early retinotopic cortex. *Journal of Neurophysiology*, *103*(3), 1501–1507. https://doi.org/10.1152/jn.00812.2009

Hu, C.-P., Huang, Y [Yi], Eickhoff, S. B., Peng, K., & Sui, J. (2016). *Seeking the "beauty center" in the brain: A meta-analysis of fMRI studies of beautiful human faces and visual art.* https://doi.org/10.1101/081539

Huang, Y [Yingying], Pollick, F., Liu, M., & Zhang, D. (2021). *Shared and Independent Neural Representation Between Visual Perception and Mental Imagery.* https://doi.org/10.21203/rs.3.rs-788978/v1

Ishai, A., Haxby, J. V., & Ungerieider, L. G. (2000). Distributed neural systems for the generation of visual images. *NeuroImage*, *11*(5), S684. https://doi.org/10.1016/S1053-8119(00)91614-8

Ishizu, T., & Zeki, S. (2011). Toward a brain-based theory of beauty. *PloS One*, *6*(7), e21852. https://doi.org/10.1371/journal.pone.0021852

Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. (2006). Empathy examined through the neural mechanisms involved in imagining how I feel versus how you feel pain. *Neuropsychologia*, *44*(5), 752–761. https://doi.org/10.1016/j.neuropsychologia.2005.07.015

Jacobs, R. H. A. H., Haak, K. V., Thumfart, S., Renken, R., Henson, B., & Cornelissen, F. W. (2016). Aesthetics by Numbers: Links between Perceived Texture Qualities and Computed Visual Texture Properties. *Frontiers in Human Neuroscience*, *10*, 343. https://doi.org/10.3389/fnhum.2016.00343

Jacobs, R. H. A. H., Renken, R., & Cornelissen, F. W. (2012). Neural correlates of visual aesthetics--beauty as the coalescence of stimulus and internal state. *PloS One*, *7*(2), e31248. https://doi.org/10.1371/journal.pone.0031248

Jacobsen, T. (2004). Individual and group modelling of aesthetic judgment strategies. *British Journal of Psychology (London, England : 1953)*, *95*(Pt 1), 41–56. https://doi.org/10.1348/000712604322779451

Jacobsen, T., Schubotz, R. I., Höfel, L., & Cramon, D. Y. V. (2006). Brain correlates of aesthetic judgment of beauty. *NeuroImage*, *29*(1), 276–285. https://doi.org/10.1016/j.neuroimage.2005.07.010

Jenkinson, M., Bannister, P., Brady, M., & Smith, S. (2002). Improved Optimization for the Robust and Accurate Linear Registration and Motion Correction of Brain Images. *NeuroImage*, *17*(2), 825–841. https://doi.org/10.1006/nimg.2002.1132

Johansson, R., Holsanova, J., Dewhurst, R., & Holmqvist, K. (2012). Eye movements during scene recollection have a functional role, but they are not reinstatements of those produced during encoding. *Journal of Experimental Psychology. Human Perception and Performance*, *38*(5), 1289–1314. https://doi.org/10.1037/a0026585

John, L. K., Loewenstein, G., & Prelec, D. (2012). Measuring the prevalence of questionable research practices with incentives for truth telling. *Psychological Science*, *23*(5), 524–532. https://doi.org/10.1177/0956797611430953

John Fox, Sanford Weisberg, & Brad Price. car: Companion to Applied Regression.

Just, M. A., Newman, S. D., Keller, T. A., McEleney, A., & Carpenter, P. A. (2004). Imagery in sentence comprehension: An fMRI study. *NeuroImage*, *21*(1), 112–124. https://doi.org/10.1016/j.neuroimage.2003.08.042

Kanizsa, G. (1976). Subjective contours. *Scientific American*, *234*(4), 48–52. https://doi.org/10.1038/scientificamerican0476-48

Kastner, S., Weerd, P. de, Elizondo, M. I., Desimone, R., & Ungerleider, L. G [L. G.] (1998). Attentional Response Modulation in Human Extrastriate Cortex as Revealed by Functional MRI. *NeuroImage*, *7*(4), S44. https://doi.org/10.1016/S1053-8119(18)30877-2

Kätsyri, J., Gelder, B. de [Beatrice], & Borst, A. W. de [Aline W.] (2020). Amygdala responds to direct gaze in real but not in computer-generated faces. *NeuroImage*, *204*, 116216. https://doi.org/10.1016/j.neuroimage.2019.116216

Kawabata, H., & Zeki, S. (2004). Neural correlates of beauty. *Journal of Neurophysiology*, *91*(4), 1699–1705. https://doi.org/10.1152/jn.00696.2003

Keogh, R., & Pearson, J. (2011). Mental imagery and visual working memory. *PloS One*, *6*(12), e29221. https://doi.org/10.1371/journal.pone.0029221

Keogh, R., & Pearson, J. (2014). The sensory strength of voluntary visual imagery predicts visual working memory capacity. *Journal of Vision*, *14*(12). https://doi.org/10.1167/14.12.7

Keogh, R., Wicken, M., & Pearson, J. (2021). Visual working memory in aphantasia: Retained accuracy and capacity with a different strategy. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *143*, 237–253. https://doi.org/10.1016/j.cortex.2021.07.012

Kleider-Offutt, H. M., Grant, A., & Turner, J. A. (2019). Common cortical areas involved in both auditory and visual imageries for novel stimuli. *Experimental Brain Research*, *237*(5), 1279–1287. https://doi.org/10.1007/s00221-019-05492-4

Koenig-Robert, R., & Pearson, J. (2019). Decoding the contents and strength of imagery before volitional engagement. *Scientific Reports*, *9*(1), 3504. https://doi.org/10.1038/s41598-019-39813-y

Komsta, L., & Komsta, M. L. (2011). Package ‘outliers’. *Medical University of Lublin, Lublin*.

Kontson, K. L., Megjhani, M., Brantley, J. A., Cruz-Garza, J. G., Nakagome, S., Robleto, D., White, M., Civillico, E., & Contreras-Vidal, J. L. (2015). Your Brain on Art: Emergent Cortical Dynamics During Aesthetic Experiences. *Frontiers in Human Neuroscience*, *9*, 626. https://doi.org/10.3389/fnhum.2015.00626

Kosslyn, S. M [S. M.] (1973). Scanning visual images: Some structural implications. *Perception & Psychophysics*, *14*(1), 90–94.

Kosslyn, S. M [S. M.], Ganis, G [G.], & Thompson, W. L [W. L.] (2001a). Neural foundations of imagery. *Nature Reviews. Neuroscience*, *2*(9), 635–642. https://doi.org/10.1038/35090055

Kosslyn, S. M [S. M.], Ganis, G [G.], & Thompson, W. L [W. L.] (2001b). Neural foundations of imagery. *Nature Reviews. Neuroscience*, *2*(9), 635–642. https://doi.org/10.1038/35090055

Kosslyn, S. M [Stephen M.], & Thompson, W. L [William L.] (2003). When is early visual cortex activated during visual mental imagery? *Psychological Bulletin*, *129*(5), 723–746. https://doi.org/10.1037/0033-2909.129.5.723

Leder, H., Belke, B., Oeberst, A., & Augustin, D. (2004a). A model of aesthetic appreciation and aesthetic judgments. *British Journal of Psychology (London, England : 1953)*, *95*(Pt 4), 489–508. https://doi.org/10.1348/0007126042369811

Leder, H., Belke, B., Oeberst, A., & Augustin, D. (2004b). A model of aesthetic appreciation and aesthetic judgments. *British Journal of Psychology (London, England : 1953)*, *95*(Pt 4), 489–508. https://doi.org/10.1348/0007126042369811

Leder, H., Goller, J., Rigotti, T., & Forster, M. (2016). Private and Shared Taste in Art and Face Appreciation. *Frontiers in Human Neuroscience*, *10*, 155. https://doi.org/10.3389/fnhum.2016.00155

Leder, H., & Nadal, M. (2014). Ten years of a model of aesthetic appreciation and aesthetic judgments : The aesthetic episode - Developments and challenges in empirical aesthetics. *British Journal of Psychology (London, England : 1953)*, *105*(4), 443–464. https://doi.org/10.1111/bjop.12084

Lee, S.-H., Kravitz, D. J., & Baker, C. I. (2012). Disentangling visual imagery and perception of real-world objects. *NeuroImage*, *59*(4), 4064–4073. https://doi.org/10.1016/j.neuroimage.2011.10.055

Lilienfeld, S. O., & Strother, A. N. (2020). Psychological measurement and the replication crisis: Four sacred cows. *Canadian Psychology/Psychologie Canadienne*, *61*(4), 281–288. https://doi.org/10.1037/cap0000236

Ma, D. S., Correll, J., & Wittenbrink, B. (2015). The Chicago face database: A free stimulus set of faces and norming data. *Behavior Research Methods*, *47*(4), 1122–1135. https://doi.org/10.3758/s13428-014-0532-5

Marković, S. (2014). Object Domains and the Experience of Beauty. *Art & Perception*, *2*(1-2), 119–140. https://doi.org/10.1163/22134913-00002020

Marks, D. F. (1973). Visual imagery differences in the recall of pictures. *British Journal of Psychology (London, England : 1953)*, *64*(1), 17–24. https://doi.org/10.1111/j.2044-8295.1973.tb01322.x

Marzi, T., & Viggiano, M. P. (2010). When memory meets beauty: Insights from event-related potentials. *Biological Psychology*, *84*(2), 192–205. https://doi.org/10.1016/j.biopsycho.2010.01.013

Mastandrea, S., Fagioli, S., & Biasi, V. (2019). Art and Psychological Well-Being: Linking the Brain to the Aesthetic Emotion. *Frontiers in Psychology*, *10*, Article 739. https://doi.org/10.3389/fpsyg.2019.00739

Menninghaus, W., Wagner, V., Hanich, J., Wassiliwizky, E., Jacobsen, T., & Koelsch, S. (2017). The Distancing-Embracing model of the enjoyment of negative emotions in art reception. *The Behavioral and Brain Sciences*, *40*, e347. https://doi.org/10.1017/S0140525X17000309

Menninghaus, W., Wagner, V., Hanich, J., Wassiliwizky, E., Kuehnast, M., & Jacobsen, T. (2015). Towards a psychological construct of being moved. *PloS One*, *10*(6), e0128451. https://doi.org/10.1371/journal.pone.0128451

Mishkin, M., Ungerleider, L. G [Leslie G.], & Macko, K. A. (1983). Object vision and spatial vision: two cortical pathways. *Trends in Neurosciences*, *6*, 414–417. https://doi.org/10.1016/0166-2236(83)90190-X

Nusbaum, E. C., & Silvia, P. J. (2011). Shivers and Timbres. *Social Psychological and Personality Science*, *2*(2), 199–204. https://doi.org/10.1177/1948550610386810

Olivetti Belardinelli, M., Palmiero, M., Sestieri, C., Nardo, D., Di Matteo, R., Londei, A., D'Ausilio, A., Ferretti, A., Del Gratta, C., & Romani, G. L. (2009). An fMRI investigation on image generation in different sensory modalities: The influence of vividness. *Acta Psychologica*, *132*(2), 190–200. https://doi.org/10.1016/j.actpsy.2009.06.009

Owen, A. M., Coleman, M. R., Boly, M., Davis, M. H., Laureys, S., & Pickard, J. D. (2006). Detecting awareness in the vegetative state. *Science (New York, N.Y.)*, *313*(5792), 1402. https://doi.org/10.1126/science.1130197

Parkes, L., Fulcher, B., Yücel, M., & Fornito, A. (2018). An evaluation of the efficacy, reliability, and sensitivity of motion correction strategies for resting-state functional MRI. *NeuroImage*, *171*, 415–436. https://doi.org/10.1016/j.neuroimage.2017.12.073

Parsons, C. E., Young, K. S., Murray, L., Stein, A., & Kringelbach, M. L [M. L.] (2010). The functional neuroanatomy of the evolving parent-infant relationship. *Progress in Neurobiology*, *91*(3), 220–241. https://doi.org/10.1016/j.pneurobio.2010.03.001

Pashler, H., & Wagenmakers, E.-J. (2012). Editors' Introduction to the Special Section on Replicability in Psychological Science: A Crisis of Confidence? *Perspectives on Psychological Science : A Journal of the Association for Psychological Science*, *7*(6), 528–530. https://doi.org/10.1177/1745691612465253

Pearce, M. T., Zaidel, D. W., Vartanian, O., Skov, M., Leder, H., Chatterjee, A., & Nadal, M. (2016). Neuroaesthetics: The Cognitive Neuroscience of Aesthetic Experience. *Perspectives on Psychological Science : A Journal of the Association for Psychological Science*, *11*(2), 265–279. https://doi.org/10.1177/1745691615621274

Pearson, J. (2019a). The human imagination: The cognitive neuroscience of visual mental imagery. *Nature Reviews. Neuroscience*, *20*(10), 624–634. https://doi.org/10.1038/s41583-019-0202-9

Pearson, J. (2019b). The human imagination: The cognitive neuroscience of visual mental imagery. *Nature Reviews. Neuroscience*, *20*(10), 624–634. https://doi.org/10.1038/s41583-019-0202-9

Pearson, J., Clifford, C. W. G., & Tong, F. (2008). The functional impact of mental imagery on conscious perception. *Current Biology : CB*, *18*(13), 982–986. https://doi.org/10.1016/j.cub.2008.05.048

Pearson, J., & Keogh, R. (2019). Redefining Visual Working Memory: A Cognitive-Strategy, Brain-Region Approach. *Current Directions in Psychological Science*, *28*(3), 266–273. https://doi.org/10.1177/0963721419835210

Pearson, J., & Kosslyn, S. M [Stephen M.] (2015). The heterogeneity of mental representation: Ending the imagery debate. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(33), 10089–10092. https://doi.org/10.1073/pnas.1504933112

Pearson, J., Naselaris, T., Holmes, E. A., & Kosslyn, S. M [Stephen M.] (2015). Mental Imagery: Functional Mechanisms and Clinical Applications. *Trends in Cognitive Sciences*, *19*(10), 590–602. https://doi.org/10.1016/j.tics.2015.08.003

Peirce, J. W. (2007). PsychoPy—psychophysics software in Python. Journal of neuroscience methods, 162(1-2), 8-13.

Pelowski, M., Markey, P. S., Forster, M., Gerger, G., & Leder, H. (2017). Move me, astonish me… delight my eyes and brain: The Vienna Integrated Model of top-down and bottom-up processes in Art Perception (VIMAP) and corresponding affective, evaluative, and neurophysiological correlates. *Physics of Life Reviews*, *21*, 80–125. https://doi.org/10.1016/j.plrev.2017.02.003

R Core Team (2013). R: A language and environement for statistical computing. Vienna, Austria. URL http://www.R-project.org/

Raichle, M. E. (2015). The brain's default mode network. *Annual Review of Neuroscience*, *38*, 433–447. https://doi.org/10.1146/annurev-neuro-071013-014030

Ranganath, C., & D'Esposito, M. (2005). Directing the mind's eye: Prefrontal, inferior and medial temporal mechanisms for visual working memory. *Current Opinion in Neurobiology*, *15*(2), 175–182. https://doi.org/10.1016/j.conb.2005.03.017

Reddy, L., Tsuchiya, N., & Serre, T. (2010). Reading the mind's eye: Decoding category information during mental imagery. *NeuroImage*, *50*(2), 818–825. https://doi.org/10.1016/j.neuroimage.2009.11.084

Reisberg, D., Pearson, D. G., & Kosslyn, S. M [Stephen M.] (2003). Intuitions and introspections about imagery: the role of imagery experience in shaping an investigator's theoretical views. *Applied Cognitive Psychology*, *17*(2), 147–160. https://doi.org/10.1002/acp.858

Richardson, D. C., & Spivey, M. J. (2000). Representation, space and Hollywood Squares: looking at things that aren't there anymore. *Cognition*, *76*(3), 269–295. https://doi.org/10.1016/S0010-0277(00)00084-6

Ripley, B., Venables, B., Bates, D. M., Hornik, K., Gebhardt, A., Firth, D., & Ripley, M. B. (2013). Package 'mass'. Cran r, 538, 113-120.

Rolls, E. T., Browning, A. S., Inoue, K., & Hernadi, I. (2005). Novel visual stimuli activate a population of neurons in the primate orbitofrontal cortex. Neurobiology of learning and memory, 84(2), 111-123.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological Bulletin*, *86*(3), 638–641. https://doi.org/10.1037/0033-2909.86.3.638

Rossi, J. S. (1977). Reliability of a measure of visual imagery. *Perceptual and Motor Skills*, *45*(3, Pt 1), 694.

Sack, A. T [A. T.], Camprodon, J. A., Pascual-Leone, A [A.], & Goebel, R [R.] (2005). The dynamics of interhemispheric compensatory processes in mental imagery. *Science (New York, N.Y.)*, *308*(5722), 702–704. https://doi.org/10.1126/science.1107784

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J [Robert J.] (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience*, *14*(2), 257–262. https://doi.org/10.1038/nn.2726

Schacht, A., Werheid, K., & Sommer, W. (2008). The appraisal of facial beauty is rapid but not mandatory. *Cognitive, Affective & Behavioral Neuroscience*, *8*(2), 132–142. https://doi.org/10.3758/cabn.8.2.132

Schäfer, P. T. (2015). *Viennese Art Picture System* [, (:none)]. DataCite.

Schlegel, A., Kohler, P. J., Fogelson, S. V., Alexander, P., Konuthula, D., & Tse, P. U. (2013). Network structure and dynamics of the mental workspace. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(40), 16277–16282. https://doi.org/10.1073/pnas.1311149110

Schneider, A. (2020). „Perceiving beauty with the mind's eye: An fNIRS study on the neural correlates of visual mental imagery of beauty " (master's thesis, University of Vienna).

Schulz, K., & Hayn-Leichsenring, G. U. (2017). Face Attractiveness versus Artistic Beauty in Art Portraits: A Behavioral Study. *Frontiers in Psychology*, *8*, 2254. https://doi.org/10.3389/fpsyg.2017.02254

Schurgin, M. W. (2018). Visual memory, the long and the short of it: A review of visual working memory and long-term memory. *Attention, Perception & Psychophysics*, *80*(5), 1035–1056. https://doi.org/10.3758/s13414-018-1522-y

Senden, M., Emmerling, T. C., van Hoof, R., Frost, M. A., & Goebel, R [Rainer] (2019). Reconstructing imagined letters from early visual cortex reveals tight topographic correspondence between visual mental imagery and perception. *Brain Structure & Function*, *224*(3), 1167–1183. https://doi.org/10.1007/s00429-019-01828-6

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensionsal objects. *Science*, *171*(3972), 701–703.

Silvia, P. J. (2005). Emotional Responses to Art: From Collation and Arousal to Cognition and Emotion. *Review of General Psychology*, *9*(4), 342–357. https://doi.org/10.1037/1089-2680.9.4.342

Silvia, P. J., & Nusbaum, E. C. (2011). On personality and piloerection: Individual differences in aesthetic chills and other unusual aesthetic experiences. *Psychology of Aesthetics, Creativity, and the Arts*, *5*(3), 208–214. https://doi.org/10.1037/a0021914

Simonsohn, U., Simmons, J. P., & Nelson, L. D. (2015). Better P-curves: Making P-curve analysis more robust to errors, fraud, and ambitious P-hacking, a Reply to Ulrich and Miller (2015). *Journal of Experimental Psychology. General*, *144*(6), 1146–1152. https://doi.org/10.1037/xge0000104

Slotnick, S. D. (2008). Imagery: Mental pictures disrupt perceptual rivalry. *Current Biology : CB*, *18*(14), R603-5. https://doi.org/10.1016/j.cub.2008.06.002

Spagna, A., Hajhajate, D., Liu, J., & Bartolomeo, P. (2021). Visual mental imagery engages the left fusiform gyrus, but not the early visual cortex: A meta-analysis of neuroimaging evidence. *Neuroscience and Biobehavioral Reviews*, *122*, 201–217. https://doi.org/10.1016/j.neubiorev.2020.12.029

Stroebe, W., Postmes, T., & Spears, R. (2012). Scientific Misconduct and the Myth of Self-Correction in Science. *Perspectives on Psychological Science : A Journal of the*

Association for Psychological Science, *7*(6), 670–688. https://doi.org/10.1177/1745691612460687

Sunday, M., McGugin, R. W., & Gauthier, I. (2017). Domain-specific reports of visual imagery vividness are not related to perceptual expertise. *Behavior Research Methods*, *49*(2), 733–738. https://doi.org/10.3758/s13428-016-0730-4

Thakral, P. P., Moo, L. R., & Slotnick, S. D. (2012). A neural mechanism for aesthetic experience. *Neuroreport*, *23*(5), 310–313. https://doi.org/10.1097/WNR.0b013e328351759f

Thomas, N. J. (1999). Are Theories of Imagery Theories of Imagination? An Active Perception Approach to Conscious Mental Content. *Cognitive Science*, *23*(2), 207–245. https://doi.org/10.1207/s15516709cog2302_3

Tinio, P. P. L., & Leder, H. (2009). Just how stable are stable aesthetic features? Symmetry, complexity, and the jaws of massive familiarization. *Acta Psychologica*, *130*(3), 241–250. https://doi.org/10.1016/j.actpsy.2009.01.001

Torchiano, M., & Torchiano, M. M. (2020). Package 'effsize'.

Trojano, L., Grossi, D., Linden, D. E., Formisano, E [E.], Hacker, H., Zanella, F. E., Goebel, R [R.], & Di Salle, F [F.] (2000). Matching two imagined clocks: The functional anatomy of spatial analysis in the absence of visual stimulation. *Cerebral Cortex (New York, N.Y. : 1991)*, *10*(5), 473–481. https://doi.org/10.1093/cercor/10.5.473

Uithol, S., Bryant, K. L., Toni, I., & Mars, R. B. (2021). The Anticipatory and Task-Driven Nature of Visual Perception. *Cerebral Cortex (New York, N.Y. : 1991)*, *31*(12), 5354–5362. https://doi.org/10.1093/cercor/bhab163

Vartanian, O., Goel, V., Lam, E., Fisher, M., & Granic, J. (2013). Middle temporal gyrus encodes individual differences in perceived facial attractiveness. *Psychology of Aesthetics, Creativity, and the Arts*, *7*(1), 38–47. https://doi.org/10.1037/a0031591

Vartanian, O., & Skov, M. (2014). Neural correlates of viewing paintings: Evidence from a quantitative meta-analysis of functional magnetic resonance imaging data. *Brain and Cognition*, *87*, 52–56. https://doi.org/10.1016/j.bandc.2014.03.004

Vessel, E. A., Starr, G. G., & Rubin, N. (2012). The brain on art: Intense aesthetic experience activates the default mode network. *Frontiers in Human Neuroscience*, *6*, 66. https://doi.org/10.3389/fnhum.2012.00066

Wallraven, C., & Freese, J. (2015). “We remember what we like?”: Aesthetic value and memorability for photos and artworks - a combined behavioral and computational study. *Journal of Vision*, *15*(12), 87. https://doi.org/10.1167/15.12.87

Ward, J. (2019). *The Student’s Guide to Cognitive Neuroscience*. Routledge. https://doi.org/10.4324/9781351035187

Wassiliwizky, E., & Menninghaus, W. (2021). Why and How Should Cognitive Science Care about Aesthetics? *Trends in Cognitive Sciences*, *25*(6), 437–449. https://doi.org/10.1016/j.tics.2021.03.008

Wickham, H. (2011). The Split-Apply-Combine Strategy for Data Analysis. *Journal of Statistical Software*, *40*(1). https://doi.org/10.18637/jss.v040.i01

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T., Miller, E., Bache, S., Müller, K., Ooms, J., Robinson, D., Seidel, D., Spinu, V., . . . Yutani, H. (2019). Welcome to the Tidyverse. *Journal of Open Source Software*, *4*(43), 1686. https://doi.org/10.21105/joss.01686

Wickham, H., Chang, W., & Wickham, M. H. (2016). Package ‘ggplot2’. Create elegant data visualisations using the grammar of graphics. Version, 2(1), 1-189.

Wickham, H., & Wickham, M. H. (2019). Package ‘stringr’.

Wynn, J. S., Olsen, R. K., Binns, M. A., Buchsbaum, B. R., & Ryan, J. D. (2018). Fixation reinstatement supports visuospatial memory in older adults. *Journal of Experimental Psychology. Human Perception and Performance*, *44*(7), 1119–1127. https://doi.org/10.1037/xhp0000522

Xenakis, I., & Arnellos, A. (2022). Ontological and conceptual challenges in the study of aesthetic experience. *Philosophical Psychology*, 1–43. https://doi.org/10.1080/09515089.2022.2062314

Zaretskaya, N., Thielscher, A., Logothetis, N. K., & Bartels, A. (2010). Disrupting parietal function prolongs dominance durations in binocular rivalry. *Current Biology : CB*, *20*(23), 2106–2111. https://doi.org/10.1016/j.cub.2010.10.046

Zeki, S., & Romaya, J. P. (2010). The brain reaction to viewing faces of opposite-and same-sex romantic partners. *PloS one*, *5*(12), e15802.

Zeman, A., Dewar, M., & Della Sala, S. (2015). Lives without imagery - Congenital aphantasia. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *73*, 378–380. https://doi.org/10.1016/j.cortex.2015.05.019

Zeman, A., Dewar, M., & Della Sala, S. (2016). Reflections on aphantasia. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *74*, 336–337. https://doi.org/10.1016/j.cortex.2015.08.015

Zeman, A., Milton, F., Della Sala, S., Dewar, M., Frayling, T., Gaddum, J., Hattersley, A., Heuerman-Williamson, B., Jones, K., MacKisack, M., & Winlove, C. (2020). Phantasia-The psychological significance of lifelong visual imagery vividness extremes. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *130*, 426–440. https://doi.org/10.1016/j.cortex.2020.04.003

Abbreviations

AES	Aesthetic Experience Scale
DLPFC	Dorsolateral prefrontal cortex
DMN	Default mode network
EEG	Electroencephalography
FA	Flip Angle
FoV	Field of View
fMRI	functional magnetic resonance imaging
PPC	posterior parietal cortex
SFG	superior frontal gyrus
TE	Echo time
TI	Inversion time
TR	Repetition time
VAPS	Vienna Art Picture System
VMI	Visual Mental Imagery
VWM	Visual Working Memory
VVMI V	Vividness of Visual Mental Imagery
VVIQ	Vividness of Visual Mental Imagery Questionnaire

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7 Appendix

Abstract

English:
Previous studies have shown that visual mental imagery (VMI) and visual perception share a substantial neural overlap which partly is modulated by the experienced vividness of visual mental imagery (VVMI). There are indications that VVMI can predict aesthetic appeal. However, research on VVMI in aesthetics is scarce. This master's thesis tries to further link both fields by replicating findings on the differences in brain activation between VMI and visual perception using functional magnetic resonance imaging (fMRI), and by further investigating the influence of experienced VVMI on the similarity of aesthetic ratings between visual perception and VMI. A sample of 34 participants were presented images of artworks and faces and rated them according to their aesthetic experiences. Subsequently, they imagined the previous seen image, again followed by rating their aesthetic experiences. Concerning the results of the fMRI-part, we successfully replicated previous findings indicating stronger activity during visual perception than VMI in the whole ventral visual stream and stronger activity during imagery in insula, dorsolateral prefrontal cortex, and medial frontal cortex. We further observed stronger activity during visual perception in relation to VMI in parts of the orbitofrontal cortex and the amygdalae. Our behavioral results indicate a significant positive relationship between higher experienced vividness and more similar aesthetic ratings between visual perception and VMI. We also found a significant effect of stimulus category on the experienced VVMI, while stimulus category did not significantly moderate the effect between VVMI and the similarity of aesthetic ratings between visual perception and VMI.

German:
Frühere Studien haben gezeigt, dass visuelle mentale Vorstellung (vmV; engl. = *Visual Mental Imagery*) und visuelle Wahrnehmung wesentliche neuronale Überschneidungen aufweisen, die teilweise durch die erfahrene Lebendigkeit visueller mentaler Vorstellungen (LvmV; engl. = *Vividness of Visual Mental Imagery*) moduliert werden. Es gibt Hinweise darauf, dass die LvmV ästhetische Erfahrung vorhersagen kann. Es gibt jedoch wenig Forschung über die LvmV in der Ästhetik. Diese Masterarbeit versucht, diese beiden

Forschungsbereiche weiter zu vernetzen, indem sie Erkenntnisse zu den Unterschieden in der Gehirnaktivierung zwischen vmV und visueller Wahrnehmung mittels funktioneller Magnetresonanztomographie (fMRT) repliziert und den Einfluss von LvmV auf die Ähnlichkeit ästhetischer Bewertungen zwischen visueller Wahrnehmung und vmV untersucht. Einer Stichprobe von 34 Testpersonen wurde Bilder von Kunstwerken und Gesichtern präsentiert, woraufhin sie diese nach den ästhetischen Erfahrungen bei Betrachtung der Bilder bewerteten. Anschließend stellten sich die Testpersonen das zuvor gesehene Bild vor, wiederum gefolgt von einer Bewertung ihrer ästhetischen Erfahrungen. Bezogen auf unsere fRMT-Ergebnisse konnten wir frühere Ergebnisse erfolgreich replizieren, die auf eine stärkere Aktivität während der visuellen Wahrnehmung im Vergleich zu vmV im gesamten ventralen visuellen Zentrum und eine stärkere Aktivität während der vmV in der Insula, dem dorsolateralen präfrontalen Kortex und dem medialen Frontalkortex, hinweisen. Wir beobachteten zudem eine stärkere Aktivität während der visuellen Wahrnehmung in Teilen des orbitofrontalen Kortex und der Amygdalae. Unsere Verhaltensdaten weisen auf eine signifikant positive Beziehung zwischen einer höheren erfahrenen Lebendigkeit und ähnlichen ästhetischen Bewertungen zwischen visueller Wahrnehmung und vmV hin. Wir fanden weiters einen signifikanten Effekt der Stimulus-Kategorie auf die erfahrene LvmV, während die Stimulus-Kategorie den Effekt zwischen LvmV und der Ähnlichkeit ästhetischer Bewertungen zwischen visueller Wahrnehmung und vmV nicht signifikant moderierte.

Adapted and Translated version of Vividness of Visual Mental Imagery Questionnaire

Bitte füllen Sie den folgenden Fragebogen aus:

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

Aesthetic Experience Scale and additional information

Auf den nächsten beiden Seiten werden Sie Fragen über Ihr ästhetisches Erleben beantworten. Bitte lesen Sie sich dafür die folgende Definition von ästhetischem Erleben sorgfältig durch:

Ästhetisches Erleben bedeutet, dass das Erleben dieser Kunstform Sie emotional oder physiologisch bewegt oder berührt. Dabei kann es sich um ein schönes, hässliches, trauriges, oder aufwühlendes Erleben handeln. 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.

Halten Sie sich bitte an diese Definition, wenn Sie die folgenden Fragen beantworten.

Bitte wählen Sie die Kunstdomäne aus, die bei Ihnen am häufigsten starke Emotionen bzw. ein starkes ästhetisches Erleben auslöst:

Musik hören
Videos schauen (Fernsehen, Kino, Youtube, etc.)
Bildende Kunst (Gemälde, Malerei, Kunstfotografie, etc.)
Literatur
Tanzaufführungen
Theater
Eigenes kreatives Schaffen
Andere

Wie häufig löst die von Ihnen angegebenen Kunstdomäne in etwa starke Emotionen bzw. ein starkes ästhetisches Erleben aus?
täglich
mehrmals die Woche
einmal die Woche
ein- bis zweimal im Monat
alle paar Monate
ein- bis zweimal im Jahr
noch seltener

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 selten 1 2 3 4 5 6 7 fast immer

Wie oft verlieren Sie vollkommen das Zeitgefühl?

niemals oder selten 1 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

Pre-screening

Sehr geehrte*r Teilnehmer*in,

vielen Dank für Ihr Interesse an dieser Studie. Ihre Teilnahme erfolgt vollkommen freiwillig und Sie können zu jedem Zeitpunkt, ohne Angabe von Gründen, die Teilnahme an der Studie verweigern und die Studie abbrechen. Durch den Abbruch der Studie entstehen Ihnen keine Nachteile.

Wie läuft die Studie ab?

Zuerst werden Sie einige demografische Fragen beantworten. Es ist sehr wichtig, dass Sie diese Fragen ehrlich beantworten. Anschließend werden Ihnen Fragen zu Ihrem emotionalen Empfinden in Bezug auf Kunst gestellt sowie einige Aufgaben, die Ihr Vorstellungsvermögen testen, vorgegeben. Es gibt kein Richtig oder Falsch. Bitte versuchen Sie die Aufgaben mit hinreichender Konzentration zu absolvieren. Die Durchführung des Screenings dauert im Regelfall etwa 10 Minuten. Ungefähr die Hälfte von Ihnen wird für die Teilnahme an der weiterführenden fMRT-Studie ausgewählt. Unabhängig davon, ob Sie ausgewählt werden, melden wir uns bei Ihnen. Falls Sie ausgewählt werden, machen wir anschließend in Absprache mit Ihnen einen Termin aus.

Gibt es Risiken?

Für die Durchführung des Screenings bestehen keine Risiken und es ist mit keinen Beschwerden zu rechnen. Falls Sie für die nachfolgende fMRT-Untersuchung geeignet sind, werden Sie in weiterer Folge über diese Studie augeklärt.

Was ist der Zweck dieser Studie?

Der Zweck dieser Studie ist es, geeignete Teilnehmer*innen für ein nachfolgendes fMRT-Experiment zum Thema Vorstellungskraft in Zusammenhang mit ästhetischem Empfinden zu rekrutieren.

In welcher Weise werden die im Rahmen dieser Studie gesammelten Daten verwendet?

Zugriff auf Ihre Daten hat ausschließlich die Studienleitung und ihre Mitarbeiter*innen.

Worin liegt der Nutzen einer Teilnahme an der Studie?

Sie erhalten einen Einblick in die wissenschaftliche, psychologische Praxis. Darüber hinaus leisten Sie einen wichtigen Beitrag zu der aktuellen Gehirnforschung.

Entstehen durch die Teilnahme an der Studie Kosten, oder ist eine Vergütung vorgesehen?

Sie erhalten einen Einblick in die wissenschaftliche Praxis und helfen bei der Gewinnung neuer wissenschaftlicher Erkenntnisse mit. Falls Sie für die nachfolgende fMRT-Untersuchung ausgewählt werden, erhalten Sie zudem eine materielle Vergütung von 20 Euro.

Namen der Kontaktpersonen:
(censored), (censored)
Mailadresse: (censored)
Einwilligungserklärung:
Ich erkläre mich bereit an dieser Studie („Vorstellungskraft & ästhetisches Empfinden") teilzunehmen. Ich wurde ausführlich und verständlich über Zielsetzung, Bedeutung und Tragweite der Studie und die Anforderungen, die sich daraus für mich ergeben, aufgeklärt. Ich habe den Text dieser Teilnehmer*inneninformation und Einwilligungserklärung gelesen.
check
Ich werde die Hinweise, die für die Durchführung der Studie erforderlich sind, befolgen. Ich behalte mir das Recht vor, meine freiwillige Mitarbeit jederzeit zu beenden, ohne dass mir daraus Nachteile entstehen. Ein Abbruch der Studie ist jederzeit durch das Schließen des Browserfensters möglich. Bitte beachten Sie, dass wir Sie ausschließlich nach Beendigung der Studie für die weiterführende fMRT-Studie in Betracht ziehen können.
check
Ich erkläre mich hiermit einverstanden, dass meine Daten, die im Rahmen dieser Studie erhoben werden, aufgezeichnet und ausgewertet werden.
Ich stimme darüber hinaus zu, dass meine Daten dauerhaft elektronisch gespeichert werden.
Ich erkläre mich einverstanden, dass meine Daten in einer Form gespeichert werden, die nur der Projektleitung und ihrer Mitarbeiter*innen zugänglich ist und gemäß aktuellem Standard gesichert sind.
Ich erkläre mich hiermit einverstanden, dass mich die Projektleitung und ihre Mitarbeiter*innen auf die von mir im Rahmen dieser Studie („Vorstellungskraft & ästhetisches Empfinden") angegebenen Emailadresse kontaktieren dürfen.
check
Einwilligungserklärung:
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check

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check
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check
Bitte geben Sie hier Ihre Mailadresse an:

Wie würden Sie Ihre Deutschkenntnisse beschreiben?
geringe oder keine Kenntnisse
mäßige Kenntnisse
gute Kenntnisse
sehr gute Kenntnisse
Muttersprache

Wie alt sind Sie (in Jahren)?

In welchen Land/welchen Ländern sind Sie aufgewachsen?

Welchem Geschlecht fühlen Sie sich zugehörig?
weiblich
männlich
divers
andere

Zu welchem Geschlecht fühlen Sie sich hingezogen?

weiblich

männlich

männlich und weiblich

zu keinem der genannten

Sind Sie Rechtshänder*in?

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

Wurde bei Ihnen jemals eine neurologische, psychologische oder psychiatrische Erkrankung diagnostiziert?
Nein
Ich bin mir nicht sicher
Ja, und zwar ...

Nehmen Sie zur Zeit irgendwelche Medikamente ein?
Wenn ja, welche?
Nein
Ja, und zwar ...

Leiden Sie unter Klaustrophobie?

Ja
Nein
Ich bin mir nicht sicher

Haben Sie weitere Fragen bzw. Anmerkungen?

Bitte wählen Sie die Kunstdomäne aus, die bei Ihnen am häufigsten starke Emotionen bzw. ein starkes ästhetisches Erleben auslöst:

Musik hören
Videos schauen (Fernsehen, Kino, Youtube, etc.)
Bildende Kunst (Gemälde, Malerei, Kunstfotografie, etc.)
Literatur
Tanzaufführungen
Theater
Eigenes kreatives Schaffen
Andere

Wie häufig löst die von Ihnen angegebenen Kunstdomäne in etwa starke Emotionen bzw. ein starkes ästhetisches Erleben aus?

täglich
mehrmals die Woche
einmal die Woche
ein- bis zweimal im Monat
alle paar Monate
ein- bis zweimal im Jahr
noch seltener

Wie häufig sind Sie der von Ihnen angegebenen Kunstdomäne in etwa ausgesetzt?

täglich
mehrmals die Woche
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alle paar Monate
ein- bis zweimal im Jahr
noch seltener

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Wie oft fühlen Sie sich vollkommen eingenommen von und versunken in Ihr Erleben?
niemals oder selten 1 2 3 4 5 6 7 fast immer
Wie oft verlieren Sie vollkommen das Zeitgefühl?
niemals oder selten 1 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?

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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

Bitte füllen Sie den folgenden Fragebogen aus:

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

Vielen Dank für Ihre Teilnahme!

Wir werden Sie per Mail darüber informieren, ob Sie für die weiterführende fMRT-Studie ausgewählt wurden. Bitte beachten Sie, dass dies unter Umständen einige Zeit in Anspruch nehmen kann.

Sie können Sie Studie beenden, indem Sie auf "Next" klicken.

(censored), (censored)
Mailadresse: (censored)

Instructions for the fMRI-Study

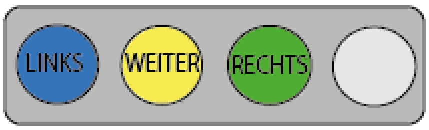
Liebe*r Studienteilnehmer*in,

Im Folgenden bekommen Sie die Instruktionen mitgeteilt, bitte lesen Sie diese aufmerksam durch, im Anschluss bekommen Sie ein paar Verständnisfragen gestellt.

Die Studie, an der Sie gerade teilnehmen, besteht aus zwei Teilen: Einem strukturellen Scan und einem funktionellen Scan. Bei dem strukturellen Scan müssen Sie keine Aufgaben ausführen. Liegen Sie einfach ruhig und entspannt da und versuchen Sie sich möglichst wenig zu bewegen. Bei dem funktionellen Scan absolvieren Sie ein Experiment, in dem Sie Gesichter/Kunstwerke intensiv betrachten und diese im Anschluss sich dann vorstellen werden. Diese sollen Sie anschließend dann beurteilen. Das Experiment besteht aus mehreren Durchgängen mit verschiedenen Stimuli. Dabei wird das MRI Bilder von Ihrer Gehirnfunktion machen. Die Aufnahmen sind sehr laut und Sie werden als Schutz Kopfhörer tragen. Die gesamte Studie wird 1,5h in Anspruch nehmen.

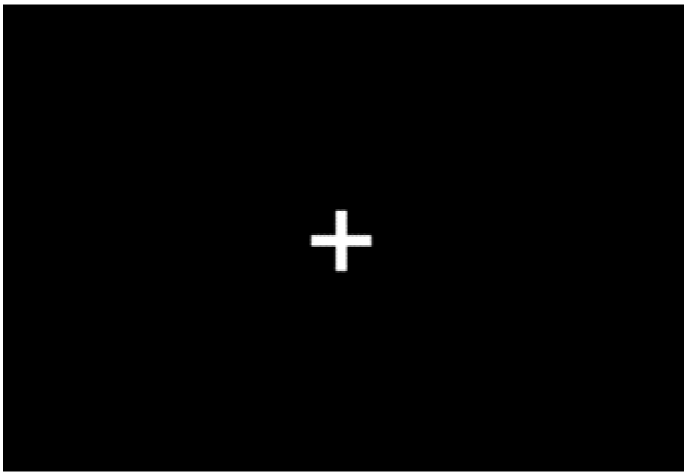
Es ist ganz wichtig, dass Sie sich während der Aufnahmen (wenn es laut ist) nicht bewegen, sonst kommt es zu Störungen in den Bildern.

Während der MRI-Erhebung werden Sie ein Gerät (Button Box) bedienen. Eine Box mit 4 Knöpfen wird auf Ihrem Oberschenkel liegen. Drei Finger Ihrer rechten Hand werden während des ganzen Experiments auf den jeweiligen Knöpfen ruhen, mittels derer Sie die Fragen beantworten können, die am Ende jedes Durchgangs auf dem Bildschirm erscheinen. Mit dem blauen Knopf navigieren Sie in der Bewertungsskala nach links, mit dem grünen Knopf navigieren Sie auf der Bewertungsskala nach rechts und mit dem gelben Knopf bestätigen Sie ihre Eingabe.



Ablauf:

Zunächst werden Sie für ein paar Sekunden ein Fixationskreuz sehen, auf das Sie bitte Ihren Blick fixieren.



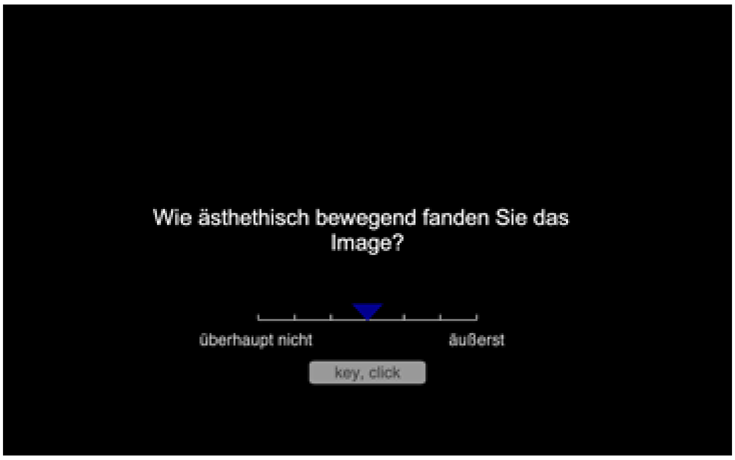
Dann wird Ihnen ein Kunstwerk oder Gesicht auf dem Bildschirm angezeigt. Bitte betrachten Sie dieses ganz genau.

Anschließend werden Sie mittels der Box und Ihrer rechten Hand einige Fragen beantworten. Die Reihenfolge, in der die Fragen erscheinen, verändert sich in jedem Durchgang. Sie haben nur einige Sekunden Zeit die Fragen zu beantworten. Auch wenn einige der Fragen Ihnen ähnlich erscheinen werden, jede Frage ist komplett unabhängig von den anderen Fragen zu beantworten. Beispielsweise könnte in Einzelfällen ein Gesicht/Kunstwerk Vergnügen bereiten unabhängig davon, ob es schön oder ästhetisch bewegend ist.

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.

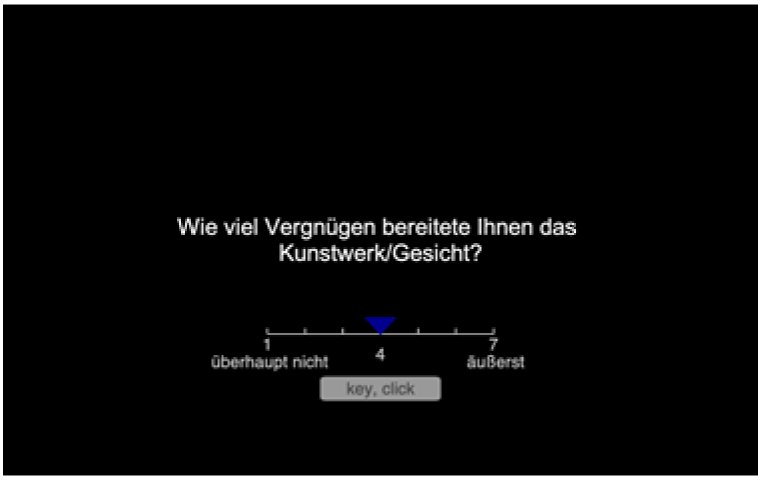
„Wie ästhetisch bewegend fanden Sie das Image?“
Bei dieser Frage geht es uns darum, dass Sie auf einer Skala von 1-7 angeben, wie ästhetisch bewegend Sie das Gesicht/Kunstwerk fanden, wobei 1 “gar nicht bewegend” und 7 “sehr bewegend” bedeutet.
"Ästhetisch bewegend” bedeutet, dass das Image Sie emotional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

Auf dem Bildschirm wird bei 1 “überhaupt nicht” und bei 7 “äußerst” zu sehen sein.



"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.



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.

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.

Während Sie im Scanner liegen, können Sie das Experiment jederzeit per Knopfdruck mit dem Notfallknopf abbrechen. Wir werden zwischen den Aufnahmen mit Ihnen über die Gegensprechanlage kommunizieren können. Diese ist allerdings ausgeschaltet, wenn die Aufnahmen beginnen. An dieser Stelle wollen wir Sie noch einmal daran erinnern, dass Sie sich während der Aufnahmen (während das MRI laute Geräusche macht) bitte nicht bewegen sollen. Sie werden zunächst einen Test-Durchgang im MRI absolvieren, damit Sie den Ablauf des Experiments kennenlernen. Im Anschluss darauf folgt die eigentliche Testung.

Ihnen werden jetzt einige Verständnisfragen gestellt. Falls Sie noch weitere Fragen haben oder Ihnen etwas unklar ist, haben Sie jetzt Zeit diese zu stellen.