

**A CRITICAL ANALYSIS OF THE PRESENT  
NEUROPSYCHOLOGICAL AND  
NEUROANATOMICAL THEORIES AND KNOWLEDGE OF  
ART PERCEPTION AND ARTISTIC PRODUCTION TAKING  
CREATIVITY INTO ACCOUNT**

by

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## DECLARATION

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I hereby declare that “A critical analysis of the present neuropsychological and neuroanatomical theories and knowledge of art perception and artistic production taking creativity into account” is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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Signature

(Andreas Romp)

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Date

## **ACKNOWLEDGEMENTS**

To my supervisor – Chris Janeke: Thank you for your support, guidance during this process, it has been of great value to me and I would not have been able to finish this project without your expertise and valuable contributions.

To my meanwhile deceased best friend Gisela: Thank you for every kind word.

## **ABSTRACT**

The present paper analyses the neuroanatomical and neuropsychological backgrounds of art reception and art creation in modern visual art and creative processes. It critically presents two models of aesthetic experience to provide a comprehensive theoretical basis for the discussion. The research purpose is to show that with increasing experience and expertise the referential frame of the aesthetic judgment is changing and that neural processes involved in object recognition provide a starting point for visual aesthetics. Thus, the investigation focuses on constructing and testing neuropsychological theories that fall in the domain called 'neuroaesthetics'. These theories, in turn, serve as a starting point to formulate neural laws of art and aesthetics and aesthetic experience. Some artistic styles, such as expressionism, reflect specific neural processes. Various studies indicate correlations between hemispheric specialisation and art or creativity and show the right hemisphere plays a particular role in it. However, studies exploring the neural correlates of aesthetic preference have yielded mixed results. Furthermore, neuroimaging studies have proved that different categories of modern artworks are processed in different areas of the brain. These diverging results will be discussed in a critical assessment of the two models of aesthetic experience. Besides, the question of identifying exclusive neural correlates of aesthetic preference will be raised.

Comparing amateurs and experts has revealed the more reduced the cortical activation, the more efficiently it works.

Biological and neuropsychological factors of creativity point out the meaning of the activation level, cognitive inhibition and prefrontal cortex. Divergent thinking differs from convergent thinking in terms of the neural level.

Neurodegenerative processes and brain injuries sometimes influence the artistic output surprisingly or even launch it. Lesion studies contributing to understanding art experience will be explained.

**Key terms:** neuroaesthetics, art perception, aesthetic experience, art expertise, visual aesthetics, creativity, neurodegenerative processes, frontotemporal dementia, Lewy-body dementia, Alzheimer disease

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## Chapter 1

### General Overview

#### 1.1 Introduction

Neuroaesthetics is a constantly growing branch of research within the field of neuroscience. It is still in the process of determining its own subject of research, without any consensus on fundamental issues yet emerging (Cinzia & Gallese, 2009; Brown & Dissanayak, 2009). For this reason, among others, a broad definition of neuroaesthetics is to be preferred, confined not only to the visual processing of artworks, and justified by interdisciplinary integration of neuroaesthetics. Nadal and Pearce therefore define neuroaesthetics as a discipline of research that examines the neural and evolutionary basis for cognitive and affective processes that occur when an individual takes an aesthetic or artistic attitude towards art, everyday objects or natural phenomena (Nadal & Pearce, 2011). This definition has the advantage of not only including studies of bottom-up processes in neuroaesthetic research – such as for example processes of neural binding that underlie laws of gestalt psychology – but also top-down processes of cultural and cognitive style (Cupchik, Vartanian, Crawley & Mikulis, 2009).

Regarding the aforementioned problems, only few attempts have been made to approach art experience at a neuronal level. A reason for this, relating to methodological aspects, may be that the inherent complexity of art experience complicates the recording of linear correlations in such a way that intervening variables and stimuli themselves can hardly be controlled. The art recipient is not a *tabula rasa*. There are countless aspects, such as personality, momentary mood, individual space of experience and memories that influence the relation between manipulation of an independent variable and a dependent variable.

In addition, interindividual differences in brain activity can occur; the topographic or tomographic activity patterns can vary considerably for the same task. To obtain meaningful results yet, a certain number of subjects are essential, for generalization from only a few results is impossible. At the same time, the methods used are time-

consuming and/or expensive. The processes underlying visual preferences can also be very subtle. Aversive and positive stimuli or different factors could activate the same areas of the brain, or associated changes might be too low to be determined with the current methods. Moreover, as already mentioned, the complexity of the stimulus material raises further problems.

Therefore statements cannot be made solely on a behavioral level, and the results of empirical and experimental observations often differ strongly. This hardly sustainable basis makes it complicated to design neuropsychological experiments and interpret their results.

Finally a critical analysis of all these jigsaw pieces is needed, like the present models concerning aesthetic experience and neuropsychological theoretical approaches, the applied research methods like functional magnetic resonance imaging (fMRI), electroencephalogram (EEG), positron emission tomography (PET) and so forth, the role of emotions and creativity, knowledge from lesion studies about artists with neurodegenerative diseases and last but not least the neuropsychological analysis of the artist's work. All that is necessary if we want to understand for example, why visual arts provide an extension of the cerebral visual system, a system that has been developed millions of years earlier than the language system in the evolution of human kind and therefore has a much greater expressiveness (Oeser, 2006).

## **1.2 Main research objective**

The present theoretical work focuses on neuroanatomical and neuropsychological aspects of art reception and art creation, particularly in the field of the visual arts and in cognitive neuroscience research on creative processes. The terms 'neuroanatomical' and 'neuropsychological' refer to neuropsychological and neuroimaging studies that are intended to reveal the widespread network of brain areas upon which it relies (Nadal, 2013). Relationships between specific aesthetic experience or behaviour connected to these aspects and the underlying biological processes will be pointed out, thus providing a theoretical contribution to the research

on biological foundations of cognitive processes. In doing so, the focus is intended to be on current research about how and with what kind of methods natural science attempts to address art and creative processes. For this reason, individual studies will be critically described in greater detail in order to evoke a comprehensive idea in the reader about the human encountering with art and the resulting neural processes.

### **1.3 Research approach**

The present theoretical dissertation performed a critical review of the research aims presented in Section 1.2 and 1.4.

To meet this requirement, the theoretical dissertation provides a critical and theory-driven (theoretical-explorative) analysis of the research results generated by research methods of electrical recording technique like electroencephalogram (EEG) and scanning techniques like positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) in combination with classical behavioural approaches, including systematic variation of style and content and systematic limitation of presentation times.

### **1.4 Research objectives**

As was previously noted, that the focus is intended to be on current research about how and with what kind of methods natural science attempts to approach art and creative processes. For this reason, individual studies will be critically described in greater detail in order to evoke a comprehensive idea in the reader about techniques and methodologies that are currently available to explore this research domain. What is the contribution of creativity, in particular in the context of neuroanatomical and neuropsychological research results, to the understanding of art experience?

These considerations above lead to the fundamental and the problematic issue whether it can be managed within the limits of this dissertation to approach the art experience at a neuronal level, using the designated experimental methods in brain research in addition to classic behavioral paradigms?

Furthermore, it shall be attempted to evaluate critically Leder Belke, Oeberst & Augustin's (2004) model of aesthetic experience and Chatterjee's (2003) model of

visual aesthetics in the overall context of art experience, taking into account the special role of expertise and visual processing stages.

Is there research evidence supporting the information-processing model of aesthetic experience of Leder et al. (2004) (see Section 2.3) on the one hand and the model of visual aesthetics of Chatterjee (2003) (see Section 2.2) on the other hand by studies including research methods of electrical recording technique like EEG and scanning techniques like PET and fMRI?

Considering studies in the context of identification of neural areas of aesthetic preference, do the results of these studies imply the identification of exclusive neural correlates of aesthetic preference?

Recent reports of changes in art performance among patients and in particular artists with some kind of neurodegenerative diseases have provided an unexpected window to the neurology of art. That, in turn, implies the question what is the contribution of the so-called lesion studies to the understanding of art experience?

### **1.5 Art and artist within the scientific context**

The research objectives of this dissertation deliberately deviates from already existing works of the same issue (e.g. Livingstone, 2002; Maffei & Fiorentini, 1995; Solso, 1994, 2003; Zeki, 1999), which, among other reasons, remain embodied in the area of visual perception probably in order to remain 'readable', thus hardly describing methods but merely 'results'.

Factors, such as emotions, environment or gender differences have been excluded or ignored.

Zeki (2002) mentioned, "that all human activity is dictated by the organisation and laws of the brain; that, therefore, there can be no real theory of art and aesthetics unless neurobiologically based" (p. 54). It is certainly hard not to agree with Zeki's words. Perhaps that is also the reason why the interaction between science and art has appeared and still appears to be rather problematic. A possible explanation for that can be found in the person of the artist himself, in particular in how he or she is influenced by the environment. Kris and Kurz (1934/1979) actually deal with this

sociological question of “the environment’s attitude towards the artist”, which is placed at the boundary of the psychological question of “where it touches the environment’s analysis of the mystery of the artistic personality” (p. 22, author’s translation). This mysterious artistic personality would thus be an issue of psychology, although in this case psychology and sociology would touch on each other in any case of interaction between the artist’s personality and the environment. The authors tried hard to point out, “that in every biography there can be found certain basic assumptions of the visual artist’s attitudes, which [...] can be traced back to the beginnings of historiography” and “which have never quite lost [...] their meaning up to the recent past “ (p. 23, author’s translation). Still the origins of these attitudes would be difficult to grasp rationally. So Kris and Kurz (1934/1979) saw parallels in the Hellenistic Age, when the independent artistic biography developed, up to the recent past, given that in any stage of historical development new social archetypes would add to the older ones. One of these basic notions would be for example that an artist’s talent became already manifest during childhood, and that fate played a significant role in this.

The source of historiography would be anecdotal based on which some conclusions are drawn about the artist. Stereotypical concepts and ideas concerning the artist, which appear to persist until today, could result in a more difficult ‘profane’ analysis of the artist’s work and his or her works of art by blending of artist and works of art, and transferring the qualities of the one to the other.

## **1.6 Variable identification**

Art production and art reception are based on the relations between three aspects, the art object and the artist who created this object and at last the recipient (Schurian, 1998). These individual aspects and their mutual effects and relations are determined by various variables.

One difficulty lies in the exact definition of the independent and dependent variables according to the research question. A standard methodological requirement is to avoid any confusion between the variables, the research question must be

clearly defined, the hypotheses must be derived precisely and the methodology must be presented and justified.

As described below, the mere quantification of the object that is the work of art's physical qualities constitutes a problem, because it would lead to an immense amount of data material. Here scientific considerations can help to clarify the focus. In one case the art recipient can be the aim of scientific research, for example regarding general functions of perception. In another case the artist can be the focus of research, the qualities of his personality and other characteristics. Differences between experts and amateurs, psychological oddities among artists or changes in their work due to neurodegenerative or other diseases would be considered. In this case the work of art itself would come more into focus but only in order to convey information about its creator. Here possibly lies one reason for the problematic relation between – especially visual – art and empirical science. The art object is operationalised as stimulus material and as such ceases to play a significant role itself, which is only natural, as the focus is on analysing behaviour, not objects. However, many investigations do not put enough care to the choice of their works of art and therefore their stimulus material. What is more, the term 'artist' is easily applied to any person producing visual arts and thus would even apply to patients suffering from a frontotemporal dementia. As mentioned below there are some indications, that frontotemporal dementia influences artistic production and creativity (Miller, Ponton, Benson, Cummings & Mena 1996; Miller & Miller, 2013). Furthermore, there are some hints in the context of people suffering from frontotemporal dementia, that there is "an improvement of functions within the spared regions of brain tissue" (Mendez et al., 1996). Metaphorically speaking, the problematic relation between visual art and empirical science as mentioned above culminates in such approaches like the following: The terms 'artist' or 'art' will be used undefined and hasty and sometimes it seems sufficient to become artistically active to be called artist, how it can happen with patients suffering from a frontotemporal dementia. In several such cases in an early stage of the disease a sudden occurrence of artistic skills could be observed. However, such procedures may be perceived as trivialising and too simplistic, and this does not just apply to the scientific approach to the subject. Accordingly, Schurian (1998) postulates:

“In the actual theory of art, art itself, it seems, meanwhile has taken a very special place, where it seems to serve firstly as a vibrational surface or a sound box for mental, scientific, social, cognitive, political, economical and other ‘relevant’ ideas. With all that theory and all that assigning of contingencies the reality of an object, like a painting, seems to have ‘vanished’ from sight. Here, too, reality is governed by virtuality, object by reflexion and experience by conception. It seems as if what mainly counts are discourses about art, which are treated as scientific and therefore are more popular than art itself. Furthermore, it is obvious that new constructions and models are created to project and apply each analysis and scientific treatise to the objects of art. Not surprisingly, a strong emphasis on theory is now noticeable. For centuries practical art teaching had been routine as for example Leonardo da Vinci’s and Albrecht Dürer’s painting instructions. Art science had not allowed studying art in a distant theoretical way for a long time” (p.5, author’s translation).

Arnheim (1971) formulates this problem as follows: “Art may seem to be in danger of being drowned by talk” (p. 5). At the same time uneasiness seems to spread among creators of art. The artist Maria Lassnig (2000) wrote on this in her diaries “Art is cornered like an intimidated chicken, while science gives her doctrines like infusions, in order to allow her only to express what is ‘objectively’ true” (p. 172, , author’s translation). In the musical field cooperation seems less problematic, as is shown in several already existing treatises (e.g. Altenmüller, Schürmann, Lim & Parlitz, 2002; Bhattacharya & Petsche, 2000; Schmidt & Trainor, 2001). Perhaps here the roles are cast more unambiguously. For composing or interpreting a piece of music requires certain skills. On the contrary, it is not as difficult for amateurs to create visual arts, complicating the question of what it takes to be an artist or what may be called art. On April 3<sup>rd</sup>, 1995 Lassnig made a note in her diary: “What is understood by art is in my case mainly concerned by the action, the intention and the necessary failure, which combined form something mysterious, not understandable” (2000, p. 173, author’s translation). Art in this case is described as something mysterious, not understandable, which might imply that it can’t be expected to reveal all the relevant information to objective scientific analysis, especially when a seriously pursued science is expected to fulfill certain criteria, such as the repeatability of



measurements or the claim of objectivity. Zeki understands by art "the translation of concepts in the artist's mind onto canvas or into music or literature" (2002, p. 67). Art would then eventually be a mere by-product of the brain's capacity to abstract acquired knowledge and to create concepts, resulting in ideals. An artist can epitomize these ideals and present them visually and accessible to others.

The fact most of the test series (presented in Section 3.4) did not employ original artworks as stimuli may be of less significance than perhaps widely assumed. The first interest is in providing information standardized for all test persons as far as possible and presented in an exact space of time. A digitalized presentation answers these claims best. Furthermore, studies (Locher & Dolese, 2004; Locher, Smith & Smith, 1999; Locher, Smith & Smith, 2001) show that the assessment of art objects on different scales (e. g. physical and structural qualities of the composition or innovation) presented in different formats (original, postcard size, diapositiv or computer screen) did not result in significant differences on most measurement scales. So individuals, no matter how experienced in art, seem to be fairly able to adjust to the media-based restrictions. Moreover, if the contrary is not the primary issue of the experimental design, the mode of presentation (e. g. pictures of art objects on screen) is the same for all test persons. What is interesting is a comparison of conditions and results, namely the influence of the manipulated independent variables on the dependent variable(s), not an absolute aesthetic judgement itself.

### **1.6.1 Stimulus material and variables**

However, the precise specification of the applied stimulus material is of essential importance, a necessity hardly ever given enough attention. It would be desirable to define and quantify the stimuli and their qualities (e. g. their physical and structural nature) as exact as possible, so that on the basis of these objectified qualities conclusions can be drawn about the connected aesthetic reactions. Obviously this claim, especially of quantifiability, is hardly possible to realize when art production is concerned. Art, due to for example its complexity and its openness towards new influences, presents itself in the most various forms. The resulting variety of

differentiated styles and within them different works can cause a broad variety of reactions in recipients of art, so that generalizations are hardly possible. It is therefore not surprising at all that many studies employed and still employ the most simple and controllable stimuli (e. g. Fechner, 1876/1897; Frith & Nias, 1974).

### 1.6.2 Quality of items

At the same time the results of different studies are problematic to compare if they have not used analogous stimulus material, or if the stimulus material was not declared unambiguously. A possible answer to this problem could perhaps be a standardized pool of items accessible to everyone. An efficient statistical instrument would be available with regard to selectivity (e.g. between different categories of art styles) by the establishment of a standardized item pool. Thus, a first step towards a better comparability of studies would be guaranteed.

Fechner (1876/1897), founder of psychophysics and experimental aesthetics, in his aesthetic writings, namely in 'Vorschule der Ästhetik'<sup>1</sup> (1876/ 1897), emphasized the dire necessity of such proceedings, to use simple and controllable stimulus material, by proclaiming a new methodical approach of the inductive 'Ästhetik von unten'<sup>2</sup>. Fechner did in fact regret that in this way it was impossible to achieve everything expected from an aesthetic theory; but claimed "that many things can be achieved in this way, which by an aesthetic theory of a higher style in its contrary direction would be left aside"(Fechner, 1897, Part I, p. IV, author's translation). At the same time Fechner kept in mind the problem of generalization:

"The way from below provides or promises at least directly a clear orientation not only in the field of concepts, to which submits the field of approval and disapproval, but also about individual and interpersonal reasons of approval and disapproval. But it hardly ever leads to common aspects and ideas, leaving one easily caught up in details, partialities, aspects of subordinate value and of subordinate significance"(1897, Part I, p. 3, author's translation).

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<sup>1</sup> Meaning 'Pre-School of Aesthetics'.

<sup>2</sup> Meaning 'Aesthetics From Below'.

In addition to the complexity of artistic stimulus material, the art recipient of course is not a tabula rasa but his emotions and reactions are strongly determined by various variables of influence, for example socio-cultural background, former experience in the field of art and others, and momentary condition. Höge (1984), for example showed, that the mood of test persons did have a significant as well as lasting influence on aesthetic judgements, that means when associations to a picture vary depending on mood in a qualitative sense. In the same way the emotional quality of stimulus material exerts influence on judgement. And the range of expertise effects cognitive processing and judgement of preference. So amateurs most of the times prefer representational works of art (e. g. O'Hare, 1976; Cupchik, Shereck & Spiegel, 1994).

### **1.7 Scientific classification and history of aesthetics**

The research domains of psychology are human experience and behaviour as well as “their inner (located inside the individual) and outer (located in the environment) conditions and causes” (Zimbardo & Gerrig, 1999, p. 2, author’s translation). Thus aesthetic experience, creativity and art production essentially constitute a research domain of psychological analysis, especially based on the original meaning of the Greek word ‘aisthesis’, which is commonly understood as sense perception. The resulting science of psychological aesthetics had its height at the beginning of the last century. It is characterized by an “effort to understand aesthetic phenomena as a special form of human acts of perception, and to analyse and explain them from an empirical-psychological perspective“(Allesch, 1987b, p. 207, author’s translation). Aesthetic phenomena are given an aesthetic meaning clearly distinguished from other, for example functional meanings. This however is not supposed to mean psychological interpretation of phenomena was an invention of the last century, for its origins go back far into the ancient world (see Allesch, 1987a).

## **1.8 Overview of the dissertation**

As already mentioned, the present work focuses primarily on research that has been conducted to develop an understanding of art experience, art creation and creativity. The current prevailing methods will at first be described in a chapter of their own to ease the way for addressing the topic.

In further chapters, two models of aesthetic experience will be introduced to provide a comprehensive theoretical basis for the study. This will be followed by theories of a more distinct neuropsychological orientation. In terms of sensory perception, neuropsychological aspects of aesthetic experience will also be introduced. In doing so, principles of perception will be explained mainly in terms of their importance for art reception and the production of art works. The neural aspects of art reception and art production that will be covered in the discussion additionally comprise preference judgements associated herewith as well as the difference between experts and amateurs. The issue of brain lateralization repeatedly comes to the fore in respect of art experience and art creation and also figures in research on creativity.

Hemispheric studies help us to understand the operation (i.e. the lateralization of functions) in the two hemispheres. In this respect, lesion studies play a decisive role (Zaidel, 2005; Zaidel, 2013; Miller & Miller, 2013).

Neurodegenerative processes and brain injuries partly show surprising impact on the artistic output and can also initiate it as such. At the same time, these observations provide a scientific opportunity to gain insight into a specific world view that is difficult to communicate otherwise. In scientific literature different forms of dementia related to that topic are discussed which will be introduced here too. The topic of creativity is also supposed to be treated, because art creation is difficult to imagine without creativity. Likewise it is conceivable that even the reception of art imposes requirements on one's own creative potential. Thus, it is imaginable that a flat associative gradient (Eysenck, 1995) associated with creativity will allow more diverse interpretations and possibly a wider variety of experience. The emphasis here lies also on biological and mainly neuropsychological aspects.

In summary it can be stated that this work is aimed at creating a critical analysis and assessment of the present state of research in regard to art production, art reception or creative processes between the poles of cognitive neuroscience, neuropsychology and creativity research.

## **1.9 Methods of experimental neuroscience**

The following short description of the most important methods of experimental brain research is supposed to support understanding of the presented series' of experiments. Further related literature will be referred to at respective points<sup>3</sup>.

### **1.9.1 The Electroencephalogram**

An electroencephalogram (EEG) provides an exact time measurement of mental processes, that is the temporal resolution is very high in contrary to the imaging methods mentioned below, which however are characterized by a good spatial resolution. Thus, an EEG can be employed to achieve quantitative as well as continuous results on the processing of information. The origin of the cortical activation can only be recorded by EEG with relative inexactness (inverse problem), and require mathematical and statistical techniques to achieve a more precise interpretation of the origins of the cortical activity. An example for such a mathematical-statistical analysis would be LORETA (Pascual-Marqui, Esslen, Kochi & Lehmann, 2002; Pascual-Marqui, Michel & Lehmann, 1994). LORETA (Low Resolution Brain Electromagnetic Tomography) shows the current density distribution most probable to adjust to a given topography. The solution space therefore is restricted to the grey matter and the hippocampus and refers to 2394 Voxel at a spatial resolution of 7mm (see Pascual-Marqui, 1999). The measurements of the local current density distribution can thus be employed as a measurement for activity. Herrmann and Fallgatter (2004) for example showed that LORETA is capable of locating the origin of event-correlated potentials in a replicable and valid way, even if those occurred in widespread cortical networks and the results were similar to those

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<sup>3</sup> For further reading on the principles of neuroscience as well as the neuronal base of cognition and perception see Kandel, Schwartz and Jessell (2000).

achieved in fMRI experiments. An EEG provides observation of spontaneously produced brain-electrical phenomena (spontaneous EEG), but also averaged event related potentials (ERP). Event related potentials are changes of current triggered by psychic or sensory stimulus or motor activities (see below). Among ERPs there are components differing by latence – exogene (early) and endogene (late) potentials – and polarity. A positive wave with an average latence of 300 ms is called P300, while N100 means its negativation by 100 ms. Potentials in the field of 0-2 Hz of the EEG signal are called slow cortical potentials (SPCs). SPCs are shifts of d.c. voltage triggered by a stimulus but reacting rather inert to it (Hinterberger, Houtkooper & Kotchoubey, 2004).

In the state of basical activity different rhythms can be detected. Frequencies over 30 Hz are called gamma-waves. The lower frequency wave spectrum of the EEG (0,5-30 Hz) is divided into the following areas (Sawyer, 2011):

- Alpha-band (8-13 Hz)

The alpha pattern, most clearly distinct in the occipital brain region, forms the most basical pattern of the electroencephalogram, is seen as an indicator of activation and symbolizes relaxed awakesness. A change in the alpha rhythm caused by a decrease of amplitude and an increase of frequency is called alpha blockade or even desynchronisation of the EEG.

- Beta-band (over 13Hz)

These low and irregular waves are an expression of desynchronized, increased cortical activity and refer to mental activity, active attention and increased concentration but also to a state of stress.

- Theta-band (4 to under 8 Hz)

Slow waves with higher amplitudes which occur connected with emotional stress and perhaps are an expression of subcortical influences of excitement. Theta-waves are observed in adults during sleep and in states of deep relaxation.

- Delta-band (under 4 Hz)

The slowest waves show different, sometimes high amplitudes and occur with tiredness and sleep; they are thus an expression of a low level of activation and show decreased cortical activity.

The EEG signals registered at the cortex surface always represent the activity summarized from various electrical processes, where the thalamic nuclei have a synchronizing effect. Frequency and amplitude however can vary in one state of consciousness at different points of the cortex (Büchel, Karnath & Thier, 2006). Isolated areas of the brain are stimulated (desynchronized) and neighbouring areas often inhibited, depending on where the information is processed. By neurometry or brain mapping frequencies, phase shifts and amplitudes are analyzed of as many areas as possible. During psychological test series, mostly frequency shifts in the alpha-, beta- and gamma bands occur, pictured by computer analyses and electronic filters. In these cases the analogous signal is dissected into digital points by a certain scan rate and further processed by the Fourier analysis as most important method of evaluation, which leads to the power<sup>4</sup> spectrum of the EEG (Birbaumer & Schmidt, 1999).

To extract event related potentials, the EEG signals are averaged. ERPs show much smaller amplitude than the spontaneous EEG and are heterodyned by this “noise” (Sawyer, 2011). ERPs are related to certain event and thus resemble each other in amplitude and form, in contrary to the spontaneous EEG where the distribution is coincidentally. By the technical device of averaging ERPs get clearer with increasing summarization until the arithmetic average is taken from the summarized graphs (Sawyer, 2011). So a sufficient number of test persons and trials are essential to a significant series of experiments. To avoid artificial results, meaning potential changes caused by extra-cerebral sources, the EEG signal must be free of artefacts. Artefacts can be caused by damaged electrodes or deflection cables, by movements and potentials of other body parts, by static charge or interference in the equipment.

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<sup>4</sup> Power means the square of the amplitude in the frequency area ( $\mu\text{V}^2\text{Hz}$ ).

Coherence analyses (Petsche & Etlinger, 1998) highlight changes in coherence. Compared with an EEG at rest or a spontaneous EEG, they display an increase of coherence because of an increased interregional functional connectivity. That means that coherences are calculated from the spontaneous EEG by frequency analysis during a cognitive process. Any measurement of coherence correlates to a certain frequency. The spectrum of coherence is summarized from all measurements of coherence between 0 and 1, 0 meaning no correlation at all among the analyzed EEG signals, and 1 meaning that two signals tally completely. Given that correlation of cortical electrophysiological processes, namely the synchronisation of different regions, is of any functional significance, conclusions can be drawn to the mode of information processing. W. Singer (1993, 1999) emphasized that it was highly probable for perceptual and motor functions of the cortex to be caused by distributed processes which happen simultaneously in different regions and involve a great number of neuron populations, who are even spread across huge areas of the brain, depending on the complexity of the task.

### **1.9.2 Functional Magnetic Resonance Imaging and Positron Emission Tomography**

Positron emission tomography (PET) as well as the functional magnetic resonance imaging (fMRI or fMRT), also known as Kernspin tomography, unlike EEG and MEG (magnetic encephalogram), allow researchers to prove cortical as well as subcortical changes in neuronal-metabolic activity (Büchel et al., 2006; Sawyer, 2011). PET and fMRI both measure the regional cerebral blood flow (rcbf). Inside activated areas there is an increase of metabolic activity and following from that an increase of blood flow and blood volume. An fMRI is characterized by non-invasiveness and thus by the opportunity to exert this method several times on the same individual and by a very high spatial resolution (1-3mm). A PET is based on the rapid radioactive decay of positrons to radioisotopes, thus it is necessary to inject a radioactive substance into the blood circulation (Büchel et al., 2006). To avoid damage by these radioisotopes they are required to decay quickly and completely, so that measurements can hardly be repeated. Depending on the radioisotope employed,



specific metabolic and transmitting products can be observed in the particular brain area.

The functional principle of an fMRI is the Blood Oxygenation Level Dependent (BOLD) contrast imaging the activated cortical areas<sup>5</sup>. Concerning an fMRI there are different techniques of measurement, each having its advantages and disadvantages. The gradient-echo technique FLASH allows a higher spatial definition but only provides a relatively low temporal resolution (5-15 s/frame) and a low volume coverage. Echo -Planar Imaging (EPI) then provides a high temporal resolution and the possibility of multilevel measurements, however the EPI-images due to registration problems can only be overlapped with morphological images after manual correction (Schad, 2008).

One possibility to map the interesting brain activities with both methods (fMRI and PET) is the technique of subtraction, where during experimental conditions the images are subtracted from the images of the control conditions (Goldstein, 2005; Schad, 2008). What gets problematic here is the missing possibility to assign significance to particular regions. The subtraction does not identify all the regions that are involved in a certain behavior, but only those that show a significant difference in activation between target and reference tasks. Those regions that are similarly involved in the target and reference task do not 'show up' in the subtraction. It is possible to argue that these regions are not specifically involved in the process of interest, but in ancillary processes, which the target task shares with the reference task. However, the fact that a brain region is similarly active during two tasks does not imply that its effects on other brain regions are the same, and it has the same function in the two tasks. Changes in connectivity can be detected by covariance-based analyses (McIntosh & Gonzalez-Lima, 1994; Friston, Frith, Liddle & Frackowiak, 1993), but they have been applied to only a few PET studies so far (e.g. McIntosh et al., 1994; Nyberg et al., 1996).

With a PET the amount of noise interference is so high that the images, as is the case with an EEG, have to be averaged. That results in a strong reduction of the spatial resolution (4-8 mm), as interindividual differences can be huge. Summaries of the images of one test person however get problematic due to the necessarily high

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<sup>5</sup> The cerebral cortex is structured differently. These structural differences are shown in cytoarchitectonical maps, commonly using the map of Brodmann areas. Structure and function however do not always correlate with each other.

exposure to radiation. The fMRI also needs a special procedure to measure the BOLD (Blood Oxygenation Level dependent) effect and at the same time suppress the noise interference. According to Schad (2008) “techniques based on the Bold contrast are detecting the influence of small susceptibility differences on the MR Signal caused by oxygenated and deoxygenated blood” (p.1295). Here analytical methods also depend on a statistic average of the coincidental, incoherent noise interference in contrast to the continuous coherent signal in the activated regions. Nevertheless the employed methods can differ in size and distribution of activity in the activated areas.

Changes of signal under different conditions require a statistical method (student's-t-test, z-statistic) to make an assignment of significance to particular regions possible. Based on the assumption of normal distribution pixel for pixel is analyzed to search for search for a significant divergence from the mean values. At last, to reduce false assignments of significance, multiple tests must be **conducted** since every single comparison has a certain likelihood of error. In contrast to the subtraction image in these statistic methods the mean differences are weighted with the dispersion of data points by the particular mean values, thus making possible a more stable evaluation (Schad, 2008).

As in an EEG, where a sufficient number of trials are necessary, the quality of fMRI parameter images increases with the amount of recorded data series. The method is similarly susceptible to artefacts, which, as in an EEG, can be due to technical insufficiencies or physiological reasons. Instability in the fixation of the head is highly problematic. To provide an optimal adjustment of the fMRI images, algorithms of motion correction are employed (Schad, 2002b). For further reading concerning fMRI are suggested Schad (2002a, 2002b) and Di Salle et al. (1999).

A direct comparison of both methods (fMRI and PET) has been tried in a study of Feng et al. (2004). The test persons were given the same visual stimulus under both methods. No significant differences concerning either the resulting brain mapping or the relative changes in regional cerebral blood flow could be observed. The results of fMRI an EEG are also comparable as far as the last is combined with a method to locate origins (Herrmann & Fallgatter, 2004). A combination of techniques allows an optimal and complete analysis of the central nervous system. The good spatial

resolution of the fMRI<sup>6</sup> shows where in the brain processes take place, while the good temporal resolution of an EEG can answer, when these processes happen, both at last complement the information concerning metabolic processes from the PET.

### **1.10 Outline of Dissertation Chapters**

The study provided in this document is subdivided into six chapters. Chapter One presents a broad overview and general introduction to the research topic. Besides the research approach, the methods of cognitive neuroscience and the research aims will be introduced.

The aim of the second Chapter is to provide and compare an information-processing model of aesthetic experience on the one hand and a model of visual aesthetics on the other hand.

Chapter Three tries to clarify the interwoven terms of neuroaesthetics. Several studies concerning this matter will be systematically discussed in the context of cognitive neuroscience. The terms will be differentiated in their complexity as well. At first, neuropsychological theories of aesthetic perception, neuropsychological aspects of aesthetic experience and neural aspects of art reception and production will be discussed. In addition, the principles of visual perception and meaning for art perception and art production will be presented. The hemispheric specialization in artistic perception and production will be outlined. Emotional reactions to artworks and their neural correlates will be given a special focus amongst the other themes. In this respect, the differences between novices and experts concerning emotional reactions and aesthetic preferences will be considered. Last but not least the complex of neurodegenerative processes and impairments (e.g. different forms of Dementia) in the context of artistic perception and production will be discussed

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<sup>6</sup> fMRI techniques of high temporal resolution provide first approaches to the question, when activations actually happen. (Schad, 2002b).

Within the framework of Chapter Four biological and neuropsychological aspects of creative processes will be discussed. The discussion will be focused again on hemispheric specialization and as a new aspect on gender differences. The meanings of activation patterns associated with different pronounced level of creativity and relating to different cognitive strategies will also be attended in this chapter. In addition, creativity and the effects on emotions will be considered.

Chapter Five includes an evaluation, verification and discussion of the two theoretical models concerning the results of previous studies.

Chapter Six presents an in-depth discussion and also provides a summary and draws some conclusions of the results of the previous chapters with regard to the given research questions.

**Chapter 2**

**MODELS OF AESTHETIC EXPERIENCE**

**2.1 Introduction**

Within the following section, two models of aesthetic experience will be described in detail. First, Chatterjee’s (2003) model of visual aesthetics will shed light on the neural underpinnings of visual stimuli. Second, Leder et al’s (2004) information-processing model will be introduced as an approach to aesthetic experience.

The presentation and review of the models should be the focus of attention here. A further elaboration in the sense of the question regarding a verification attempt of the models in the context of fMRI studies will take place in Chapter 3 and 5.

**2.2 A Model of visual aesthetics**

Anjan Chatterjee (2003) presents a general model for the processing of aesthetic elements in the visual arts and derives this from the framework of the general processing of visual stimuli (see Figure 1). He derives the model from the findings of the cognitive neuroscience of vision, in order to have a working model for testing neuroaesthetic hypotheses. Particularly visual processes that take place if objects are recognized can be used as a framework for visual aesthetics.

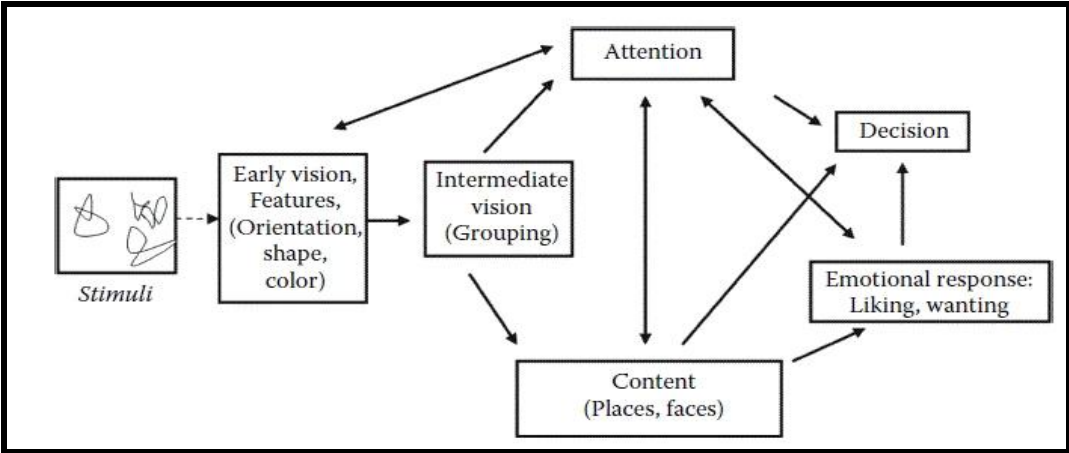


Figure 1:

### 2.2.1 Central assumptions and the special role of emotions

Chatterjee's basic assumptions are reflected in the notion that vision exists of different components (i.e. cognitive processes) and that a single answer to a component not properly **represents** aesthetic experience. According to Chatterjee (2003) this aesthetic experience is derived from answers to different components. Therefore, research should focus on the interaction of the different components.

As a special and central component in the context of aesthetic experience in addition to the cognitive aspects of visual aesthetics, he describes an *emotional component (emotional response)*. He refers here to neuroscientific research by Breiter, Aharon, Kahnemann, Dale and Shizgal, 2001, Delgado, Nystrom, Fissel, Noll & Fiez, 2000; Elliot, Friston and Dolan, 2000; O'Doherty, Kringelbach, Rolls, Hornack & Andrews, 2001; Schultz, Dayans and Montague, 1997. These research results suggest, that the anterior medial lobe, medial orbitofrontal cortices and subcortical structures are responsible for the regulation of emotions in general and reward systems in particular (Chatterjee, 2003, p. 56).

Chatterjee (2003) differentiates between '*liking*' and '*wanting*'. He considered '*liking*' within the context of the aesthetic tradition where it means 'liking without wanting' in terms of a pleasure without the corresponding utilitarian consequences that are for example the case with desire for sex or food. In this context, Chatterjee (2003) postulates that "the process by which humans react to stimuli and engage neural circuits that respond or rewarding stimuli may effect a probe into the neural basis for *liking without wanting*" (p.55). The neural basis of '*wanting*' according to a desire for reward is well known and can be traced back to "dopaminergic circuits including the ventral striatum and the nucleus accumbens" (Chatterjee, 2003, p. 56). In contrast to this, the neural basis of an aesthetically determined '*liking*' has not yet sufficiently been worked out. He noted, however, that "widely distributed circuits, most importantly the dorsolateral frontal and medial frontal cortices are probably involved" (Chatterjee, 2003, p. 56).

## 2.2.2 The processing levels in general

According to Vartanian and Nadal (2007) Chatterjee's neuroscientific model of aesthetic preference is founded on the basic assumption that "aesthetic experiences related to visual objects involve three visual processing stages common to the perception of any visual stimulus, as well as an emotional response, a decision, and the modulating effect of attention" (p. 432).

Based on the research results from van Essen, Feleman, DeYoe, Ollavaria and Knierman, 1990; Zeki, 1993 and Farah and Malden, 2000, he concludes that "the nervous system processes visual information both hierarchically and in parallel" (Chatterjee, 2011).

In this regard Chatterjee (2011) postulates that "any work can be decomposed into its early, intermediate and late vision components and individual works of visual art (paintings) can be identified that exemplify each of these different componential stages" (p.393). Furthermore, he refers to investigations from Russel and George, 1990 and Woods, 1991 by arguing that "aesthetic writings commonly distinguish between form and content" and that "early and intermediate vision process form and later vision processes content" (Chatterjee, 2011, p.393).

Schematically described, the levels of visual processing are the following (Chatterjee, 2003, 2011):

- Simple visual aspects such as color, shape or orientation are extracted in a primary, early processing level and analyzed in different brain areas (early vision).
- Within an intermediate processing level (intermediate vision), some visual aspects are segregated and others are grouped together (grouping). As a result of this, coherent regions are formed. Otherwise, a chaotic sensory array would overstrain the visual system.

- In a late visual processing, a further processing and modelling is performed, whereby the visual elements cause attention within the visual field. This leads to a further detailed analysis. Information that has been already stored (knowledge, emotion) can be connected accordingly with the new visual stimuli. In this context of memories, objects can be recognized and meanings can be attached. After object recognition, emotions can be evoked and decisions made about the object.

### **2.2.3 The processing levels within a neuroscientific context**

As already mentioned, ideas derived from visual neuroscience stimulate research and lead to the formation of research hypotheses within neuroaesthetics. Chatterjee (2003) assumes that a large part of the areas involved in the processing of visual stimuli play a role in the process of perception and classification of aesthetic elements within art as well.

Chatterjee (2003) reflects again on how far this level of visual processing can be found in empirical aesthetics. According to findings by Russell and George, 1990 and Woods, 1991 he compares the distinction between form and content of a stimulus in aesthetics with findings of neurophysiological research.

Accordingly and already mentioned, form is processed in the early and intermediate level of processing while content is in the late level of processing.

Chatterjee (2003, 2011) explains that early attributes of an art work like colour will be processed in parts of the occipital cortex, area V4. The neural context of the grouping of these early features to larger visual units proceeds probably in the extra-striate cortex, whereas this process would be difficult to understand. In this respect, the visual attributes of art works will be initially processed like any other visual objects.

Chatterjee (2003) states that “the process of grouping gives unity in diversity, a fundamental feature of compositional balance, which itself is a central idea about the



formal structure of aesthetic objects. If compositional forms are apprehended automatically by intermediate vision, then sensitivity to such forms should also be automatic “(p. 55).

Furthermore he express that “subjects are sensitive to form ‘at a glance’ with exposure as short as 50ms. By contrast, preference for detail (which requires serial attentional processing) predominates when images are shown for slightly longer times” (Locher & Nagi, as cited in Chatterjee, 2003, p. 55).

Finally and for the positioning of his model within the neuroscientific context, Chatterjee (2003) proposes a model of visual processing levels starting with the assumption that “visual attributes of an art work initially are processed like any other visual object” (p. 55). He stresses in this context, that “various combinations of early and intermediate vision” like color, shape and composition are processed within fronto-temporal attentional circuits. This is even more the case if “they are balanced” (p. 55). With reference to studies from Huphreys, Riddoch & Price, 1997; Motter, 1993, 1994; Pessoa, Kastner & Ungerleider (2003), Shulman et al., 1997, and Watanabe et al., 1998, he emphasizes an ongoing and modulating processing of these attentional networks within the ventral stream. In this ongoing modulation he presumes the contribution for a more “vivid experience of the stimuli” with regard to attributes colors or forms and content like “faces and landscapes” as well (p. 55).

Vartanian & Nadal ( 2007) postulate that

“in late visual stages, included under the representational domain in this model, certain regions of the object are selected for further scrutiny. At this moment, memories are activated, and objects are recognized and associated with meanings. This visual analysis leads to emotions associated with the aesthetic experience, and it grounds decisions about the stimulus. However, this is not a strictly linear model. In fact, it posits an important feedback flow of information via attentional processes, from higher visual and emotional levels towards early visual processing” (p.432).

The question of what kind of everyday visual stimuli processing differentiates from the processing of aesthetic experience remains unresolved in Chatterjee (2003, 2011).

However, this model helps to justify and eventually explain the different results of the studies (e.g. Vartanian & Goel, 2004; Kawabata & Zeki, 2004; Cela-Conde et al., 2004; Jacobsen, Schubotz, Höfel & von Cramon, 2006) presented in the context of aesthetic experience (see Section 5).

### **2.3 Aesthetic emotion and aesthetic judgment as an evaluative output**

The model of of aesthetic experience by Leder et al., (2004) includes five levels of aesthetic experience: perceptual analysis, implicit memory integration, explicit classification, cognitive mastering and evaluation (see Figure 3). The model also differentiates between two types of output, the aesthetic emotion and the aesthetic judgment. The model of information processing from Leder et al. (2004) presents like Chatterjee's (2004) model of visual aesthetics an instrument for the generation of the dependent variables in aesthetic research, namely aesthetic judgement and aesthetic emotion (Vartanian & Nadal, 2007). The model could also be considered to be a working model for testing neuroaesthetic hypotheses. Similar to Chatterjee (2003) the authors mainly concentrate on visual arts in the sense of painting. Leder et al. (2004) emphasize, however, that the model could be applied to other forms of art and aesthetic experiences in general. The focus is especially on modern art.

Classification, understanding and cognitive coping with an art work are subsumed under aesthetic experience. At the same time, this cognitive process is continuously accompanied by affective states, whose evaluations result in aesthetic emotions. Aside from, the successful coping with an art work is the source of intrinsic motivation, and it could lead to the phenomenon that an individual still devotes himself to the exposition of art works in the future. In the long run, this kind of motivation results in an increased interest in art again. Leder et al. (2004) considered the acquisition of expertise as significant, through which recipients of art could heighten their own coping ability with art. In this context, the authors emphasized the

style-relevant processing, which, especially in modern art, was seen as an essential art-specific challenge. The five levels proposed by Leder et al. (2004) concern different cognitive analyses. In this case, serial information flow is not assumed, but rather a relative hierarchy of processing levels, whereby a throwback to an earlier level is considered possible. The latter levels of information processing will be formed to feedback loops in this way. According to the authors, ambiguity can be herewith reduced and both understanding and affective coping can be heightened. In addition, particularly these higher levels are those which would be affected by expertise.

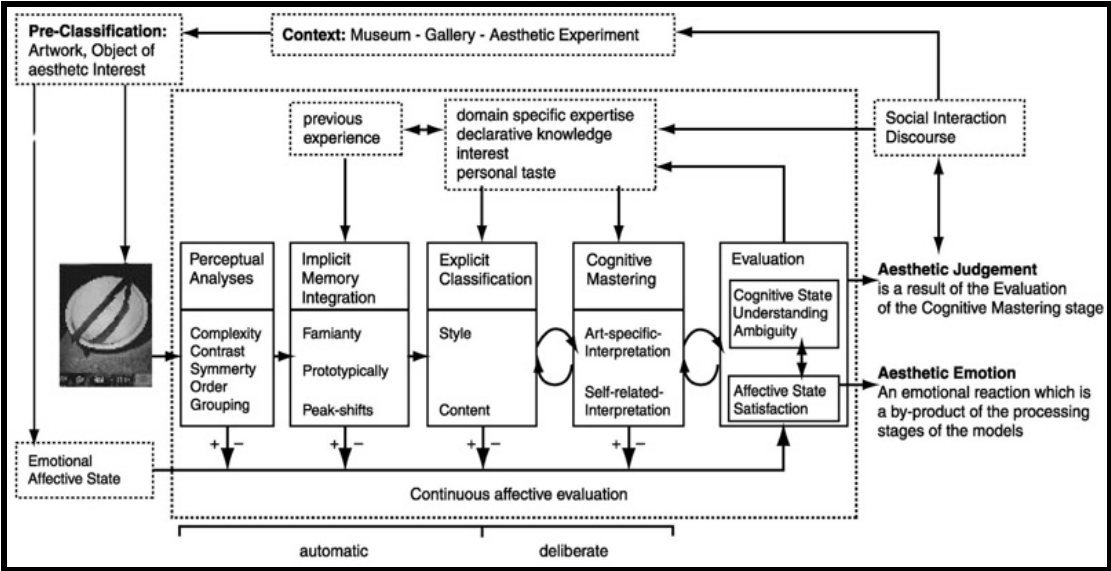


Figure 2:  
The model of aesthetic experience by Leder, Belke, Oeberst and Augustin (2004, p.492).

Within the model, the input is represented by an art work. The classification of a work of art is ensured by a number of context characteristics according to authors. Among other things, it is the framework within which an object appears, for example in the context of an art exhibition, an art gallery or a museum. The art recipient in turn must reside in a particular state to feel aesthetically. According to Leder et al. (2004) the problem with respect to the laboratory situation that does not match the natural situation of the art reception could be reduced by explicit education/information of the test persons that take part in an aesthetics and art reception experiment. A more representative form of art reception would be ensured in the context of such a

communication. In addition, the emotional situation of the test persons has to be taken into account before the experiment has been started. This is important because the initial state of emotional experience could have an effect on the artistic experience. A negative affective starting situation could prevent a positive experience.

According to the model, (see Figure 2) the artwork will be analyzed on the first level, the so-called level of perceptual analysis, with regard to perception. Contrast, complexity, symmetry, order and grouping play a role. Visual information processing at this level involves mainly occipital regions of the cortex. Previous psychological work focused mostly on perception characteristics of art works (e.g. Berlyne, 1974; Ramachandran & Hirstein, 1999; Solso, 1994; Zeki, 1999) and thus remains a subject of this early level of processing. Ramachandran and Hirstein (1999), Livingstone (2002) and Shimamura (2013) considered the importance of some features mentioned above (contrast, symmetry, etc.) that also play a role in terms of the aesthetic preference (see Section 3).

Concerning a further level, the level of implicit memory integration, the aesthetic processing is based on implicit memory effects, whereby the effects are not required as being accessible to consciousness. In this context, familiarity, prototypicality and peak shift effects are of importance. In terms of familiarity effects on aesthetic judgment, it could be observed through repeated presentation of a stimulus within the framework of experiments to the 'mere-repeated-exposure' paradigm (e.g. Leder, 2002; Zajonc, 2001). Regarding to a neuronal level Vandenberghe, Dupont, Bormans, Mortelmans and Orban (1995) studied stimulus familiarity. Peak shift effects were also taken into account by Ramachandran and Hirstein (1999) and are described below (see Section 3.2).

Prototypicality stands for the degree in which the object for a class of objects is representative. Prototypes partly causing increased judgments. Hekkert and van Wieringen (1990) could demonstrate with Cubist paintings depicting human figures that prototypicality in the context of images with high categorization can influence to a certain extent the judgment of representational art works. Martindale and Moore (1988) demonstrate higher judgments for prototypical colours. In regard to art, Leder

et al. (2004) indicate that the effect of prototypicality probably most often occurs in connection with the prototypicality of an art work for an artist or a specific artistic style. In addition, it should be taken into consideration, that expertise affects information processing at this level, because experts have acquired knowledge of typical artistic styles. It must therefore be assumed that art experts can rapidly classify art works with respect to style or an artist, whereas novices cannot perform such a classification.

According to Leder et al. (2004) expertise and knowledge of the recipient plays a very important role in the context of the following level of explicit classification. The explicit classification no longer happens automatically, but thoughtfully and verbally. Analysis at this level relates to content and style. In those cases in which expertise and knowledge are restricted, however, the output probably relates to descriptions of what is depicted. Therefore, with increasing knowledge the likelihood of other solutions arises to the question regarding the content of a work. The authors postulated that with increasing expertise, the historical significance of the work or specific knowledge about the artist will be taken into account as a part of the content of the aesthetic object. An overlap of this level with the previous level is also conceivable. The authors emphasized the assumption that in the 20th and 21st century, recognition and understanding of individual styles would play an essential role in the aesthetic experience. Aesthetic experience involves the processing of stylistic information accordingly. This, in turn, requires a minimum level of artistic knowledge. Abstract images of modern art supply artworks that can be distinguished by the style of representation and not by their content. The processing of artistic styles in turn leads to their possible generalization (Hartley & Homa, 1981), and as a result, new examples of a style can be detected successfully.

According to the model of Leder et al. (2004), cognitive mastering and evaluation are closely linked and are available on the next levels. Art expertise enables the provision of information, which in turn supports cognitive processing. A successful classification of the style of an artwork will probably be prepared by a self-rewarding cognitive experience. According to the model, the results on the level of cognitive mastering undergo a constant evaluation in regard to satisfactory understanding in the context of an artwork and its level of ambiguity.

Therefore, the level of evaluation is linked by performance measurement and aesthetic experience. According to the authors, the quality of these feedback loops would also reflect in the form of expertise. Art experts would handle artworks based on style and visual characteristics of the artwork. Naive recipients, in turn, would relate to a greater extent to the content or to external references or they would make judgments on the basis of information by self-referential cognitive information through association of the content of an art work with one's own situation or own emotional states (Forgas, 1995). With increasing expertise, aesthetic experience would always become more differentiated and would probably more rewarding, too. Leder et al. (2004) point out that with increasing experience and expertise a different basis would underlie aesthetic judgment, which further extends the referential framework.

In addition to cognitive processing, further processing is done on the affective or emotional level. Within the model of Leder et al. (2004) a continuous change of the affective states is assumed. Thereby, it is assumed that the typical affective state that can be observed at the beginning of an art-related situation has a positive nature, and that the recipient is a continuous access point to the result of the affective evaluation. The continued success of cognitive processing would lead to a positive change of the affective state. Furthermore, the authors postulate that the affective state would be evaluated by the recipient, and that this information would be used to stop processing as soon as a satisfactory status has been reached. In special cases, a flow experience can be caused by the aesthetic experience in connection with the accompanying emotional state (Csikszentmihalyi, 1999).

The model of Leder et al. (2004) considers two relatively independent types of output, the aesthetic emotion and the aesthetic judgment. As mentioned above, the aesthetic emotion is based on the subjective success of information processing and is often described as pleasure or joy. The authors assumed that the interdependence of the two outputs for art novices is probably greater than that of art experts. Most probably, the art reception of amateurs happens on a rather emotional basis while experts would rather see the challenge in a cognitively-based reception. The "affect

infusion model”<sup>7</sup> by Forgas (1995) draws attention to the importance of affective states in regard to the formation of judgment. The degree of influence concerning emotional states varies according to the model along a procedural continuum. Judgments that require heuristic or substantial processing are more likely exposed to emotional influences than judgments that are based on a direct or motivationally justified access. Affective states would be used in the case of heuristic judgments as information while in constructive structures of a judgment, affective states would serve as priming. It can be assumed that art novices refer to heuristic judgments with regard to the assessment of art considering the lack of consistent information and that the current emotional situation has a strong impact respectively. Of course, it is conceivable that art novices, with the corresponding motivation, choose a constructive approach and that they have to deal with the stimulus material seriously. It can be assumed that the different stages reflect in the reception of art at the neuronal level. The comparison of novices and experts in the field of art is a way to approach this method (see Section 3.6). In any case, a model of the aesthetic experience requires neuropsychological validation. Neuropsychological theories of aesthetic perception will be presented under Section 3.2.1. However, these models usually lack the basis of a profound underlying model.

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<sup>7</sup> The "affect infusion model" by Forgas (1995) identified four different information processing strategies that can underlie a judgment. The "direct access strategy" is based on an access of previous, existing crystallised judgments; the "motivated accessing strategy" is applied if the formation of a judgment has passed a specific motivation; the "heuristic processing strategy" occurs if any attempts are made to make a judgment on the basis of various "short circuits"; the "substantive processing strategy" takes place if a selective, constructive processing of related information is necessary, based on a variety of association- and memory processes.

## Chapter 3

### NEURAL ASPECTS OF ART RECEPTION AND ART PRODUCTION

#### 3.1 Introduction

Up to date, very few attempts have been made to approach art experience at a neuronal level, which may be partly due to the complexity inherent in art experience. It complicates the understanding of linear correlations, since intervening variables and the stimuli themselves are difficult to be controlled. The art recipient does not represent a tabula rasa. There are countless aspects between the manipulation of the independent variable and the result of the dependent variable, such as personality, current mood, individual experience space and personal experience influence the result. Another aggravating factor is the inter-individual differences in brain activity. The topographical or tomographic activity patterns can considerably vary at the same task. A certain number of test persons is essential in order to obtain significant results, because one cannot generalize from only a few findings. At the same time, the applied research methods (see Section 1) are very time-consuming or expensive, or both. Furthermore, the processes underlying visual preferential judgements can also be very subtle. Aversive and positive stimuli or different factors could result in the activation of the same brain areas, or the associated changes could be so little that they cannot sufficiently be determined by current methods. In addition, as already mentioned, the complexity of the stimulus material raises another problem.

Furthermore, partly for the reasons mentioned above, tangible results cannot always be obtained on a mere behavioural basis and results of empirical and experimental observations often drift apart. The, therefore, little solid basis complicates the test design of neuropsychological experiments and the interpretation of its findings. As mentioned previously, Fechner (1876/1897) has already tried to explore the laws of pleasure and displeasure by means of experimental procedures. Despite manifold test series (e.g. Frith & Nias, 1974; O'Hare, 1976), it has not been possible until today to definitely clarify by what aesthetic preference is eventually determined, although the effects of preferential judgements have been examined on a neural level (see Section 3.4).



In the present section, the results of psychological studies will be introduced. In spite of all inherent difficulties, they have tried to find a way to bring some light on the matter of art reception and art production. However, this is not always done explicitly, as for example, in the individual case studies of neurodegenerative diseases (see Section 3.7). Brain damages and its resulting specific impairments can change the artistic expression in various ways. The kind of changes shed in turn light on the degenerative processes and help to increase the understanding thereof. Furthermore, issues of the hemisphere specialization for art perception and creation (see Section 3.4) will be discussed. It is a subject that continues to prevail within the 'scientific landscape' and will also be reflected in this dissertation, where aspects of lateralization will be repeatedly picked up. A further interesting point that will be treated, although it has not often been a subject for research, are emotional reactions to artworks and their neural correlates (see Section 3.5)

The models of aesthetic experience, as presented in Chapter 3, postulate a differentiated cognitive processing of artworks with the increase of experience or the involvement of attention/memory processes. The associated neural differences between laymen and experts will be discussed in Section 3.6.

The central point of discussion will be neuropsychological theories of aesthetic perception as well as principles of perception and the resulting consequences for the reception and production of artworks.

### **3.2 Neuropsychological aspects of the aesthetic experience**

The concept 'aesthetic perception' is used here limited in terms of the reception of visual stimuli, which are very likely meant to evoke an aesthetic response. Such an example would be an artist who creates a piece of work in order to elicit a particular reaction in the art recipient. Ramachandran and Hirstein (1999) discussed these aspects in an essay. Livingstone (2002) and Shimamura (2013) focused on the principles of perception and the resulting consequences for the reception and production of artworks. Livingstone (2002) paid particular attention to the distinction between colour and brightness. Zeki (2002), in turn, placed special emphasis on the connection between concept formation and art.

### **3.2.1 Neuropsychological theories of aesthetic perception**

One is bound to agree with Zeki (2001; 2002) that art, like all other human activities, has a biological basis and is as such subject to the laws of the brain:

"Art has a biological basis. It is a human activity and, like all human activities, including morality, law, and religion, depends upon, and obeys the laws of the brain" (Zeki, 2002, p. 53).

In order to understand the biological basis of art, one has, according to Zeki (2002), to investigate the biological origins of knowledge because art constitutes a form of knowledge or is knowledge. We might be still far from understanding the neural basis of those laws dictating artistic creativity, performance and appreciation. Nonetheless, the spectacular progress in the knowledge of the functioning of the visual brain would enable first steps towards the formulation of neural laws of art and aesthetics. The term associated with it, is called 'neuroaesthetics'. According to Zeki (2002), an important role would be played by a fundamental property of the brain, namely its ability of concept formation. At the same time, this ability would be itself a by-product of another essential property of the brain, namely its abstraction ability, which, in turn, served the primary function of the brain, the acquisition of knowledge.

Zeki (2002) declared the brain's ability of concept formation as the essential basis of art. He illustrated this by Dante, Michelangelo, and Richard Wagner. The motivational force in art would come "from the creation of ideals and concepts by the brain" (p. 54). The formation of ideals would be, in turn, a necessary and inevitable by-product of an efficient system of knowledge acquisition. Zeki assumed that similar neural processes would control all concept formations and that art was a manifestation of this neural capacity. However, all brain systems, regardless of their functional task would be involved in abstraction and concept formation. That means, each cortical region had the capacity for abstraction in its specialized area. The parallel processing by specialized areas would of course not exclude the interaction of different parts (the resulting problem of 'bindings' will be further discussed below). Zeki emphasized the unconscious character of these processes and postulated that the capacity for abstraction was not acquired by experience, but could be regarded as innate.

One of the undisputed primary tasks of the brain is the acquisition of knowledge about the essential, permanent and constant properties of objects and situations within a permanently changing world. The capacity of abstraction and generalization required for this, eventually also bears witness to the limitations of the brain. It is the brain's solution to cope with an infinity of details. Thus, the abstraction leads to the formation of an idea or a concept, but the actual experience cannot always satisfy the superordinate idea:

“Abstraction leads to an idea or concept, but our experience remains that of the particular, and the particular that we experience may not always satisfy the idea formed in and by our brains. One way of obtaining that satisfaction is to 'download' the idea formed in the brain into a piece of artwork” (Zeki, 2002, p. 58).

However, in what form abstraction occurs is only known for more simple constructs. Abstraction already occurs at a very early level of visual information processing. For example, cells react, in the orientation columns of ocular dominance columns, to the particular direction of a contour in the receptive field (see Footnote 13, p. 42).

Furthermore, there are columns of neurons reacting to colours. A cell, for example, that is responsive to a vertical line, responds to any type of vertical line, no matter whether to any differences in brightness or to an object (e.g. a pencil). The fact that the properties of such cells are to great extent genetically determined implies according to Zeki (2002) that the process of abstraction as such is innate. Even though, when during the so-called sensitive phases the input of visual stimuli is necessary to maintain the sensitivity and thereby the abstraction ability of the cell.

The result of such an abstraction process is, according to the author, the formation of an 'ideal'. In this process, all sensory experiences are synthetically combined to generate a construct that may be dependent upon many details, but at the same time independent of a given single detail. Hence, it follows "that the ideal formed by a brain is dependent upon its neurological machinery (an innate mechanism) as well as the experience acquired by the individual" (Zeki, 2002, p. 60). Zeki applies this principle of concept formation both to objects, namely to a kind of a formation of prototypes, and to complex emotions, such as romantic love. Zeki went even a step

further and postulated: "The only 'ideals' that we have are those constructed by the brain" (p. 60).

As aforementioned, the ideals of the brain could now be recreated in and by the arts. The concepts of an artist may however change, both by a further development of his creative work and the accompanying learning process. Subsequently, Zeki has also found the answer to the question of "what constitutes art", namely "the translation of concepts in the artist's mind onto canvas or into music or literature." (p. 67). However, the question remains open, what exactly defines an artist. Great art, in turn, "is that which corresponds to as many different concepts in as many different brains over as long a period of time as possible" (p. 67). Therefore, ambiguity would be a characteristic of all great art since it allows for correspondence to many differing concepts. An explanation of how the formation of such ideals is precisely taking place on a neuronal level, Zeki has yet to give. However, it has recently become apparent that considering art as a product of neural functions can be helpful for its understanding.

Ramachandran and Hirstein (1999) attempted to formulate a theory of the aesthetic experience with particular regard to the underpinning neural mechanisms. Claiming to determine artistic principles, the authors developed a list of eight laws of aesthetic experience. They were meant to contain a set of heuristics, which artists would apply consciously or unconsciously to stimulate visual areas of the brain in an optimal way. Ramachandran and Hirstein (1999) introduced the 'peak shift effect'<sup>8</sup> in order to explain, among other, the impact of caricatures. They regarded this principle as the key to the understanding of some aspects of visual art. According to their theory, artists would seek - (though not necessarily consciously) - to extract and even intensify the essence of an object in order to achieve a stronger activation of the neural mechanisms that occur in the imagination of the original as well. One way to accomplish this is by abstraction. Moreover, the authors suggested that perhaps in abstract art exaggerated ('supernormal') stimuli would be applied in order to activate form areas in the brain more intensely than it would be the case with natural stimuli: "even abstract art may employ supernormal stimuli to excite form areas in the brain more strongly than natural stimuli" (p.15). One can, however, not conclusively

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<sup>8</sup>The 'peak shift effect', as a principle from the discrimination learning in animal experiments, may be explained by an example: If a rat is rewarded for discriminating a rectangle from a square, it will react even more to a rectangle that is longer and narrower than the prototype.

ascertain whether the authors speak here of abstract - that is of non-objective art – or rather had an abstract figurative art in mind. Considering the fact that the authors compared these supernormal stimuli with natural ones, one may, however, conclude that they had abstract stimuli in mind.

The object recognition, including properties associated with the object, such as size, colour and shape, is a task of the ventral visual path in the temporal lobe (for a detailed representation of the physiology, psychology and ecology of visual perception (Bruce, Green & Georgeson, 2003; Chatterjee, 2003, 2011). Consequently, it would be conceivable that pictures of a different abstraction degree of the artwork (from abstracted figurative to figurative) could excite quantitatively different activations in the temporal lobe. It would also be possible that this applies to works of abstract art and abstract objective works. Vartanian and Goel (2004, see Section 3.4) explained that representational works in comparison to abstract works caused significantly stronger activations bilaterally in the occipital lobe (BA 18/19), in the right temporal lobe (BA 37/39) and in the right parietal lobe (BA 7). However, it is important to remember that only different degrees of abstraction have been compared here in a general way - which does not entirely correspond to the intention of the authors who wanted to have various levels of abstraction to be compared with an overemphasized essential form of the same stimulus. It would also be possible to compare the effect of photographs and drawings representing the same object, but overemphasising prominent features, since both forms of representation (i.e. not the comparison of drawing and real object) are at least two-dimensional and could also be better standardized. In no way should the importance and effect of abstraction and exaggeration in the art be questioned, nor the meaning of abstraction for perception. The acquisition of sensory data in the perceptual system takes place as a bottom-up processing where the actual physical stimulus properties are converted into abstract representations. Separated neuron ensembles respond to particular stimulus aspects (orientation, colour, shape, contrast, structure, movement). The activity of a neuron ensemble is related to the subjective perception. According to the authors, artists can extend the 'peak shift effect' to other dimensions, such as colour or motion. Furthermore, the authors discussed the effect of key stimuli. These are exogenous stimuli that lead to a correlating automatic behavioural response. The

behavioural response can be elicited by mocks or natural stimuli. Underlying neural processes of stimulus filtering suppress the deviating stimuli. Such key stimuli also affect humans, as, for example, the baby schema or the partner determination schema. Tinbergen (1951) undertook animal experiments and found out that mocks with solely highlighted key stimulus led to even stronger reactions than the natural stimulus. Ramachandran and Hirstein (1999) interpreted this as a generation of a super-stimulus or a cartoon. The authors concluded it might also be that some art movements, such as Cubism, would activate processing mechanisms in the brain in the same way as exaggerated, congenital 'form primitives', even though these have not yet been fully understood as such. According to the authors, it may also be conceivable that, for example, the Sunflowers by Van Gogh or the Water Lilies by Monet activated those neurons representing memories of the colours of those flowers, more than they would be activated by a natural sunflower or lily. However, key stimuli are biologically relevant stimuli that are quite often depicted in the art, such as sexual contents, social relationships, aggressions and fighting as well as food. However, the stimuli in turn hardly elicit the instinctive behaviours, at least not during their presentation, which is already due to the cultural environment. Attention and mood are influenced, whereas the key stimuli have a far more immediate and intense effect if rationality is excluded. It is, therefore, hardly surprising if such mechanisms are often used by artists and that is also used in advertising. In addition, contemporary artists have the possibility to apply these techniques consciously, on the basis of insights gained from such results (Schuster, 1992).

'Perceptual grouping' was mentioned as another important principle. One of the primary functions of visual areas consists of the figure-ground mechanism. The tendency to perceive objects on a background is so strong that figures are recognized even where they do not exist. The objects in the visual field are differentiated from the ground by detecting correlations between stimuli, for example by means of groupings or other gestalt laws<sup>9</sup>. Furthermore, Ramachandran and Hirstein (1999) assumed that the associated process would be reinforcing for the organism. Consequently, areas in the limbic system would be already involved in this

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<sup>9</sup> The laws of visual perception formulated by the Gestalt psychology are based on the principle "The whole is more than the sum of its parts". Thereby, one tries to find out the laws and principles, which may explain the organization of parts into a whole.

process and not only after completely recognizing an object. The reinforcement of the process, in turn, would serve as an incentive for detecting correlations and associations of stimuli. As an example, the authors mentioned the aesthetic pleasure, likely to occur when discovering colour correlations; for instance, if someone harmonizes the colours of his clothes and carries a blue cloth with red flowers on a red T-shirt. Figure 3 demonstrates another example: Recognizing the Dalmatian before the mottled background leads to an 'aha experience', "a pleasing effect, caused perhaps by activation of the limbic system by temporal lobe cortex" (Ramachandran & Hirstein, 1999, p. 21).



Figure 3: An example of the figure-ground separation. The recognition of the Dalmatian leads to an 'aha experience' (R.C. James, from: Marr, 1982, p. 101).

The neural aspects underpinning the grouping shall be explained here in a brief and simplified way. The primary visual cortex (VI or BA 17) is organized retinotopically: spatial stimuli patterns of the retina are reflected in the spatial stimuli patterns of neurons in the visual cortex. Characteristics that are proximately situated in the perceivable space are, so to say, also proximately located in the cortex. The secondary extra striate visual cortex areas V2, V3, V3A and V4<sup>10</sup> in the occipital lobe are also organized retinotopically. The neurons of area V4 are mainly colour specifically organized so that the object recognition takes place based on characteristic surface colours and colour contrasts. Grouping would happen, in this

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<sup>10</sup> According to Zeki's "functional specialization theory", different cortical areas are specialized with respect to different visual functions. The main functions of the respective areas are the following: V1 and V2 contain different cell groups that respond to colour and shape; cells in V3 and V3A react to shapes (especially to the shape of moving objects), but not to colour. Cells in V4 respond primarily to colour, but many also to the orientation of lines. Cells in V5 respond to movement, but not to colour.

case, on behalf of the conformity of wavelengths, without requiring a physical proximity (Bariow, 1986). Therefore, points with similar wavelengths in the retinal image would induce proximate activations in the colour specific area. In this case, proximity would be defined within a particular characteristic dimension. With regard to the example above, this would mean that the fictional wearer of a blue cloth with red flowers on a red shirt may additionally choose matching shoes in the same shade of blue, and would be happy to have succeeded in creating an elegant combination. Sensory, cognitive and motoric processes are the result of parallel interactions between large neuron populations of multiple cortical and sub-cortical structures. The process responsible for the functional relations of this distributed activity is called 'binding' (Engel, Roelfsema, Fries, Brecht & Singer, 1997; Seth, McKinsty, Edelman & Krichmar, 2004).

In the visual system, this process corresponds to identifying relationships between different features within an image in order to recognize objects. It means the different information about colour, shape, and movement of an object has to be integrated. Evidence suggests that the grouping of features evokes on a neuronal level the synchronization of the action potentials of neurons that extract such features. Accordingly, those neurons are synchronously active that are responsive to the same object. For reviews on the Temporal Correlation Hypothesis of Visual Feature Integration, refer to Singer (1993, 1999) and Gray (1999).

One possible interpretation, according to Ramachandran and Hirstein (1999), could be that these synchronizations direct a corresponding signal to the limbic system, thus enhancing the binding process by a feedback process. The authors draw the conclusion that artists would therefore try to stimulate the system with the aid of as many cues of potential objects as possible. Ramachandran and Hirstein (1999, p.23) commented that this might help to clarify why grouping and 'perceptual problem-solving' would be used both by artists and fashion designers. On the other hand, visitors beholding abstract art at an art exhibition do not only strive to recognize its (supposed) content, but find this process in itself to be quite rewarding. Many a reader might have already experienced this. Furthermore, examining artworks on compositional aspects seems to enjoy great popularity. The authors thus postulated



that the reinforcement of the binding process is a source of aesthetic experience, which, in turn, influences the effect of compositions and groupings within artworks.

In order to validate this hypothesis, the authors proposed to test patients suffering from the Kluever-Bucy syndrome caused by a bilateral destruction of the amygdala. These patients would not only suffer from visual agnosia<sup>11</sup>, but would also have difficulties to segment objects from noisy backgrounds. The amygdala represents an important part of the limbic system; by a bilateral lesion, the reinforcement of the binding process and thereby of the object recognition would be impaired (Ramachandran & Hirstein, 1999, p.24). However, the Kluever-Bucy syndrome is a rarely occurring disease and usually described as a result of bi-temporal lesion.

Another principle dealt with the isolation and enhancement of the visual modality and the associated focusing of attention ("Isolating a single module and allocating attention"). Therefore, according to Ramachandran and Hirstein (1999), a drawing or sketch would be more efficient as 'art' than a colour photograph. The distribution of attention is subject to limitations; that means one cannot simultaneously focus on several components to the same extent. The authors concluded that art appeared to be particularly appealing if it led to an increased activation of a particular dimension (e.g. by means of the 'peak shift effect' or grouping). Such would be the case with redundant activation of multiple modalities. By isolating a singular modality (e.g. shape), the recipient would be able to focus his attention more efficiently on that particular source of information, so that the emphasis effected by the artist would become apparent. Thereby in turn an increased activation of the limbic system would be evoked. Consequently, "less is more" would also apply to the art. The effect of outlines, sufficient to recognize objects, might be based on the fact that the cells in the visual pathways would be stimulated adequately by edges and were indifferent to homogeneous areas (Hubel & Wiesel, 1979). Hereby it would be explained, according to the authors, why outlines were sufficient for object recognition, but not why they were more effective than a colour photograph that provides additional information. In order to validate the authors' hypothesis that outlines are more efficient (see Figure 4), a portrait consisting of outlines would have to cause a

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<sup>11</sup> A visual agnosia refers to the inability to name objects by visual identification.

stronger activation in the brain areas relevant to face recognition (Haxby, Hoffman & Gobbini., 2000; Kanwisher, McDermott & Chun, 1997) than a photograph.

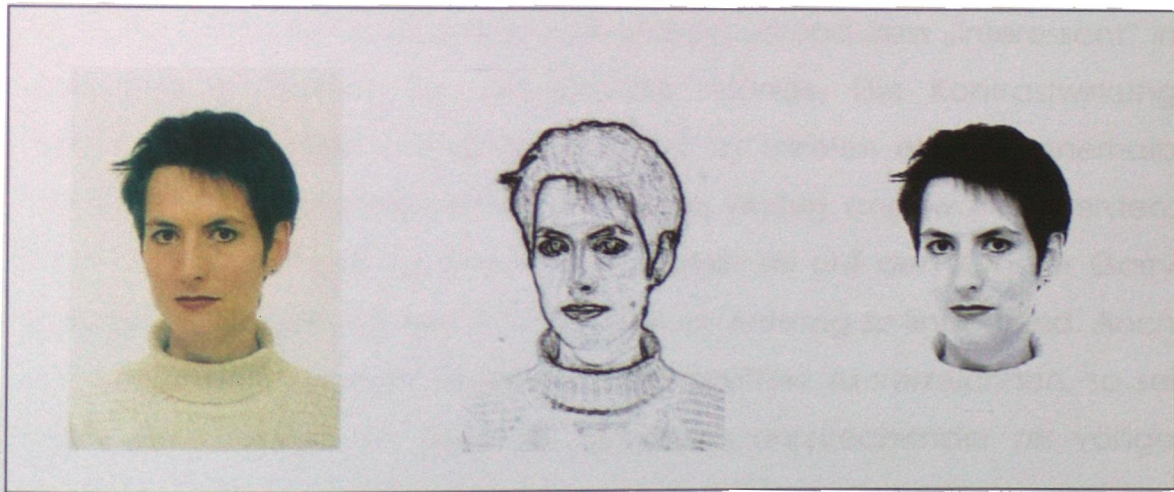


Figure 4: Example of the effect of different representations of a portrait in a colour photograph, a drawing and a contrast reinforcement.

If, for example, skin colour and skin texture were not decisive for identity recognition, this additional redundant information could deduct the limited attentional resources from the attributes relevant to object recognition. Ramachandran and Hirstein (1999) considered this principle of isolation moreover as a possible explanation for the sudden occurrence of artistic activities in patients with frontotemporal dementia (see Section 3.7.2.4) or in autistic persons.

Another law was related to the extraction of contrasts ("Contrast extraction is reinforcing"). Here, it was also assumed that the process as such has an enhancing effect. Marr (1982)<sup>12</sup> proceeded in an influential algorithmic approach from the assumption that the analysis of the retinal image according to differences in the intensity or brightness, and subsequently, the extraction of edges, contours and surfaces represented an early stage in object recognition. Ramachandran and Hirstein (1999) described the extraction of contrasts as possibly "intrinsically pleasing to the eye" (p. 25), thereby explaining the efficiency of outline drawings. The reason

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<sup>12</sup> Marr is considered as a pioneer of algorithmic approach to object recognition. He explains the process of perception as a process, taking place in steps. It eventually leads - within three segments - to more and more detailed information regarding the visual environment and, finally, from the two-dimensional image to the three-dimensional representation.

this process of edge detection<sup>13</sup>, initiated by cells autonomously and at a very early stage, should have a rewarding effect, the authors explained again with the distribution of attention. Information is found primarily in regions of change, such as in edges (due to differences in the intensity or brightness distribution). Therefore, it would be useful if these areas attracted more attention to themselves, thus becoming more 'interesting' than homogeneous surfaces. The authors concluded, what would be 'interesting' for a cell could also be considered as 'interesting' for the whole organism – and - that 'interesting' in certain circumstances - would stand for 'pleasing'. Artist would apply the contrast effect - like other stimulus properties (e.g. colour, texture) - in order to achieve attention. The aforementioned contrast effect would also be noticeable in other dimensions. For example, a female nude with jewelry would be aesthetically more pleasing than total nudity or than a combination of clothing and jewelry. Caravaggio (1573-1610) should be mentioned as a further example. His images gain significantly in intensity from the contrast effect of light and dark (see Figure 5).



Figure 5: Caravaggio, 'The Holy Catherine of Alexandria', 1597. Madrid, Fundación Colección Thyssen-Bornemisza.

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<sup>13</sup> The retinal ganglion cells whose axons form the optic nerve, have concentrically organized receptive fields. If a light stimulus falls on the receptive field center, the discharge frequency of the cell is increased, in contrast, the discharge frequency is reduced when a light stimulus falls on the surrounding periphery (this applies to on-center neurons and vice versa to off-center neurons). In this way, the cells respond better to abrupt discontinuities of the light pattern penetrating the retina than to gradual changes in light and to the absolute light level, whereas the latter usually have lower biological significance. These concentric organization and antagonistic nature of the processing can be also applied to coloured light stimuli. This organization of the cells can moreover be found in the thalamus, in the lateral geniculate body.

Thus, the impact of outlines and drawings may be explained by the selective sensitivity of retinal ganglion cells to discontinuities (see Footnote 13, p. 42). Cells are stronger responsive to abrupt changes and weaker to constant stimulation. This phenomenon plus the fact that each part of the visual scene is analysed separately by the system can be exploited by changing the perceived brightness of the foreground of an image by gradually altering the brightness of the background (Livingstone, 2002). If the background becomes darker, it seems that the front becomes brighter in relation hereto.

Symmetry was described as another aesthetic pleasure-inducing factor. Most biologically relevant objects are symmetrical (e.g. hunter, prey, potential partners). Ramachandran and Hirstein (1999) concluded that this property might serve as early warning system to achieve attention and to facilitate further processing steps until the object would be recognized as a whole. Evolutionary psychological theories postulate that the judgement regarding attractiveness of faces would reflect information concerning the health status of an individual (Thornhill & Gangestad, 1999).

In addition, the authors introduced the 'generic viewpoint' principle ("The Generic Viewpoint and the Bayesian Logic of Perception"). Object recognition presents itself as a complex task if the given stimulus configurations are ambiguous, for example if they are partly covered. So-called puzzling pictures or dual-aspect pictures also represent ambiguous stimulus patterns where the same stimulus pattern evokes two different perceptions, not usually occurring at the same time. The two-dimensional image on the retina allows for multiple interpretations whereas the most likely one will be preferred. Interpretations arising from projections of very distinct perspectives that occur with lower probability are rejected (see Figure 6). Improbable coincidences are somewhat suspect. The authors then postulated that just the opposite might be the case in art and that the violation of this principle would rather cause more pleasure than complying therewith.

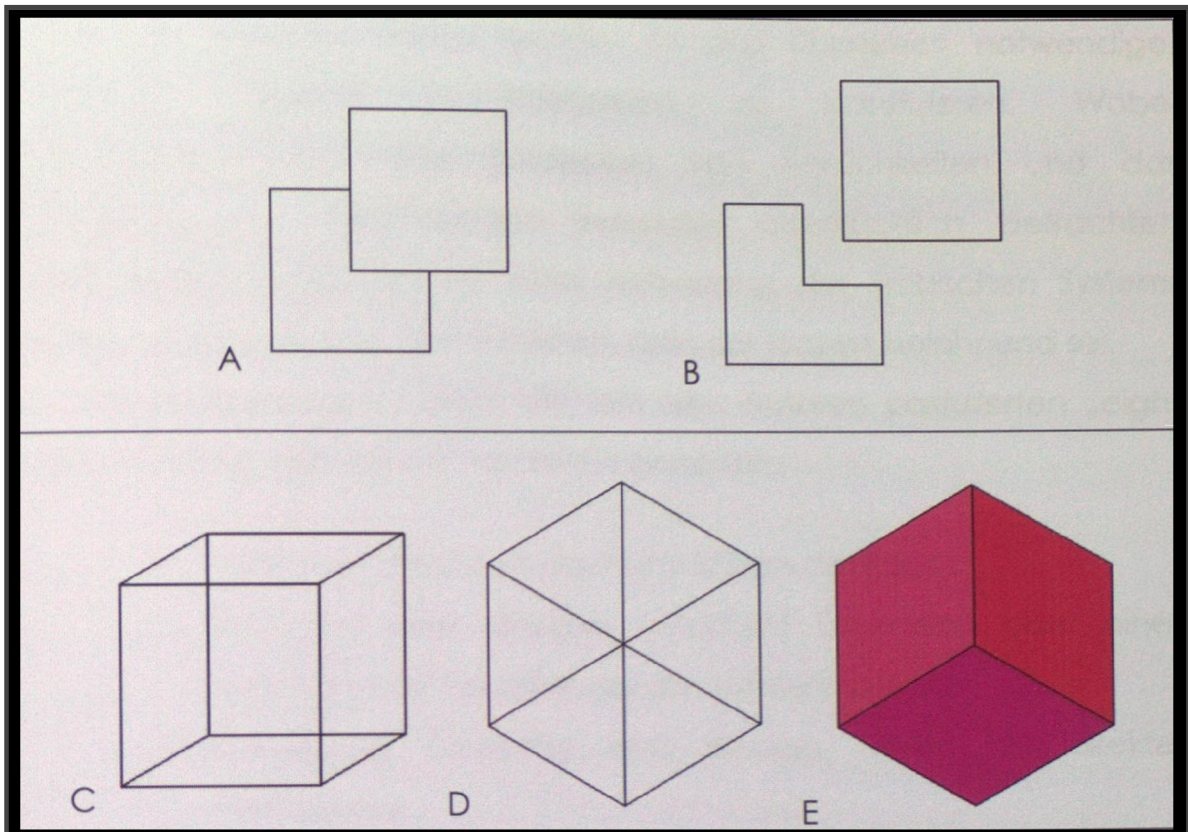


Figure 6: Representation of the "generic viewpoint". A seems to represent two overlapping squares different to B, shown from a particular point of view. The flat hexagon in D could correspond to the cube C from a special point of view but will not be interpreted as a cube as in E.

In the following principle, Ramachandran and Hirstein (1999) investigated the question, why 'art as metaphor' appears aesthetically pleasing and why capturing artistically designed analogies is perceived as rewarding. According to the authors, it may be the use of a simple, specific, or simply to be visualized example, which makes it possible to ignore irrelevant, potentially distracting aspects of an idea or a concept and allows us to highlight the most essential aspects.

Whether this phenomenon is a means of effective communication or "a basic cognitive mechanism for encoding the world more economically" (p 31), remains to be clarified. According to their theory, there would be many paintings, which directly evoked an emotional response, long before the metaphor had become explicit. The authors concluded that "this suggests that the metaphor is effective even before one

is conscious of it, implying it might also be a basic principle of achieving economy of coding rather than a rhetorical device" (p. 31).

The underlying principle would be the ability, necessary for survival, to classify objects into categories. Whereby consequently, the discovering of similarities and the detection of connections between superficially regarded dissimilar events would lead to the activation of the limbic system, to ensure again that the process is rewarding.

Again, the 'eight laws of artistic experience' postulated by the authors are summarized as follows:

1. Peak shift effect and filtering out of the essence
2. Isolation of a single (visual) dimension or feature and focus of attention
3. Perceptual grouping and binding lead to direct enhancement.
4. Extraction of contrasts has a rewarding effect
5. Perceptual problem-solving and recognizing implicit meaning
6. Generic viewpoint or the probability of a specific perception
7. Art as a metaphor
8. Aesthetic preference for symmetry

Thus, the authors primarily described visual perceptual phenomena and processing mechanisms related to the reception and production of visual arts. They referred to a possible involvement of the limbic system during these processes, which would have a reinforcing and rewarding effect. In order to validate these assumptions, Ramachandran and Hirstein (1999) proposed to capture the degree of the limbic activation or rather the emotional reaction to the reception of images by means of measuring the psycho-galvanic reflex.

Astounding and at the same time symptomatic of the difficulties of understanding that apparently exist between art and science, were the partly angry responses to the (1999) essay written by Ramachandran and Hirstein (1999).

Gombrich (2000) criticized, for example, that the authors had too much not taken into account of what is found today as art in museums. Ramachandran replied that



Gombrich had not given sufficient attention to certain aspects of artworks found in museums. Ione (2000), an artist herself, criticized that artists, who were, in some sense, the experts in the field of art, had been excluded from the discussion. Wheelwell (2000), in turn, spoke out vehemently against a reductionist approach to art, which she saw realized here by a confusion of activation and beauty. Although the authors claimed that a large part of what is called art, was actually based on these eight principles, they were nevertheless aware "that much of art is idiosyncratic, ineffable and defies analysis but [we] would argue did whatever component of art is lawful - however small - emerges either from exploiting these principles or from a playful and deliberate violation of them " (p. 50).

### **3.2.2 Principles of visual perception and their meaning for art perception and art creation**

Livingstone (2002) emphasized the difference between colour and luminance or brightness<sup>14</sup>. The first one may probably serve as a carrier of emotion and symbolism, the latter, on the other hand, only defines shape, texture and line.

As stated above, Marr (1982) postulated the extraction of edges using brightness differences in an early stage of object recognition (see also Footnote 13, p. 56). Brightness differences between two gray levels can be readily perceived, though the same distinction between two proximate colour values may often be difficult. Accordingly, artist would have to deal with different brightness levels, regardless of the colour, because colour and brightness are carriers of differing visual information<sup>15</sup> and are processed by various structures of the brain (neural brightness system and neural colour system). Thus, they can play different roles in the arts. The author analysed ways in which various artworks reflect different characteristics of our visual system. She was referring preferably to exhibits of impressionist painters, particularly because these artists had developed some techniques, whose effects could be found in the parallel structure of our visual system. Unrealistic brightness levels can, in turn,

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<sup>14</sup> Brightness is the subjective description of the luminance; the brightness measured physically, whereby there is no simple linear relationship between the two. Luminance is the amount of visible light that leaves a point on a surface in a given direction. Thus, brightness is the amount and colour of the perceived frequency of visible light. Colours described under the same conditions are described in the dimensions of brightness, shade and saturation.

<sup>15</sup> The sense of sight is divided in the qualities of brightness (or gray level) and the colours red, green and blue, divided according to the spectral sensitivities of the photoreceptors. With respect to pigments, red, yellow and blue are referred by convention as primary colours; with respect to light, the primary colours are red, green and blue, in printing and photography cyan, magenta and yellow, the "negative" of the optical primary colours.

lead to an illusory experience of luminosity, depth, and movement. As an example, Livingstone (2002) refers to Monet's impression at sunrise ('Impression, Soleil Levant', 1872, see Figure 7), from whose title the corresponding art direction Impressionism derived its name. This example may demonstrate how difficult it can be to assess different brightness values. The sun in the original picture (A) appears to the recipient as bright, vibrant, intense and alive. The corresponding black-and-white reproduction (B), however, reveals that the sun and the surrounding cloud layer exhibit nearly the same brightness value. In the manipulated version of the picture (C), the sun receives a higher brightness value - (as it can also be seen in the black-and-white reproduction (D) and would correspond to natural circumstances) - but does, however, no longer have the same effect and looks rather dull and pale.



Figure 7: Claude Monet, 'Impression, Soleil Levant', 1872, Paris, Musée Marmottan. A represents the original version, B shows the corresponding black and white reproduction; the sun has nearly the same brightness as the clouds in the background. C shows the altered version with the sun brightened. D shows the corresponding black-and-white reproduction with brightened sun (based on Livingstone, 2002, p 38).



The sun of the painting has different effects on different parts of the visual system. While the sun seems almost invisible for the system, which, among other things, is responsible for movement, depth perception (three-dimensional), figure-ground structure and position in space (dorsal path), it seems clearly visible for the primate-specific colour sensitive part, later developed in evolution, which is responsible for object and face recognition (ventral path)<sup>16</sup>. From this discrepancy possibly arises the vibrating, pulsating effect. The importance of the surrounding light conditions for the perception of colour and brightness, and therefore for the perception of artworks, depends on the different sensitivity of the retinal photoreceptors to certain wavelengths (spectral sensitivity to light). With increasing light intensity, the response of the photoreceptors increases, they react by a change in the membrane potential and the optical pigment contained in different sensors decomposes. The photoreceptors are, in the whole, most sensitive to light in the green / yellow range of the spectrum (e.g. Livingstone, 2002; Shimamura, 2013). In contrast, there are more photons required in the red / blue regions of the spectrum in order to sense an equivalent brightness.

During the colour perception at light (photo topic vision), the rods are active, for the black and white vision at dusk (scotopic vision) the cones, which contain more photosensitive pigment and can already react to a single photon. Since there are only cones at the point of the sharpest vision, the so-called fovea centralis, the visual acuity decreases with decreasing brightness as well. The two types of photoreceptors have a different sensitivity with respect to the frequency of light. In comparison to cones, rods react more sensitive to short - wave light (blue/green), with a maximum sensitivity at 505 nm. The maximum sensitivity of the cones is at 555 nm. With increasing twilight, the eye adapts to darkness. Thus, the rods are increasingly involved in the process. The result is a shift of the perceived brightness of the colours: at the same luminance, red is perceived as more dark and blue as relatively

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<sup>16</sup> The last section of the visual pathway, the optic radiation, ends in the retinotopically organized primary visual cortex (area VI or Brodmann area [BA] 17) in the occipital lobe. The signals from these regions are transmitted to the visual association and integration areas. From Area VI leave at least two largely independent extra striate visual pathways that act in parallel. A dorsal path of VI goes towards the parietal visual regions and mainly serves the object localization, but also the visual control of movement. It is colourblind. The object recognition, including all properties associated with the object, such as size, colour and shape, is a function of the ventral visual path in the temporal lobe and responds to colours, but with a lower resolution than to shapes. This is consistent with the larger receptive fields of colour-specific ganglion cells that react antagonistically to the complementary colours red-green and yellow-blue.

brighter ('Purkinje shift'; see Anstis, 2002). There are about twice as much red as green cones, and only about 1% of cones are blue; thus, the combined response of the cones is relatively insensitive to the blue range of the spectrum<sup>17</sup>. Rods, on the other hand, are, as mentioned beforehand, more sensitive to the corresponding blue light wavelength and less susceptible to longer wavelength (red) light. Therefore, in dim light, the same quantity of shorter wavelength (blue) light appears 100 times brighter than the same amount of longer wavelength (red) light (Livingstone, 2002).

An object can only appear in colours or mixtures of colours, which are also included in the light source. White yellow sodium lamps, which may occasionally be found along roads, may be mentioned as an example: They radiate very little green and red light. As a result, some objects appear colourless. Reflectance and context of the object are also significant, because the colour surroundings of an object influence its perceived colour (Livingstone, 2002).

Thus, the perception of brightness and colour value depends, among other things, on the lighting conditions<sup>18</sup>, the reflectance of the surface, from the context, the frequency of the reflected light (obtained by multiplying the reflectance with the lighting spectrum) and the degree of adaptation of the eye. Accordingly, the design of a painting could be adapted to the conditions of later exposure, provided that the spectrum of the later illumination is known. About self-tests, it should be remembered that the eye requires a particular time for adaptation to the dark. The greatest sensitivity of the eye, and thus of the rods, begins only after remaining at least for 30 minutes in the dark (Livingstone, 2002).

Thus, colours show a different variability in brightness, which, in turn, affects the perceived three-dimensionality of various parts of the painting. Shading results from variations in the light level without changes in saturation. For example, shading and the resulting contrast effects within a garment painted in dark colour are limited,

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<sup>17</sup> There are three types of cones (L M and S), which have different spectral sensitivities due to their different colour pigments. Within the L-system (long-wavelength sensitivity cones), the maximum sensitivity is at 590 nm, thus in the red zone, at the M-system (middle-wavelength sensitivity cones) at about 540 nm (green) and for the S-system (short-wavelength sensitivity cones) at about 440 nm (blue). All three systems are always activated, although to a different extent. The ratio of the number of the respective types of receptors is 40: 20: 1 for L: M: S.

<sup>18</sup> An increase of the luminance of a stimulus also leads to an increase of the colourfulness, thus lighter coloured stimuli appear more colourful (Hunt effect).

which leads to a reduction of the perceived three-dimensionality. Perceived depth through shading is a function of the dorsal 'colour-blind' path (see Footnote 16. p.49), that responds only to contrasts within the brightness dimension. The varying extent to which shading effects the depth of different colours could undoubtedly evoke, however, interesting effects within a painting.

Pictures applying the same colour brightness value, therefore, stimulate only the ventral path of the visual system and lose some depth. Very small contrasts in brightness with very little or no colour contrast stimulate, in turn, only the dorsal path of the visual system, which is far more sensitive to contrasts than the ventral path. In this case, there would be a sensation of space and a perception of the form, yet, at the same time, increasing difficulty to recognize contents. Three-dimensional sensations are therefore also achieved by applying completely unrealistic colours, as long as the brightness contrasts are right. Livingstone (2002) takes the style of Fauvism (e.g. Matisse) as an example. On the basis of differing properties of the two visual pathways, Livingstone (2002) also explained the illusory perception of movement that appears to come from some paintings, exemplifying the art of the Impressionists again. According to her, some colour compositions of these artists showed such a small brightness contrast, that it would result in this illusory motion perception. The reason for this would be the same as why one would also perceive little or no depth in such images. The dorsal path, which plays a role in the perception of depth, position, and movement is as already mentioned, highly sensitive in terms of brightness differences, but insensitive to colour (Livingstone, 2002; Shimamura, 2013). However, the ventral path is quite capable of recognizing objects painted with the same brightness values, but different colours, whereas their position and stability would remain poorly defined through the dorsal path. Subsequently, an oscillating impression could thus be created (see Figure 7). The dorsal path is also responsible for constancy in perception, in terms of the stability of the perceived visual scene despite eye movements. A lack of brightness contrasts impaired this function; this would lead in turn to an illusory sensation of movement. In that sense, it would be enough to let the eyes wander over a pattern of spots and dots with the same brightness values in order to cause such a sensation, that is, independent of the perception of objects (Livingstone, 2002). As already mentioned, the ventral path of

the visual system is sensitive to both colour and shape and serves the object recognition (see Footnote 16, p. 49). Here, the colour system operates at a relatively small resolution: the cells have larger receptive fields within the colour system. Livingstone (2002) postulated, if a strong contrasting line was added to colours with a low brightness contrast in relation to the background (e. g, watercolour or pastel colours), the effect would be that the coloured area seemed to conform to the outline, even if this was not the case in reality. This effect would be correlated, in turn, with a higher sensitivity to contrasts of the colour sensitive ganglion cells, which are less responsive to homogeneous surfaces. Accordingly, the colour would be perceived as being "filled into" the contrasting edges. Therefore, if one drew an object, and coloured its borders and made the colour fade towards the centre, one still produced a relatively homogeneous colour impression. Therefore, it is assumed that a high-resolution form system defines an object, whereas a colour system, working with lower resolution, 'fills' the colour 'in'. If dots or patches of colours with similar brightness values are painted next to each other (as e.g. in the Neo-Impressionism and Pointillism), it produces an effect of a colour mixture and thereby of a relatively homogenous surface defined by illusory edges. The similar brightness values within a region lead to the illusory perception of the border to an area defined by different brightness values, which is not the case, if the colours showed large differences in brightness (Livingstone, 2002; Shimamura, 2013).

As already explained above, the visual processing runs parallel as different qualities of vision are processed in parallel (see Footnote 16, p. 49) and sequentially. The visual system consists of separate subsystems, independent from each other, which analyse different characteristics of the retinal image (contrast, shape, colour, movement, structure). At each stage of the visual process, the neurons become more sensitive to specific features; this is the case over growing regions of the visual field. Thus, cells in the retina and the thalamus react selectively to discontinuities (see Footnote 13, p. 42). Cells in the primary visual cortex (VI) react, among other, to the direction of the contour (orientation columns). Further processing steps take place in the visual association and integration regions. Higher visual areas may then be sensitive to faces (fusiform gyrus) or other complex features (Livingstone, 2002).

The perception of our environment is based on the cellular activity of all these stages. Thereby, we can become simultaneously aware of local and global visual information. If global and local information are consistent, there is no conflict between the information on the individual stages of visual processing. If this is not the case, there may be an interference with information of the different phases. An example to be mentioned are photo mosaics (as known from posters) representing objects consisting of individual photographs. In this case, global and local information is inconsistent. Usually, there is a dynamic interaction, at one time amplifying the global information (the entire object is detected), then again, the local information becomes prominent (and the individual photographs are better perceived). Images usually have in common that they are designed on a flat surface, the image carrier; hence, they are two-dimensional, as the retinal image is also. However, from the retinal images, especially of both eyes, visual information can be extracted, which paintings do not deliver. J. J Gibson (1979/1982) understood by visual information the one "which can be extracted from an in-flow optical arrangement" (1982, p 67). The characteristic of this kind of information is, according to him, that it will not be transferred, does not consist of signals and does not require neither a transmitter nor receiver. By 'array', everything is understood which is "distributed in any way, structured or arranged" (p. 69). It cannot be assumed though, that paintings met these requirements since they represented "an image on a flat surface" (p. 69). The optical arrangement of still images is fixed, that means is not in a state of flux. Nevertheless, also still images would be characterized by invariants providing the

information, but not shapes and colours<sup>19</sup>. J. J. Gibson, therefore, formulated the concept of information particular to perception, differentiating it from a concept of information based on the theory of communication:

"We cannot explain perception by concepts of communication; it is rather the other way around. We cannot share any information about the world with others if we have not previously perceived the world. And the information that we have at our disposal for our perception radically differs from the information that we share." (1982, p.67)

The formation of shades, interposition or occlusion, the size-distance relation and the associated linear perspective and distribution of the surface structure (texture gradient) and the more pronounced blue colouring and blurring of further distant objects are available for developing depth in paintings. These factors are called mapping factors and can be perceived with only one eye and motionless head. In the real world, however, there are more factors available for depth perception, such as the motion parallax and two binocular sources, the lateral disparity and convergence.

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<sup>19</sup> Perceiving the environment means, according to J. J. Gibson (1979/1982) "to extract information from the surrounding light assembly" (1982, p. 287), whereas the information contained in the ambient light does not consist of shapes and colours but of invariants. An image was "an arrangement of permanent structure invariants that are without form and name" (1982, p. 291). It is supposed that "some invariants of an optical arrangement can be separated from their perspective structure, not only with changing perspective as in everyday life, but also when the perspective is held, as indicated in a still image (p. 291). A picture without motion showed no transformation, hence no invariants could be found under transformation, but still would this image show invariants, albeit weaker than in a moving image. J. J. Gibson developed a nativist approach to perception by focusing primarily on the analysis of the ecological context. His theory of 'ecological optics' dealt rather with the stimuli than with the mechanisms of perception as such. The active exploring of the environment through movement would be essential in this process. It was assumed that information regarding the invariant or stable characteristics of the environment was directly accessible.

The lateral disparity originates from the fact that the pupils of the two eyes have a distance of about 6 cm (2.3 inches), thereby shifting the horizontal positions of the corresponding retinal images. The eyes will therefore receive slightly different images since they perceive the subject from a slightly different perspective<sup>20</sup>. The amount of lateral disparity depends on the relative distance of the objects from the beholder. However, lateral disparity appears as depth information only up to a distance of 6 meters (Shimamura, 2013).

Depending on the distance of the objects to the beholder, the axes of both eyes converge and meet at the fixation point. This binocular depth information is called convergence. The angle of convergence is evaluated as a measure of the distance of the fixation point. However, the information obtained therefrom is only useful up to a distance of 3 meters; beyond that, the differences are too small.

The motion parallax<sup>21</sup> conveys depth relevant information: During motion, even small movements of the head or eyes are sufficient for the retinal images in the two eyes to determine the relative distances of objects in the real world and the amount and direction of their relative motion. As we move, nearby objects are moving faster over our visual field than objects farther away.

Within paintings, there is now no relative movement between the objects, and the two retinal images are also similar (absence of binocular disparity); thus, an image appears flat in any case, regardless of the applied mapping factors for depth perception. If one closes an eye, however, and maintains a greater distance to a painting, the depth perception increases. The reason is that, in this case, the binocular depth cues are suppressed and the monocular, the mapping factors,

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<sup>20</sup> In order to visualize the effect of lateral disparity, the following self-test is described: with left eye closed both index fingers are held in front of the right eye. One is held at arm's length, the other about an inch from the face away. Both are one on the line of some object. Keeping this position and fixing on the distant object, now the right eye is closed and the left open. With the left eye you can see the fingers, due to the somewhat different perspective, clearly shifted laterally (Zimbardo, 1996; Shimamura, 2013). This simple experiment demonstrates once again the calculating power our brain during visual perception, by combining the two different retinal images into a unified perception and interpretation of the horizontal displacement as depth.

<sup>21</sup> To illustrate the phenomenon of motion parallax, take the same position as described in the self-test for lateral disparity (see Footnote 20, p.54). Subsequently, upon further fixation of the object, the head has to be inclined to the side. Now you see both fingers moving, the nearer one faster than the more distant, while the fixed object remains quiet (Zimbardo, 1996; Shimamura, 2013).

become more apparent - provided the corresponding mapping factors have been applied to the painting.

As during binocular vision the differences between the two retinal images are only subtle, enough details have to be recognized in order to be able to discriminate them at all. If there is a deprivation of binocular depth cues, the mapping factors will gain new relevance - (if monocular and binocular depth cues convey contradictory results, the latter are of greater importance) - and convey an illusory sense of three-dimensionality. Livingstone (2002) postulated that paintings without any exact details, which seem to be blurred in some way, do not represent an effective stimulus for binocular depth perception and thereby evoke a greater depth effect.

Here, the author referred once again to the art of the Impressionists, whose mostly airy, light and colourful brushwork would favor such effects.

As an explanation, Livingstone (2002) refers to the particular organization of individual ganglion cells at an early stage of the processing in the visual system. As already stated (see Footnote 13, p. 42), there exist cells in the visual system with concentrically organized receptive fields. They work antagonistically and are more responsive to abrupt differences in brightness and wavelength than to gradual changes. Cells organized in this way respond to differences in depth in the same way. Consequently, the visual system responds to abrupt changes in depth stronger than to gradual ones, and this applies largely to local rather than to global depth variations. Livingstone (2002) then assumed that the effect of bas-reliefs was attributable to the fact that they appeared three-dimensional, more than they actually were, since local depth information would be more prevalent here. Furthermore, a paste application of colours would favor an illusory sensation of depth, just as the binocular depth cues react more sensitive to abrupt than to gradual discontinuities.

Images showing horizontally repeated patterns can likewise evoke false depth impressions as the brain produces wrong connections between various points within the two retinal images. The elements of these 3-D-images are arranged minimally different within each vertical row. If the axes of the two eyes now cross in front of or behind the picture (that is, look through the picture), they are not directed to the same element, which leads to a systematic disparity and a sense of three-dimensionality.



A further possibility of how semi-regular patterns can cause an illusion of depth is that the visual system establishes a connection between non-corresponding elements within the pattern. The illusion occurs even with a correct fixation point of both eyes on one level of the image. The retinal images of the two eyes are identical if we look at a plane surface, that is, each element of the surface projects an image on corresponding points of the two retinas. In a three-dimensional scene, objects, which are in front of or behind the fixation line, project images on non-corresponding points of the two retinas. Repeated patterns can now lead to a faulty connection of the different retinal images, as there are in this case more identical valid ways of connecting, which, in turn, can cause the effect of the illusion of depth.

Livingstone (2002) referred to paintings of Impressionism and Neo-Impressionism, which can trigger an atmospheric sensation. She indicated to the possible reason for an illusory depth impression: semi-regular patterns (leaves, flowers) or a coarse, rough duct may evoke this effect.

### **3.3 Hemisphere specialization in artistic perception and creation**

In former and present times, art and creativity have been discussed in the context of hemisphere specialization (see Section 3.6 and 4.5.2). Manifold investigations support the assumption that the right hemisphere plays a predominant role in artistic abilities. In simplified terms, the picture processing is predominantly attributed to the right and language processing to the left hemisphere. However, studies indicate that both regions are involved in linguistic and spatial cognition (Ng et al., 2000), though in a different way and manner. In the majority of right-handed people, the planum temporale, a part of the temporal lobe of the left hemisphere, is stronger and more pronounced than in the right hemisphere<sup>22</sup>. On one hand, this is connected with the localization of language processing in the left hemisphere, on the other hand with the identification of a 'dominant' hemisphere. However, it cannot be spoken here of a hemisphere dominance in the absolute sense; each hemisphere is specialized in different functions and therefore dominant in terms of these particular functions. The

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<sup>22</sup> Morphological left-right asymmetries seem to be rather an exception than the rule in biological systems (see Good et al., 2001).

right hemisphere shows a greater involvement in visual-spatial tasks, geometric patterns, mental rotations and imagination, as well as in face processing. Zaidel (2013) notes that:

"The right hemisphere is now widely regarded as specializing in spatial perception, in topographical layouts of personal and extrapersonal space, mental visualization of two-dimensional and three-dimensional figures, mental rotation of visual representations, and in facial processing for recognition and identification. The strong specialization in the right hemisphere for faces is supported by neuroimaging fMRI studies, from cases of prosopagnosia (the loss of the ability to recognize people by their faces alone), and from poor performance by right anterior temporal lobectomy patients on facial memory tests (Damasio, Damasio, Van Hoesen, 1982; Kanwisher, 2010)" (p. 8).

The left hemisphere, in turn, is the language and analytically oriented and allocates meaning to visual scenes that are not clearly defined, as, for example, in surrealistic art.

Concerning characteristic thinking and cognitive computational styles that distinguish the cerebral hemispheres, Zaidel (2013) postulates:

"the left hemisphere applies detailed sustained attention piece meal, analytic, and logical computational approaches, whereas cognitive computations in the right hemisphere are based on global, holistic, or gestalt principles. However, it is highly likely that many normal human perceptions and expressions are modulated bihemispherically, either jointly or through complementarity, when some cognitive subcomponents are controlled by one hemisphere and other subcomponents are controlled by the other hemisphere" (p. 9).

Zaidel (2013) bases his hypothesis of the left hemispheric involvement at the perception of surrealistic art on a study by Zaidel and Kasher (1989). In their hemifield study, they investigated the question of right or left hemispheric involvement, examining healthy subjects in terms of remembering a series of paintings. The stimuli consisted of two types of paintings, surrealistic (by Magritte, Dali, and so on) and realistic (typical representations of reality). The authors revealed,

"that surrealistic paintings were remembered better by the left hemisphere than by the right hemisphere while no significant hemispheric differences emerged with the realistic paintings. These results show that the fine art is not a unitary entity, at least not from the viewer's point of view. Conceptual features applied by artists distinguish the format of the works; visual art is multifaceted and highly diverse, thus requiring a range of cognitive processing on the part of the viewer. To wit, there are numerous schools of art, impressionism, expressionism, surrealism, realism, symbolism, and so on and so forth. All of this has sadly been overlooked in exploring the neural underpinning of art (Zaidel et al., 1989) "(Zaidel, 2013, p. 11).

At tasks related to steered attention, it could be observed that by global attention, that means attention oriented on the picture as a whole, the right gyrus lingual nerve was activated. Conversely, in focal, detail-oriented attention an activation of the left inferior occipital lobe (Fink et al., 1996) appeared. The right parietal lobe processes probably global features of complex stimulus arrangements, as well as the corresponding spatial relations, whereas the left parietal lobe is involved in a detailed visual analysis (Ng et al., 2000). In this respect, both hemispheres are involved in the visual-spatial information processing. However, the right parietal lobe seems to play a more dominant role as consistent earlier and greater frequency changes can be observed there, and brain lesions have a stronger effect.

Studies describing artistically creative individuals with neurodegenerative processes and other brain lesions (see Section 3.7), support the assumption that visual art mainly evokes the involvement of the right hemisphere. The left parietal lobe creates the visual-spatial preconditions for art, while the right temporal lobe integrates and interprets these percepts. The right temporal lobe appears also to play a role in terms of the extraction and highlighting of essential features of artistic compositions. In contrast, it seems that the left parietal and temporal lobes exercise inhibitory effects on artistic expression by drawing the attention to visual-spatial details and a semantic labelling. Frontal executive functions are in terms of artistic creation probably also of importance, in particular with regard to a behaviour referred to as 'novelty – seeking' (Méndez, 2004).

Besides, the two cerebral hemispheres appear to play different roles in relation to emotions, with the right hemisphere apparently being more involved in negative

emotions and the left in inhibiting such negative emotions (Altenmüller et al., 2002; Schmidt & Trainor, 2001).

When considering a face with asymmetries in the expression (see Figure 8), it depends on the left half of the face, consequently on the one corresponding to the right hemisphere, which impression one gains. From such observations one can infer that the right hemisphere is superior to the left with regard to emotional reactions.

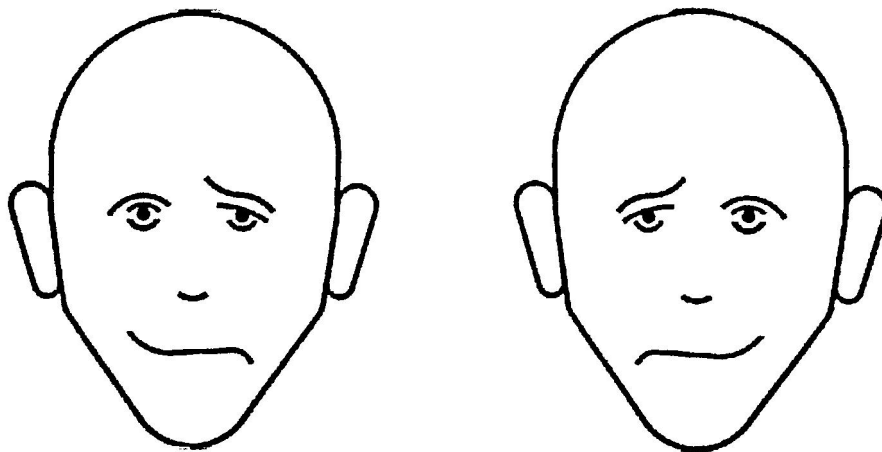


Figure 8: Faces with asymmetries in the expression. If you look in the middle of the one or the other image, one senses a different facial expression respectively, laughing or sad (from Maffei Florentini, 1995, p. 169).

In viewing and processing an image, the possible conversion of content into terms, that means the verbalization, is undoubtedly of importance. Related herewith is probably the greater challenge of abstract art to the untrained viewer. In this context, Linke (2001) pointed to 'Melancholia I', (1514), a work of Albrecht Dürer, in which he discovered evidence of the hemispherical division of the brain functions (see Figure 9). According to this theory, the verbalization of the polyhedron in the left half of the picture of the emblematic work would cause difficulties. The placement of the visual-spatial analysis task in the left visual field, which is associated with the right hemisphere, would be thus in optimum correspondence. Furthermore, a far stronger depth effect is realized in the left half of the picture than in the right half (corresponding to the left hemisphere), which seems to correspond more to a narrative character, as for example by the writing Putto. Spatial thinking is as aforementioned, allocated to the right hemisphere and located mainly in the parietal

lobe. If we assume that consciously or unconsciously artists seek to arrange their artworks in such a way that visual areas of the brain are optimally stimulated (Ramachandran & Hirstein, 1999; Zeki, 1994), one may suspect that the artist in the presented work has been successful. In Figure 9, an illustration of Dürer's melancholy is shown both according to the original and in a mirrored-reverted perspective. The viewers of the picture may now cover one-half of the image and decide for themselves which of the two representations are more pleasing to them. The fixation of the viewing direction should be in the middle since the information should be presented separately to the hemispheres, which is however difficult due to the small size of the pictures.

Dürer's engraving 'Melancholia I' is also symbolic because the many tools, the polyhedron, and the globe refer to artistic activity, representing at the same time a relationship with geometry as the basis for all arts. In addition, the melancholy comes into play, which has been related to talent and creativity since antiquity. The number '1' is to be understood as a reference to the expression of the slightest form of melancholy, supposed to be essentially in art (Anzelewsky, 1988). Indeed, a more severe depressive episode would be hardly conducive for artistic or any other activities. Depressive patients are at least at the beginning of treatment, hardly to be motivated to draw (Kraft, 1986). The interaction of art and psychopathology will be briefly addressed later on.

A reduced inhibition of the right hemisphere by the left hemisphere may result in an increased artistic output as observations of patients with frontotemporal dementia have demonstrated (Miller, Boone, Cummings, Read & Mishkin, 2000; Miller, Cummings et al., 1998; Miller et al., 1996; see Section 3.7.2.4). At the same time, the temporary inhibition of the left hemisphere leads to increased negative feelings. Affective disorders have more frequently been observed in artists (Post, 1994). A disinhibition of the right hemisphere appears to be one hand related to creative skills, but possibly also promotes the occurrence of negative feelings and affective disorders.

An important role with regard to the dynamics of neuropsychological processes in the picture analysis is also allocated to the frontal lobe. To the forebrain, memory functions (e.g. Ranganath, Johnson, & D'Esposito, 2003) and higher cognitive



aforementioned studies are indeed displayed in Chatterjee's (2003) model of visual aesthetics. In this respect, a detailed analyse in the context of the question whether the model can be verified by studies including research methods of electrical recording technique will be presented in Chapter 5. One can illustrate, according to the authors that the neuroimaging results of research are not contradictory in nature, but complement each other and are to be determined as a thematic enrichment (Nadal et al. 2007).

The study by Cela-Conde et al. (2004) to be presented here, was based on the core statements made by Bartels and Zeki (1998), namely that the artist is able to make intuitively use of this processing/perceptual system in order to stimulate aesthetic perception.

Cela-Conde et al. (2004) concede to Bartels and Zeki (1998) the identification of some "laws" of aesthetic experience, but they also stress the important role of an aesthetic variable in the context of identification of such brain areas that are involved in visual perception. The lack of such an involvement of an aesthetic variable should be critically scrutinized. This has been the reason for a more specified study on the involvement of the prefrontal cortex in aesthetic perception.

Considering the previous point, Cela-Conde et al. (2004) have asked whether the prefrontal cortex is eventually selectively activated and furthermore whether this activation can be observed by means of the neuro imagination technique of magneto encephalography (MEG).

Concerning the use of neuroimaging methods (MEG) by Cela-Conde et al. (2004) it should be prefaced that this is the most obvious distinguishing feature in comparison to the other studies, all of which were carried out by means of event-related fMRI.

Cela-Conde et al. (2004) tested eight women, inexperienced in the art, at an average age of 30 years, using MEG. The stimulus material consisted of 320 "artistic and natural colored pictures" (Cela-Conde et al., p.6321). In order to achieve the highest possible standardization, the authors have homogenized the stimuli with regard to "pictorial complexity, color spectrum, luminosity and light reflection" (Cela-Conde et al., p.6321).

Every stimulus was also set to 150 pixels per inch and a dimension of 12 x 9 cm. Photographs containing close views of people were discarded (Cela-Conde et al., 2004) to avoid neural face recognition effects. In comparison to the other studies presented, Cela-Conde et al. (2004) were, moreover, the only ones who used non-artistic stimuli besides artistic stimuli.

The results showed a statistically significant activation of the left dorsolateral prefrontal cortex of the participants while viewing beautiful stimuli ( $p < 0.01$ ). This activation was observed both with natural and artistic stimuli. The said activation was recorded with a latency of 400-100ms; the other related latency of the visual cortex was carried out after 130ms.

Bartels and Zeki (1999, as cited in Cela-Conde et al., 2004) remarked on this that, "time is crucial because it shows that in a multistage process attributes perceived at different times are processed at different sites" (p.6323).

A series of variance analyses (two-way hemisphere x aesthetic / non-aesthetic condition) also led to the conclusion for late latencies (400-900ms) that aesthetic stimuli resulted in comparison to non-aesthetic stimuli into a significantly higher number of activation sources in the left prefrontal dorsolateral cortex (Cela-Conde et al., 2004). In the right dorsolateral prefrontal cortex, this distinction was not to be observed (see Figure 10). Similarly, clear differences in the left hemisphere with regard to dipole activation were observed in each test person.

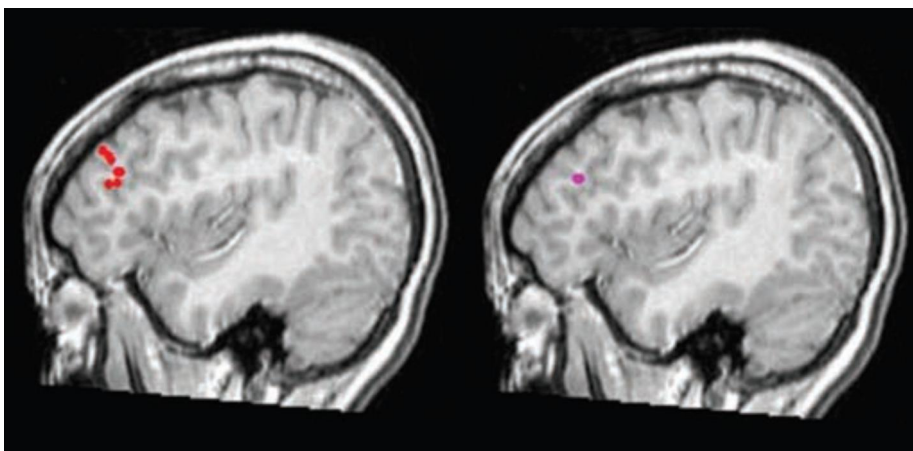


Figure 10: Activation of the PDC under stimuli qualified as beautiful by participant (left) and under stimuli qualified as not beautiful (right) (Cela-Conde et al., 2004, 6323).



According to the above-mentioned “multistage process of perceiving attributes”, Cela-Conde et al. (2004) see parallels to the “theory of multistage integration (TMI)” in the visual system (Bartels & Zeki, 1998, Zeki & Bartels, 1999; Zeki, 1999). Zeki and Bartels (1999) postulate that "The visual brain consists of several parallel, functionally specialized processing systems, each having several stages (nodes) which terminate their tasks at different times; consequently, simultaneously presented attributes are perceived at the same time if processed at the same node and at different times if processed by different nodes" (p.225).

The authors consider the concept of TMI as sustained in several aspects by their experimental results.

Firstly, the research results have confirmed that the visual perception could be regarded as a system built up of different stages (Cela-Conde, 2004). As far as Bartels and Zeki’s multistage system is concerned, further considerations will be made in Chapter 5. As mentioned above, these distinct stages of processing occur in different temporal epochs. Secondly, Cela-Conde et al. (2004) take into consideration special brain areas underneath the dorsolateral prefrontal cortex in the context of aesthetic experience. Referring to this consideration, the authors assume the existence of a perception area for aesthetics. According to the authors, this area has an additional function to areas involved in a perception of forms and colors that is more fundamental. Cela-Conde et al. (2004) refer in this connection to the experiments of Zeki and Martini (1998), who describe this area in the context of subjects perceiving abnormally colored objects. Zeki and Martini (1998, as cited in Cela-Conde et al. 2004, p.6324), were inspired in their study by the "liberation of colors", as in fauvist art, thus heightening its emotional and expressive power. By their experimental results, Cela-Conde et al. (2004) consider the results of Zeki and Martini (1998) confirmed with regard to the perception of aesthetic attributes induced by this "liberation of color“. Furthermore, the authors describe the dorsolateral prefrontal cortex as a cortex area of "perception-action interface in multiple brain functions" (Cela-Conde et al., 2004, p. 6324).

Cela-Conde et al. (2004, p.6324) also note that the dorsolateral prefrontal cortex is involved in a complex proceeding processing of the "information from posterior parietal and occipital areas", even more than is required for the creation of a

correlated action. The authors conclude that this would lead to a special series of actions aroused by a series of visual stimuli. According to several studies, the dorsolateral prefrontal cortex plays an important role "for the monitoring of multiple events in working memory" (Petrides, 2000, as cited in Cela-Conde et al., 2004, p.6324) and "plays a key role in making decisions that call for the consideration of multiple sources of information" (Krawczyk, 2002, as cited in Cela-Conde et al., 2004, p.6324). Consequently, the dorsolateral prefrontal cortex is a dominant part in terms of "evaluative judgment" (Cupchik et al., 2009) and "visuospatial working memory" (Glahn, et al., 2002, as cited in Cela-Conde et al., 2004, p.6324) .

The aforementioned Cela-Conde et al. (2004) conclude that an activation of the dorsolateral prefrontal cortex and the cingulate cortex can be noted during judgment tasks.

While an activation of the cingulate cortex can be observed both by 'beautiful' and 'not beautiful' stimuli, which may be a result of the judgment decision, a "selective activation in the dorsolateral prefrontal cortex" can only be observed by stimuli considered as 'beautiful' (Cela-Conde et al., 2004, p.6324). However, this selection in favor of the positive stimuli, the authors do not ascribe to a behavioral response, that means raising the finger as a sign for a stimulus considered as 'beautiful', because exactly this condition had been counterbalanced before.

Also Cupchik et al. (2009) have emphasized the special role of the prefrontal cortex in connection with the aesthetic experience. Their results also showed a greater activity in the left lateral prefrontal cortex.

Cupchik et al. (2009) advised the participants of the study "to approach the stimuli with an engaged aesthetic attitude" when they were required to take an objective and detached approach. Nadal et al. (2013, p. 141) herein have seen the reflection of the "top-down control of perception".

Vartanian and Goel (2004) examined the neuroanatomical correlates of aesthetic preference for artworks using fMRI. 20 pictures (from the archives of <http://www.artcyclopedia.com>) of abstract and figurative paintings were graphically manipulated resulting into three different conditions per image. Images were referred to as 'original', whose size was adapted in such a way that they fit into a framework

of 500 x 500 pixels. Pictures were called 'altered', where a section of the image had been placed to a different location. Images were dubbed as 'filtered' which were manipulated by the use of a filter, so that the colours within a radius of 16 pixels were randomly distributed. These filtered images served as a control condition, as by the pixel shift the basic stimulus properties, such as colour and brightness, remained, but no detailed content of the image was recognized. Through the manipulation of figures, was then investigated whether compositional changes had an effect on judgments of preferences. Twelve right-handed subjects (of which two were male) were presented the resulting 120 pictures in a direct sequence of 6 sec. each, each three corresponding images in randomized sequence. The subjects were asked to specify their preference judgments per image on a five-point scale, with 0 = very low preference and 4 = very high preference.

The average rate of preference within the 'original' format for the representational works amounted to  $2.32 \pm 1.19$  and to  $1.36 \pm 1.23$  for the abstract works. Figurative works thus received a higher score on an average. The statistical test by means of analysis of variance with repeated measurements showed that the figurative works were preferred to the abstract works ( $p < .05$ ). The 'original' and altered works received better judgments in relation to the filtered works ( $p < .001$ ). Eventually, a significant interaction between type (abstract or representational) and format (original, altered, filtered) was found ( $p < .001$ ). The decline in the preference rate between 'original' and altered works in relation to the filtered works within the group of representational works was more pronounced than it was the case in the group of abstract pictures. In addition, the response latencies were raised, amounting to  $ms\ 2351.4 \pm 1033.4$ . A significantly positive, however low correlation ( $r = 0.16, p < .05$ ) could be observed between the rate of preference and response latency. As the preference rate increased, so did the latency of responses. The implication is that the more the participants 'liked' a picture, the longer they contemplated it before delivering a judgment of preference. The activations corresponding with the preference judgments were collected by fMRI, irrespective of the response latency. The results showed that the activation in the right nucleus caudate, with expansion up to the putamen, declined in relation to the preference rate.

The less 'favour' an image evoked, the less activation there was in this brain structure. If images received a very low score, only a minimal activation could be observed. Conversely, the following structures were stronger activated, the higher the preference judgment: left sulcus cinguli (BA 32/10), bilateral gyrus occipitalis, including bilaterally the gyrus fusiformis (BA 18), right gyrus fusiformis (BA 37/39) as well as bilaterally the cerebellum (Vartanian & Goel, 2004, p. 895).

Representational works (see Table 1), which were preferred according to behaviour data, evoked, in comparison to the abstract works, significantly stronger activations bilaterally in the ventral occipital poles (BA 18/19), in the right posterior gyrus temporalis medius (BA 37/39) as well as in the right precuneus (BA 7). At a comparison of 'original' and altered works, the former evoked a significantly higher activation in the right gyrus lingualis (BA 18) as well as in the right cerebellum. The comparison of 'original' versus filtered works showed significant differences in the right gyrus fusiformis (BA 18/19). With regard to the interaction analysis (type x format), significant activations could be observed bilaterally in the gyrus lingualis (BA 19), in the left sulcus parietalis superior (BA 5/7), and medial occipitotemporalis in the right gyrus (BA 19).

**Table 1: Comparison of the activation types (representational, abstract) and format (original, altered, filtered).**

comparison	Area of activation	BA	Laterality
representational - abstract	Ventral polus occipitalis	18/19	L
		18/19	R
	Gyrus temporalis medius	37/39	R
	Praecuneus	7	R
original - altered	Gyrus lingualis	18	R
	Cerebellum		R
original - filtered	Gyrus fusiformis	18/19	R
(representational original - representational filtered) - (abstract original - abstract filtered)	Gyrus lingualis	19	L
		19	R
	Sulcus parietalis superior	5/7	L
	Gyrus occipitotemporalis medialis	19	R

BA stands for the Broadman area to which the activation is allocated; R stands for the right, L for the left hemisphere.

Vartanian and Goel (2004) concluded from the results that activations in the right nucleus caudatus, bilaterally in the occipital areas, in the left sulcus cinguli, bilaterally

in the gyrus fusiformis, and in the cerebellum are in different ways connected with preference judgments. The decrease of activation in the nucleus caudate in the presence of a decreasing preference judgment is compared with other studies, in which, in the case of patients with depressive disorders compared to the non-depressed control group also a reduced activation of the mentioned structure can be found. The role of the striatum (of which the nucleus caudatus is an essential front part) with respect to emotional and reward-related stimuli is empirically well proved (e.g. by Delgado et al., 2000; Elliott, Newman, Longe & Deakin, 2003). Consequently, the observed activation in the nucleus caudate may be interpreted in this context as specific activation patterns in terms of less rewarding stimuli. The increase in activation in the two occipital poles, and bilaterally in the gyrus fusiformis in relation to the increase of favour judgment is consistent with other studies observing the role of the primary and secondary visual cortex when processing images of faces of different emotional valence (e.g. Geday, Gjedde, Boldsen & Kupers, 2003; Taylor, Phan, Decker & Liberzon, 2003). It became also apparent in the above presented test series by Hansen et al. (2000), that the activations in relation to the primary and associative visual cortex correlated quantitatively with the favourable judgements. However, Vartanian and Goel (2004) pointed out that the increased activation in these areas could also be attributed to an increased visual attention, triggered by the higher rates of preference. Thus, also increased positive favour judgments appeared, which could be brought in that sense in connection with increased visual attention. Likewise, confirmations regarding the increase in activation in the left sulcus cinguli in relation to emotionally significant content appear in the literature as well (Taylor et al., 2003).

The behavioural data showed that figurative works produced more positive favourable judgments than was the case in abstract works. The comparison of figurative and abstract works revealed in the former case increased activations in the two occipital poles, in the posterior gyrus temporalis medius, as well as in the praecuneus. The simultaneously found increased activation in the presence of an increasing favour rate in both occipital poles and bilaterally in the gyrus fusiformis might have partly determined the above result, since figurative works found more

favour. The calculations regarding the neural correlates of preference judgments were not separately conducted for the two styles.

The comparison 'original' works versus modified compositional ones showed a significantly higher activation in the right gyrus lingualis. The authors concluded that probably an element of the compositional structure of 'original' works (e.g. perceived harmony of arrangement) was connected therewith. When the "original" works were compared with the filtered works, a higher activation was shown for the 'original' works in the right gyrus fusiformis (BA 18/19). The authors brought this process into connection with the probably more emotional or rewarding properties of the 'original' works. The comparison with the filtered works was in the case of figurative images in relation to the abstract ones more pronounced. Vartanian and Goel (2004) consider the relevant activations to be in connection with a stronger distinction with regard to relevant preferential activation in the visual cortex. The comparison of altered versus filtered works resulted in no significant difference in the activation. As a possible explanation, the authors suggested, that the compositional reorganization may have adversely affected the relevant quality of images (Locher, 2003). If the structural composition was now connected with aesthetic preference, the reduced compositional quality of altered pictures may have reduced the probability to determine differences on a neuro-anatomical level.

Kawabata and Zeki (2004) focused their research on the neural correlates of the sense of beauty in relation to artworks. The authors investigated the question whether there were brain areas, which exhibit a consistent activation between the subjects, if these judge the paintings as beautiful or as ugly. In a preliminary testing, 300 illustrations of paintings per different categories (abstract art, still lifes, landscape painting and portrait painting) were given to the subjects (N=100, half females) via monitor.

Each representation of a painting was assessed by the test subjects on a ten-point scale. Values 1-4 were classified as 'ugly', values of 5-6 as neutral, values of 7-10 as 'beautiful'. 16 stimuli, for each of the three types of taste, from each category were extracted from this pool. In total, each test person during the scanning operation

using fMRI 192 were offered paintings in randomized order twice. Only such paintings categorized as 'beautiful' at a value of 9-10 or, respectively, in the category of 'ugly', valued 1-2, with 5-6 remaining unchanged were used. The subjects were presented 12 blocks in random order, whereby each block corresponded to a category of images (e.g., landscape painting or portrait painting). Each image was presented for 2 seconds and shown a total of two times resulting in a total of 384 presentations. The subjects had to submit their judgments (beautiful, ugly, neutral) with button press.

The results showed no significant differences in the response times with regard to the different assessments. This is in contrast to the study by Vartanian and Goel (2004), which observed a response latency in positive assessed images. However, as a reflection of the functional specialization of the visual cortexes, activations were observed in different regions of the brain for the various categories of images (see Figure 11). This was especially true for portrait images and landscape pictures, regardless of the respective assessment. The contrast portrait versus non-portrait evoked activations in the right middle gyrus fusiformis and bilaterally in the amygdala. The gyrus fusiformis (fusiform face area) has been associated in multiple studies with facial recognition (e.g. Haxby et al., 2000; Kanwisher et al., 1997). The contrast landscapes versus non - landscape images in turn showed activations in the anterior part of the right gyrus lingualis and in the 'parahippocampal place area' up to the anterior gyrus hippocampalis ranging into BA7 of the right parietal lobe. As repeatedly evidenced, the parietal lobe is, among other things, in connection with object localization and spatial aspects of visual stimuli, but also with aspects of attention (Behrmann, Geng & Shomstein, 2004; Culham & Kanwisher, 2001). The contrast still lifes versus not still lifes showed activations within the occipital gyri, especially in the left area V3, also areas of areas V1 and V2 of additional extensions up to the posterior gyrus lingualis were included (see Footnote 10, p. 39). The contrast of abstract works versus non-abstract works resulted in no significant differences (i.e. different patterns of activations were found with abstract than with figurative works).

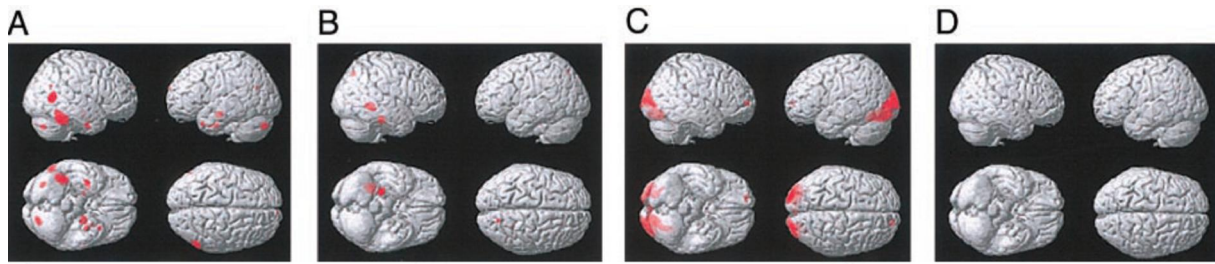


Figure 11: The category-specific activations within the comparisons portrait vs. non-portrait (A); landscape vs. non-landscape (B); still life vs. non-still life (C) and abstract vs. non-abstract (D) (from: Kawabata & Zeki, 2004, p. 1701).

In addition, the activations produced by the assessments regardless of the category of images were computed (see Figure 12). The contrast 'beautiful' versus 'ugly' corresponded to activations only in the middle orbitofrontal cortex. The contrast 'beautiful' versus 'neutral' showed activations in the frontal lobes (BA 11), in the anterior gyrus cinguli (BA 32) as well as in the left parietal lobe (BA 39) on. In the study by Vartanian and Goel (2004) also increased activations at positive favour judgments were recorded in the BA 32, in the left sulcus cinguli. The contrast 'ugly' versus 'beautiful' showed bilateral activations in the motor cortex, of far higher degree in the left hemisphere. The contrast 'ugly' versus 'neutral' in turn displayed surprisingly no significant differences. The areas of the brain involved in the described comparisons, were therefore limited to the orbitofrontal cortex, the anterior part of the gyrus cinguli, the parietal-and the motor cortex.



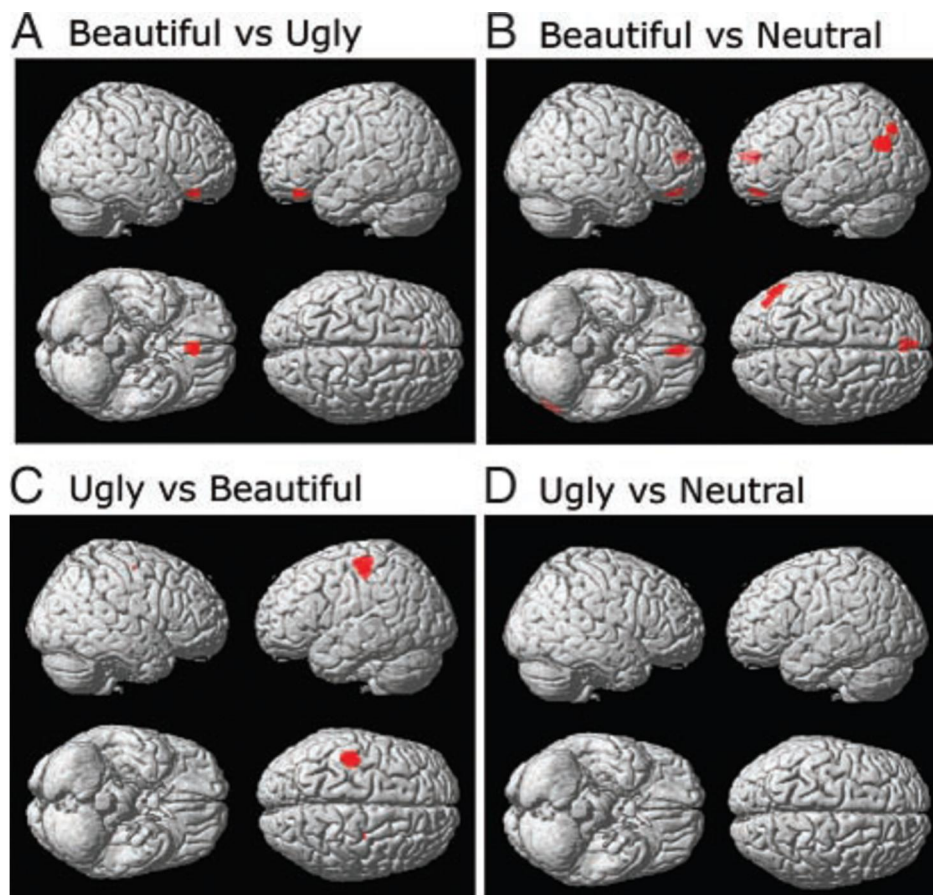


Figure 12: The specific judgment activations within the comparisons beautiful vs. ugly (A); beautiful vs. neutral (B); ugly vs. pretty (C) and ugly vs. neutral (D) (corrected,  $p > 0.05$ ). A: activation in the medial orbitofrontal cortex, B: activations within the medial orbitofrontal cortex, the anterior cingulate, and the left parietal cortex. C: activations within the bilateral somatomotor cortex. D: at given significance level no activation (from: Kawabata & Zeki, 2004, p. 1701).

The quantitative characteristics of the activations within these regions were collected with the neutral stimuli as a baseline, in function of the corresponding response category of the stimulus. Parameter estimates showed a linear function of the activity in the orbitofrontal and motor cortex, where stimuli classified as 'beautiful' displayed the highest activations in the former one and stimuli classified as 'ugly' showed the highest activations in the latter. Such a function could not be observed within the cingulate and the parietal cortex. Vartanian and Goel (2004) could, however, observe that the higher the favour judgment, the more did the activation in the left sulcus cinguli (BA 32/10) increase. Therefore, the same brain areas are involved, according to Kawabata and Zeki (2004), when 'beautiful' or 'ugly' classified stimuli were observed, whereat the extent of activation reflects the response category in the appropriate area. It has to be noted that in the study by Vartanian and Goel (2004) at

least the quantitative characteristics of activations correlated with the quantitative characteristics within the response categories (see Table 2).

Since the image categories, such as portrait, still life and landscape, resulted in different activation patterns, the authors Kawabata and Zeki (2004) investigated the question, whether there were any additional activations within the specific areas of the brain, which resulted in judging the images as beautiful or ugly. An analysis of the interaction took place between the typical activations triggered by portraits and landscapes (respectively the most activated voxels, on the one hand in the gyrus fusiformis and on the other hand, in the parietal lobe) and the medial orbitofrontal cortex (stimuli classified as beautiful showed the highest activations in the orbitofrontal cortex). The results showed no consistent connection between produced activity in the two areas (gyrus fusiformis and parietal lobe) and judgment ('beautiful', 'ugly' or 'neutral'). Consequently, it is not additional activity within a specific stimulus centre that causes this stimulus to be perceived as 'beautiful' or 'ugly' in the present case.

In summary, the study by Kawabata and Zeki (2004) showed that a functional neuro-anatomical base underlies aesthetic judgments, in the sense that pictures of a specific category lead to increased activation in specific brain areas. This does not mean however to assume that specific brain areas become active independent of others. It is rather considered probable, that there are networks in specific areas which produce higher activations and reciprocal influences. In addition, the study indicated that special aesthetic judgments ('beautiful', 'ugly') correlate with activations in specific regions of the brain, especially in the orbitofrontal cortex and probably also in the motor cortex. A specific area reacting to stimuli perceived as 'ugly', was not observed in this study (comparison 'ugly' versus 'neutral'). Parameter estimates indicated that it is mainly a question of relative activity in the orbitofrontal cortex, whether a stimulus was perceived as 'beautiful' or 'ugly'. The same was evident because of the activations in the motor cortex, where stimuli both classified as 'ugly' and as 'beautiful' showed activations comparable to the baseline changes, with the former provoking the strongest and the latter the least activity. If you see beauty and ugliness or like and dislike as extreme poles of a continuum, it may not be surprising

to find quantitative changes, which may explain the characteristics on this continuum. As the authors themselves pointed out, this raises the question what precisely causes the increase in activity.

**Table 2: Studies on the activations at preference judgments in comparison.**

Study	Stimuli	Judgement	Area and direction of the activation	BA	Lat
Cela-Conde et al.(2004) MEG	40 × (abstract art, classic, impressionist, postimpressionist) +160 photos (=320)	Beautiful	dorsolateral prefrontal cortex ↑	8/9	L
		beautiful	anterior cingulated cortex↑	25	L/R
		not beautiful			
Vartanian and Goel (2004) fMRI	(20 x (representational, abstract)) x (original, filtered, altered) (=120)	Positive	sulcus cinguli ↑	32/10	L
			gyrus occipitalis ↑		L R
			gyrus fusiformis ↑	18	L R
			gyrus fusiformis ↑	37/39	R
			cerebellum ↑		L R
		Negative	nucleus caudatus ↓		R
Neutral	not calculated				
Kawabata and Zeki (2004) fMRI	16 x (abstract, still life, landscapes, portraits) x (beautiful, neutral, ugly) (=192)	beautiful vs. neutral	orbitofrontal cortex	11	R/L
			anterior gyrus cinguli	32	R/L
			parietal cortex	39	L
		ugly vs. neutral	No significant activation		
		beautiful vs. ugly	medialer orbitofrontal cortex		
		ugly vs. beautiful	motor cortex (increased left)		L/R

BA designates the Brodman area to which the activation is allocated; Lat stands for laterality, R for the right, L for the left hemisphere. The direction arrows stand for a quantitative increase or decrease of the activations.

### 3.5 Emotional Reactions to Artworks and Their Neural Correlates

Although the authors of the following study had apparently did not primarily intend to explore art experience as such, they nevertheless used artwork paintings as stimulus material. Carretie, Iglesias and Garcia (1997) examined the effect of complex emotion-laden visual stimuli on the cerebral activity by means of event-related

potentials ERPs (see Section 1.9.1). The emotional factor **scores** were determined by two dimensions, on one hand by the arousal (relaxing-activating), on the other by the emotional valence (attractive-repulsive). The stimulus material consisted of 12 paintings, which, by means of pre-testing, were assigned to the characteristics of these two dimensions:

■ Three activating attractive paintings (A+ group):

Titian (1490-1576): "The Bacchanal"

Pierre (1713-1789): "Jupiter and Antiope"

Rubens (1577-1640): "The Fortune"

■ Three activating-repulsive paintings (Group A):

Goya (1746-1828): "Las Parcas" and "La Romería de San Isidro and "Aquelarre"

■ Three relaxing paintings (R):

Poussin (1594-1665): "Landscape with buildings"

Lorraine (1600-1682): "Landscape with Moses saved from the Nile."

Dughet (1613-1675): "Landscape"

■ Three neutral paintings (N):

Meléndez (1716-1780): "Bodegón: Servicio de chocolate" and

"Bodegón: Rodajas de salmón, limón y recipientes"

Sánchez-Cotán (1560-1627): "Bodegón"

All three paintings are still lifes.

(= „bodegón")

The ERPs were recorded in 31 subjects (students, five of which were male) at nine electrode positions (F3, Fz, F4, C3, Cz, C4, P3, Pz and P4<sup>24</sup>).

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<sup>24</sup> see Figure 13 with regard to the electrode positions.

The investigation focused on the evoked slow potentials in relation to visual, emotional stimuli and on their sensitivity to the two affective dimensions, arousal and valence. Johnston, Miller, and Burleson (1986) found that emotionally positive and negative stimuli evoked larger P300 amplitudes than neutral visual stimuli. Other investigations showed, however, that an increase in amplitude of the P300m, a positive wave with an average latency of 300ms, was even possible when the subjects considered a stimulus as relevant for testing, regardless of its emotional charge (e. g. Bashore & van der Molen, 1991). For this reason, Carretie et al. (1997) used non-explicit stimulus material, not distinguishable for the subjects with regard to its relevance level. In order to increase the number of passages, each stimulus showed up nine times on the screen.

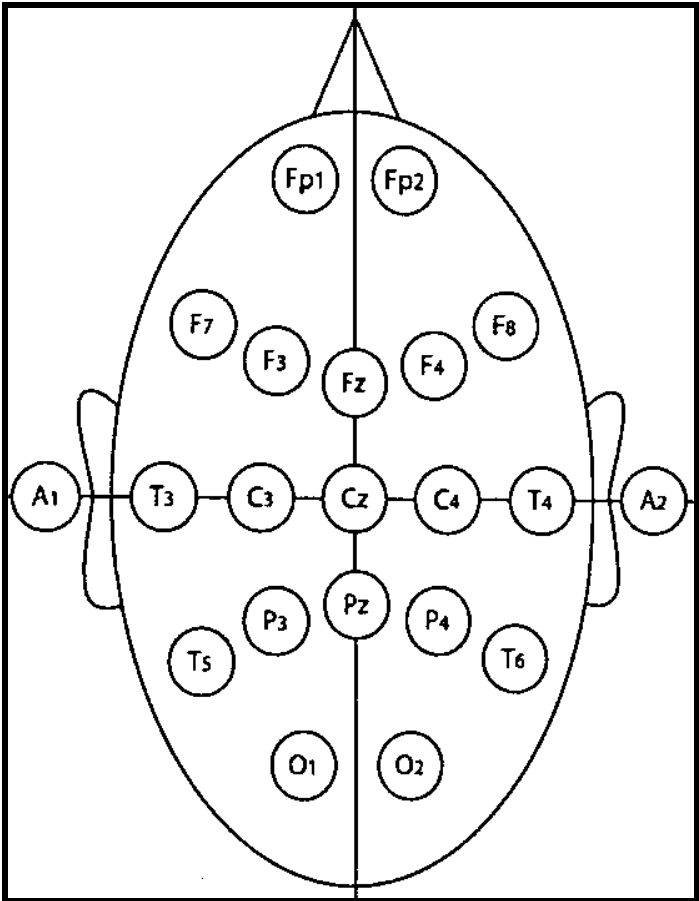


Figure 13: The 10/20 electrode placement system by Jasper (1958).

Two negative components could be clearly distinguished after evaluating the results, namely an N200 and an N300.

The P300 also occurred in parietal and right hemispheric regions.

The N200 appeared with a latency between 150 and 250ms; the N300 occurred within an interval of 275 and 324ms, the P300 again occurred between 350 and 450ms. The average amplitude values were calculated from these three intervals and subjected to an analysis of variance (with the factors stimulus (A+, A-, R and N) and electrode position) and to a post hoc procedure.

Significant differences manifested themselves only in the negative component N300, namely with regard to the factor electrode position and the interaction stimulus x electrode position.

The amplitude values at positions F3, Fz, C3, Cz, and Pz differed in their response to activating-repulsive pictures (stimulus group A) significantly from their response to neutral pictures (N). Furthermore, the electrode positions Cz and C4 showed different amplitude values to the activating-repulsive paintings (A-) in comparison to the relaxing landscape pictures (R). However, in the case of the parietal regions (P3 and PA), it were the activating-attractive paintings (A+) which resulted, in contrast to the other stimulus groups (A-, R, N), to increased reactions. The amplitudes of the stimulus group A+ differed at the Pz electrode position from the groups R and N, but not from A-. Differences with respect to the hemispheres were only significant in response to the activating-repulsive painting (A-J, namely only between positions F3 and F4) and with respect to the neutral painting (N) between the positions C3 and C4.

The amplitude values of the electrode positions of the centreline were significantly higher than those in the lateral positions (with the only exception of Fz-F3 in respect to all four stimulus groups). Fz-F4 and Cz-C4 were higher regarding the neutral and Pz-P3 the activating-attractive paintings.

According to Carretie et al. (1997), this would be because the underlying activity was localized mainly subcortically, most likely within limbic structures.

According to the results of the study of Carretie et al. (1997), the components N200 and P 300 show little sensitivity to emotional stimuli. The authors suggest that P300 responds only to intense emotionally laden stimuli.

In a previous study, the authors (Carretie & Iglesias, 1995) were able to show that N300 could respond to affective characteristics of visual stimuli, namely with the highest amplitudes to activating visual stimuli. In the study just discussed, the amplitudes of N300 demonstrated in general (with the exception of the electrode position F4) the highest values in response to the activating-attractive or activating-repulsive or both paintings.

The authors concluded, “[...] that N300 reflects mainly neural reactions associated with arousal charge of visual stimuli” (p.213).

In view of the emotional valence, the results showed that the activating-repulsive paintings (A-) evoked the highest N300 amplitudes, namely within the frontal position (F3, Fz, C. and C4J), thereby significantly differing from the relaxing (R) or neutral (N) paintings.

The activating-attractive paintings (A+), in turn, demonstrated, as already described, the highest amplitudes of the N300 components in parietal regions (P3, Pz and P4). Therefore, Carretie et al. concluded that the effect of the emotional valence of visual stimuli expresses itself in the component N300 within spatial relations.

In summary, the study of Carretie et al. (1997) leads to the observation that in the absence of significant differences in the P300, the component N300 showed the highest amplitudes in response to activating stimuli. Namely, within frontal regions during the presentation of negative or repulsive stimuli, and within parietal regions during the presentation of positive or attractive stimuli.

Inter-hemispheric differences were at the same time only very slight. One of the differences, however, manifested itself in the reaction to negative stimuli, which turned out stronger left frontal than right frontal. The result, in turn, stands in contrast to other studies that postulate a more pronounced right hemisphere activation at negative stimuli.

Carretie et al. (1997) as Kawabata and Zeki (2004, see Section 3.4) were able to observe that different image categories, such as nudity, portrait, still life and landscape, led to differentiated activation patterns. Carretie et al. let 40 paintings of classical figurative style, all exposed in the Museo del Prado in Madrid, be categorized by 174 persons by means of a five-level scale with the opposite poles of the above mentioned dimensions arousal (activating-relaxing) and emotional value (attractive-repulsive).

The combination of extreme forms of the two dimensions eventually led to the selection of 12 paintings with the corresponding highest values, subsequently used as stimulus material.

The procedure resulted in the interesting effect that the stimuli within a group were each associated with a common theme. Stimuli of group A+ were nudes, those of group A all came from Goya's 'Pinturas Negras' (Black Pictures), the pictures of the R group were landscapes, those of group N were still lifes.

As already mentioned at the outset, the authors did not primarily target at investigating the neuronal correlates of differing art styles. Still, it turned out that these do not only exhibit different emotional qualities in different dimensions, but are also reflected in the activation. In this respect, it is important to consider these aspects in the choice of stimulus material, not least in order to minimize interfering influences.

### **3.6 Experts and amateurs – Differences on the neuronal Level**

In some studies, artists were contrasted with non-artists. Kaplan (1998) focused her investigation on neurophysiological correlates of artistic talent. Among other, she collected differences in the cortical activation of female artists and non-artists on the level of perception, imagination and imaginative execution with respect to the EEG-parameters amplitude and coherence. These were determined by means of spectral analysis and additionally correlated with behavioural data.

The sample consisted of 38 right-handed female subjects. The experimental group consisted of 19 female painters with appropriate training at the art academy, who made their living from artistic activity. The control group consisted of 19 art-interested



non-professionals. The stimulus material consisted of four paintings presented via slide projector<sup>25</sup>. The individual paintings were presented for two minutes each to both the experimental and the control group. Between the presentations of the individual paintings, the subjects had to read a text for 1 minute as an interference task. Subsequently, they had to remember the painting just shown to them (for another 2 minutes). In the ensuing narrative phase, the subjects were supposed to describe their imagination of the painting, which was then evaluated by content. For this a category and assignation system was used that led to the identification of scores with respect to memory and imagination.

Consequently, the subjects were instructed to 'create' a mental picture of their own and put it then on paper. A recording of an EEG in rest took place at the beginning and the end of the experiment. EEG-measurements were based on 19 scalp electrodes placed according to the 10-20-system of Jasper (1958). Amplitude and coherence were analysed for six frequency bands from 1.5-31.5 Hz.

These calculations were carried out for each of the groups as a whole and both groups (female painters and control group) separately while they were contemplating paintings and memorizing them. The procedure was repeated each time both for all paintings and each individual painting separately, as well as for the mental creation of a picture of their own in relation to the EEG in rest.

The spontaneous EEGs in rest of the two groups were compared as well. The EEG data were correlated with the scores on memory and imagination. The most important findings from the resulting complex data set will be described in the following section. Significant differences were obvious in the visual cognitive processing of the female painters and the control group. At the same time, one has to point out that, in case of these calculations, no localization of the original activity had been made before. Therefore, the observed activation below an electrode position does not necessarily indicate that the source of activation is also located at that place.

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<sup>25</sup> Jordaens: "the festival of the king of beans"- a moving grouping; Rembrandt: "the windmill"- a drawn landscape; Kandinsky: "Aquarelle et Encre Rouge" – an abstract coloured picture; Holbein: "Jane Seymour" – a portrait.

It is assumed that there exists “a connection between the degree of coherence and strength of the fibre connections on the one hand, and the difficulty of a task on the other” (Kaplan, 1998, p.343). Hence, if a task is perceived as easier, coherence decreases. When comparing the two groups, this training effect became evident. Both when they created a picture of their own and when the spontaneous EEG was recorded, the female artists showed a lower coherence in the left hemisphere and in the inter-hemisphere.

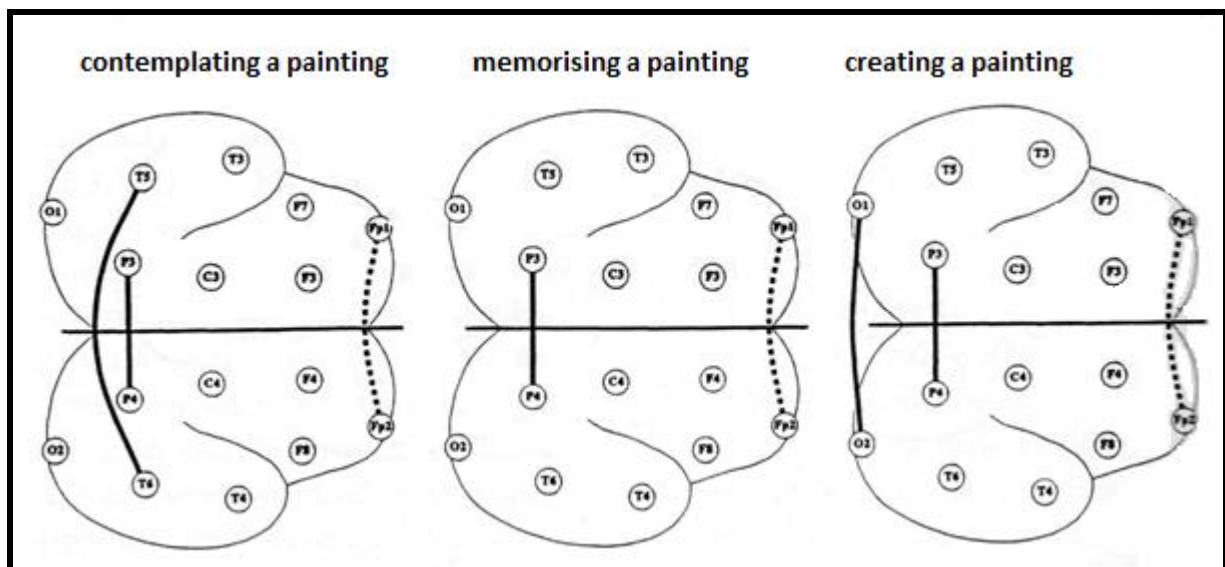


Figure 14: Significant differences in inter-hemispheric coherence for all frequency bands. Group compared (painters vs. control group) while contemplating a painting, memorising a painting and creating a painting of their own. Each time, both the right and the left hemisphere are visible. The solid lines indicate higher coherences in the group of female painters; the dashed lines indicate higher coherences in the control group (according to Kaplan, 1998, p. 336).

This observation was interpreted as a lower exchange between the hemispheres, that means that they work more autonomously, and as a reflection of a localized operation<sup>26</sup>. With regard to the inter-hemispheric coherence across all frequency bands, a consistent increased cooperation between the parietal areas could be observed in the female painters. The same applied to all three conditions (contemplating paintings, memorizing paintings, creating their mental pictures). In

<sup>26</sup> It should be mentioned again that increases in coherence are understood as an increasing functional cooperation between brain regions within a certain frequency range. In connection to this, decreasing coherence is interpreted as a decrease of coupling and therefore as an increase of functional independence of the affected brain regions. Consequently, a decrease of coherence is *not* to be equaled to a decreasing neuronal activity. Other studies not based on coherence analyses were able to show that training or expertise results in a lower activation of the same brain areas than in untrained persons (e.g. Solso, 2000; see further below). Expertise, training and skills result, in this case, to a lower activation in the cortex.

turn, the same could be observed in the control group with regard to frontopolar cooperation (see Figure 14). These group-specific inter-hemispheric relationships were interpreted as correlates of cognitive load and may, according to Kaplan, be related to attentional processes.

Regarding the activation patterns within the hemispheres across all frequency bands, differences between the painters and the control group (see Figure 15) became manifest. The differences were particularly distinctive for the left hemisphere, while the extent of activation in the right hemisphere was similar despite involvement of different areas in both groups (see Figure 15).

The female artists showed higher right centro-parietal coherences (electrodes position C4-P4) while they were memorizing a picture and mentally creating one. Increased coherence values were also perceived between parietal and frontal (Pz-Fz).

According to these findings, in the group of female painters more interactions are taking place in the right hemisphere than the left one. Kaplan considered this result as an evidence suggesting “that visual perception and visual imaging, as two aspects of artistic talent, are reflected in higher Centro parietal coherences, whereas the right hemisphere can be considered as decisive for the global form processing” (1998, p.344).

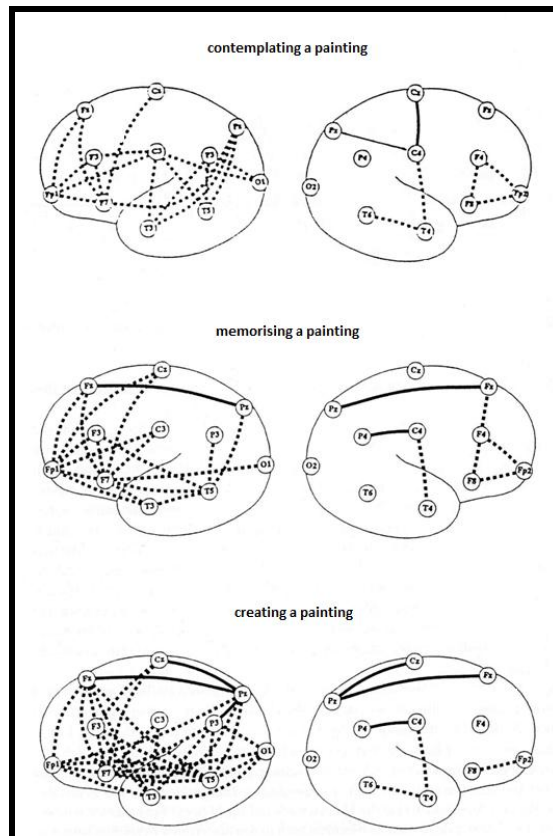


Figure 15: Significant differences of the intra-hemispheric coherence for all frequency bands in a group comparison (female painters vs. control group) while contemplating a painting, memorising a painting and creating a painting of their own). Each time both the right and the left hemisphere are visible. The solid lines indicate higher coherences in the group of female painters; dashed lines represent higher coherences in the control group (according to Kaplan, 1998, p. 335).

The control group showed a much greater extent of activation in the left hemisphere. The result may be due to the more efficient neuronal processing within the group of female painters. Evidence that expertise results in a facilitated neuronal processing within the corresponding domain can also be found in the studies mentioned further below (e.g. Solso, 2000, 2001).

In the control group in all three conditions, left temporal connection between P3-T5 could be recorded. According to the author, it is located in the area involved while reading, namely the area of the gyrus angular, as well as an intense involvement of the frontal cortex.

He suggested that the reason was an increased use of semantic processing in addition to visual processing, which would prove “clearly the increased verbal processing of visual cognitive activity” (p.346). However, once again it has to be

pointed to the above-mentioned objection of a missing localization of the original activity. Therefore, one can by no means claim that the activation clearly falls into the area of the angular gyrus. In no way should the significance of neuronal networks and parallel processing be questioned, it is only questionable whether the method chosen here is purposeful to uncover such networks.

Bhattacharya and Petsche (2002) took a similar approach and compared functional and topographical differences between female artists and non-artists by means of EEG phase synchronization analysis during the visual perception and imagination of four art works of different styles and epochs.

Their experiment was based on the assumption that different frequency bands reflect functionally different components of information processing from sensory perception to encoding (Klimesch, 1999). The experimental design corresponded in part to the study by Kaplan (1998). Even the stimulus material was the same (see Footnote 25, p. 80). The sample consisted of ten female artists having completed their training at the art academy and ten female non-artists.

The subjects were presented with a picture for 2 minutes by slide projection, followed by a rest period of 1 min. After a distraction task of 2 minutes, a rest period of 1 minute and an imaginative task followed, in that the picture shown before should be visualized. After another rest period of 1 minute, another painting was shown. In the group of female artists, a significantly higher synchronization in the highly frequent beta- and gamma bands was observed during the perception of the artworks.

At the same time, a high involvement of the right temporal electrodes (T4, T6) became evident, as well as an amplification of the inter- and intra-hemispheric connections of temporo-parietal areas. Within the group of non-artists, especially the alpha-band showed an enhanced extent of synchronization, bilaterally within the frontal cortex, both between the frontal (Fp1, Fp2, F7) and the right temporal occipital cortex (T6, O2).

Within each group, the topographies of the imagination task exhibited, apart from the delta band, a comparatively high degree of similarity. The observation is consistent with the assumption that brain regions, active during sensory-induced perception, are reactivated when remembering, that means while imagining such information. In the

low-frequency bands (especially delta) synchronization was significantly increased only in the group of artists and particularly high for the imaginative task, with particular involvement of the posterior regions, both intra- and inter-hemispheric. During the perceptual task, the increased synchronization was mainly perceived in central and parietal areas. A definite coherence decrease within the alpha band was found predominantly in the female artists during both tasks.

Furthermore, the right hemisphere showed a higher synchronization in the female artists than the left one. A hemisphere asymmetry was less significant in the group of non-artists than in the artists. The authors conclude from the results that within the panel of artists, the increased synchronization of the high-frequency bands was probably due to a stronger integration of multiple visual features. Thus, they would be able to integrate even minor details of elaborate works of art to generate an internal representation of the artworks. At the same time, the increased synchronization of low-frequency bands is presumably due to the larger involvement of the long-term memory, especially during the imaginative task.

Consequently, the artists would be characterized by a greater ability to integrate visual patterns from long-term memory. Artistic training would, therefore, have an impact on the dynamic cooperation between distant cortical areas during visual-related cognitions. Accordingly, these artistic skills would be reflected in the synchronizations within differing frequency bands and their correlations with specific cognitive functions.

Both the study by Kaplan (1998) and the one by Bhattacharya and Petsche (2002) emphasize a more pronounced visual memory in artists, as compared with a group of non-artists. It consists of the “easier perception, processing, recognition and retrieval of visual information from associative networks and ensembles” (Kaplan, 1998, p.361) while generating pictures. The visual encoding starts in the artists already at the perception level and therefore would favour a long-term storage.

Furthermore, within both studies, the female artists display a higher synchronization of the right hemisphere, and both studies emphasize the activations of parietal regions. Consequently, a greater role for visual artistic talent should be assigned to the right hemisphere. In the same way, both studies within both groups demonstrate

a similar neuronal activation with regard to perception and imagination, that means regarding bottom-up and top-down processes. As already mentioned, the method of coherence analysis used by the authors, however, is, controversial and only seldom applied.

Solso (2000, 2001) presented an fMRI study in which a famous British portraitist (Humphrey Ocean) and a control person, inexperienced in the art, were drawing portraits and geometric figures during the scanning procedure<sup>27</sup>. A notepad was fixed above their face; arm and elbow of the subjects were supported. Six faces and six complex geometric shapes were alternately presented on a page of the notepad. 30 seconds per drawing were available. Surprisingly, the subjects reported that both their drawings as well as their thoughts regarding the drawings were similar to those under normal conditions.

The activations, while drawing geometric figures, were subtracted from the activations during portrait drawing in order to control interference factors, such as motoric activities and individual visual operations (e.g. activities in the primary visual cortex). The author observed in both subjects an increased activity in the right posterior parietal lobe and associated this with processes related to face recognition. However, in the comparison, it appeared that the activation in the mentioned area was comparatively stronger in the control person.

According to the author, the lower activation in the portraitists justifies the conclusion that the artist is more efficient in face processing than a non-artist. Moreover, the artist demonstrates a stronger activation in the right middle frontal lobe, which was associated with a more complex association and manipulation process of visual forms and the planning of motoric activities of the right hand. The author postulated that the portraitist, who sees and draws faces more often, spends comparatively little energy for the basal face processing, but more for the processing of these features as regards the associated correlations. The interpretation of these features therefore takes place at a higher level, based on an abstract representation of the face. Conversely, the control person without such relevant experience would process faces

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<sup>27</sup> Innerhalb eines Ganzkörper-MRI-Scanners ist die Bewegung massiv eingeschränkt, der Kopf ist immobilisiert.

at a lower level, which would be more involved with features than with the interpretation of faces.

Solso (2000, 2001) himself emphasized that these results were based on the comparison of only two individuals, that means further studies would be needed to make more definitive statements. However, it has to be considered that drawing will be far harder for the non-artist control person than for the experienced artist. During the process of drawing, there are also activations in the parietal lobe to be observed (Makuuchi, Kaminaga & Sugishita, 2003), to which the results may partly be due to. Moreover, face processing seems to be predominantly a function of occipital temporal areas (see review of Haxby et al., 2000).

The findings of the studies on the comparison of experts and non-experts show that art expertise and artistic talent in painting may lead to an altered approach on the level of perception, imagination and performance and, in turn, the efficient use of stimulus material to a reduced activation of a certain brain area.

The presented studies on neuronal aspects of art reception and art production indicate that to date there does hardly yet exist any clear idea of how to approach the complex field of art experience on a 'neuronal' level. Experts and non-experts have been compared (Battacharya & Petsche, 2002; Kaplan, 1998; Solso, 2000), correlates of preference judgments identified (Cela-Conde et al., 2004; Kawabata & Zeki, 2004; Vartanian & Goel, 2004) and a variety of theoretical thoughts been provided (Ramachandran & Hirstein, 1999; Zeki, 2002).

Mostly in the course of these studies, one did not follow a superordinate theoretical model, but rather investigated isolated aspects of art experience. Researches of a not neurophysiological nature have rarely been considered (the same applies vice versa). Equally problematic appears the choice of stimulus material to which apparently not enough attention had been paid. Consequently, it has partly not been possible to make a statement regarding even a selected area of the spectrum of art, or just only regarding a too specific area. These circumstances, regardless of the complexity of the material, make it impossible to formulate laws of a general nature.



### **3.7 Neurodegenerative processes, brain damage and artistic creation**

Art is an expression of neuronal functions as well as an expression of the organization and interpretation of perception. Brain injuries, as some studies have proven, change artistic expression. By evaluating the effects of brain injuries on the perception and expression of art, insight into the changes of neuronal universal principles of perception and cognitive organization can be gained (Mendez, 2004). Furthermore, awareness shall be raised to the fact to what extent human beings, with all their (artistic) thinking and acting and their (artistic) personality, are subject to neuropsychological processes and laws. Descriptive individual case studies are naturally prevalent here, which do not correspond to the intended focus of the present study, namely, reporting on studies based on experiment. However, by no means shall the fate of several individual artists be explored here, nor their medical history or changes in their artwork and personality associated therewith are worked up meticulously. For this aspect, one can refer, among others, to Bankl (2005), who described the cause of death of some famous artists, scientists and politicians, which brought him broad public success. Bankl reported on educating artists (e.g. Manet, Makart, and Gauguin) who died from syphilis. Syphilis or 'lues' is a chronic infectious disease, which may cause changes in the central nervous system (progressive paralysis). Bankl quoted for example Makart and added:

"In his death year, he painted a large number of flower parts, hardly to be differentiated from one another, a mental stereotype characteristically for his syphilitic brain disease" (2005, p. 223).

Due to his life story, Van Gough became the object of many analyses and retrospective diagnoses (e.g. Marrant, 1993). Likewise, the present study will not dwell on changes in the perception and artistic creation caused by substance abuse or exposure to other toxins, although some artwork may have been created under such influences. Nor are psychiatric disorders and their potential impact on artistic creation its subject. To this end, there exists, however, at least since Prinzhorn (1922/1994), a variety of literature, which in this context often alleges diseases from the spectrum of schizophrenic disorders. An early study of this subject comes from Reja (1907/1997). Besides, refer, for example, to Bader and Navratil (1976), to Navratil (1983) and to Kraft (1986), who presents various individual case studies.

However, neurodegenerative processes and brain lesions mostly allow valid conclusions about the function of the brain; consequently, they can thus provide more insight into the creation of art and creativity. Simultaneously, works of art, as a very specific expression of human existence, and changes in their style caused by degenerative processes, may facilitate conclusions about the neuronal correlates of artistic activity.

“Acts of creation such as paintings capture our imagination, not just, because we can explore their nature, but also because they reflect the nature of their creator. It is this relation that makes the examination of artistic and creative talent in the context of illness so revealing” (Crutch, Isaacs & Rossor, 2001, p.2129).

Works of often, but not exclusively of well-known artists were examined under the aspect of traces of neurological and psychological disorders by comparing them with their premorbid creative ability. However, considerable differences in artistic talent and style in their premorbid work make that approach more difficult so that the question arises whether this allows for the formulation of general principles. The same is true for style and content. Different artistic traditions might underlie different cognitive behaviour.

In the context of artistic production and neuropsychological deficits, Chatterjee (2004) emphasized the difference between ‘description’ and ‘expression’. According to him, a general understanding of the difference was, “descriptions emphasize representations of the world and expressions emphasize representations of an artist’s internal state” (p.1568). Brain lesions may affect the descriptive and the expressive manner of artistic production differentially. For example, the loss of the ability to apply line and form descriptively may lead to a broader expressive style. Consequently, one may conclude that the neuronal basis of visual descriptions and visual expressions had to be different.

As it will become evident in the discussions below, neurophysiological deficits do not necessarily lead to an artistic output of lower quality. Style or content may change and indeed gain a higher expressive force or rather, result in greater aesthetic experience. A manifestation of the opposite case could according to Chatterjee (2004) possibly be observed in artists affected by frontal-temporal dementia. In them,

a more naturalistic and detailed kind of art comes to the fore, lacking abstraction and symbolism.

Neuropsychological syndromes may be associated, in addition to deficits, with positive phenomena. Such phenomena, e.g. caused by epilepsy or migraine, can mutate into a source of artistic inspiration (Chatterjee, 2004).

### **3.7.1 Neuropsychological deficits, perception, and artistic output**

Specific neuropsychological deficits change artistic creation in most cases. However, such artworks, created under certain impairments, give an eloquent information about the underlying deficits. Smith, Mindelzun and Miller (200) for example described the occurrence of a simultanagnosia<sup>28</sup> in the course of a stroke in an artistically active female patient. While it may be difficult to imagine the effects of deficits in the visual perception, artistic works may enhance the understanding thereof.

The patient presented by Smith et al. (2003) painted objects and scenes from memory. Her works before and two years after a stroke showed usual ability to centre objects and present them as a whole. The works created during her recovery however revealed a sort of selective attention towards a part of the object, “as if she could not simultaneously create the image in her mind’s eye” (p. 1832). Until her recovery, the works displayed a progressive change. Agnosia seemed to distort the inner representation of the whole; probably, the authors concluded, on the level of the associative visual cortex. Thus, the hypothesis would be supported that the associative visual cortex is not only involved in the abstraction of visual inputs, but also in the formation and interpretation of visual memories. Therefore, artistic works can increase the understanding of experiences otherwise difficult to communicate since the patients merely described their perception as ‘not right’.

Cantallago and Della Sala (1998) described the case of the famous producer Federico Fellini who, in addition to his talent to produce movies, had distinct graphic skills. Fellini suffered a stroke in the right parietal lobe resulting in a left-sided visuomotor neglect<sup>29</sup>. It was unusual that the artist showed a high degree of

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<sup>28</sup> A simultanagnosia describes the inability to perceive a visual scene or a group of objects as a whole.

<sup>29</sup> Due to lesions, mostly in the parietal cortex, complex disorders in the visual-spatial attention may occur. A hemi-neglect arises mainly at right hemisphere lesions, whereby the response to stimuli contralateral to the lesion is non-existent or

awareness of his attentional and motoric deficits. In the course of two months, Fellini was exposed to intensive observation and a number of physical examinations.

The motoric symptoms improved over the two-month-period only slowly, sensory deficits, mainly restricted to the lower left quadrant of the visual field, remained unchanged. The artist showed no deficits in intelligence, language, simple perception and verbal memory. In part, Fellini, showed evidence of an implicit processing of neglected parts of the visual stimuli, partly reflected by the tendency to personalize the drawings (e.g. in a line dividing task; see Figure 16).

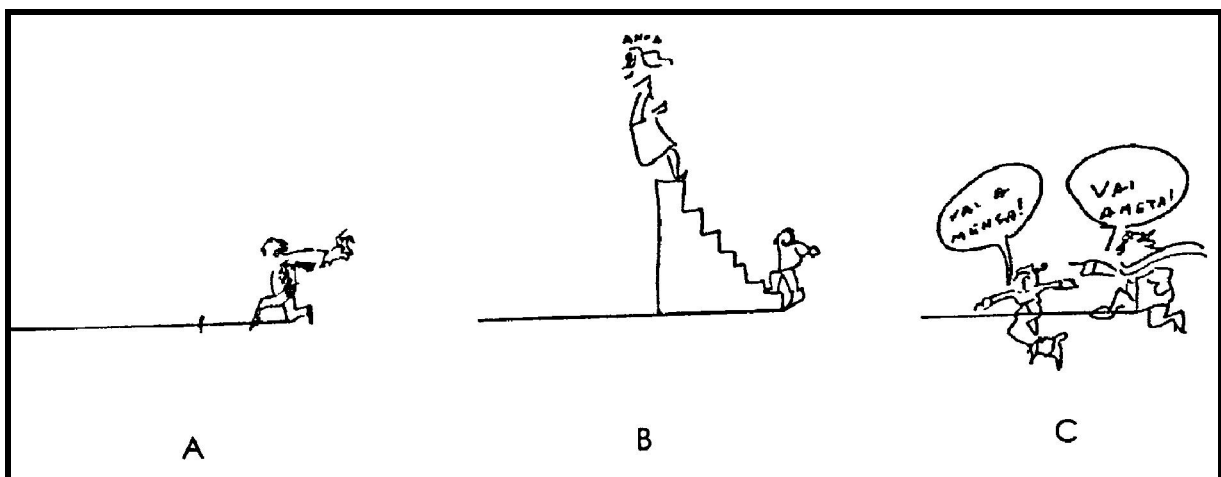


Figure 16: Examples taken from line-dividing tasks, performed by Federico Fellini, with a tendency to personalize these (A-C). They partly revealed an implicit awareness regarding the left-sided final point of the line, in spite of a shift of the centre to the right ("Vai a metà" – Go into the center) (from: Cantagallo & Deila Sala, 1998, p. 168-169).

Fellini's drawings from memory provided, in turn, no direct evidence of the existence of a representational neglect, in spite of the fact that he omitted several times details on the left side and a tendency to draw on the right side of the page. Spontaneous drawings displayed only mild evidence of a unilateral neglect. However, Fellini expressed his frustration with his visual deficits and his partly inadequate

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insufficient. The neglect therefore affects mostly the left side of one's own body and of the space. Segment division tests show that the sense for the center of the room has shifted to the right. If items have to be copied, only or mainly the right side of the template is copied.

performance of the defined task in his drawings (see Figure 17). Sixty days after the brain infarction, his drawing abilities were completely restored. However, the artist died soon after that as the result of a second massive brain stroke.

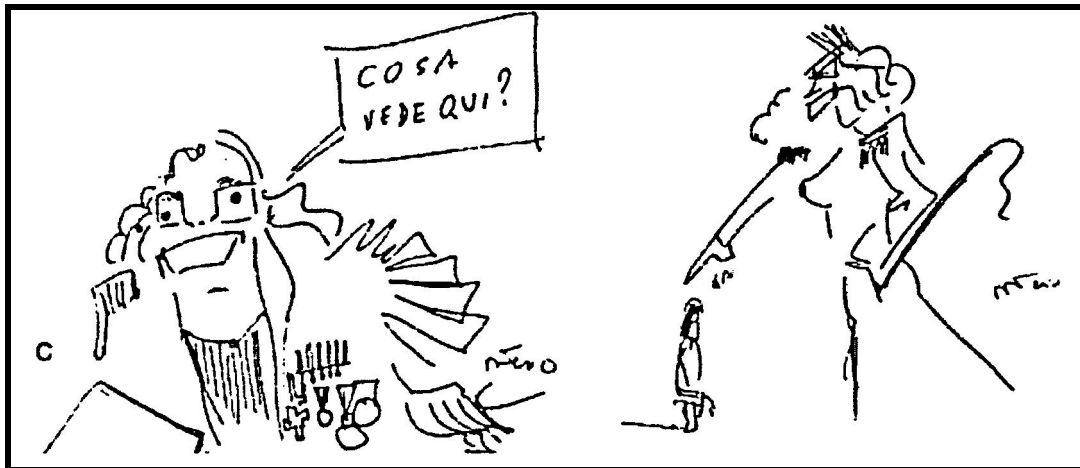


Figure 17: Two of Fellinis' spontaneous drawings reflecting his feelings regarding his visual deficits ("cosa vede qui?" – What do you see here?). (From: Cantagallo & Deila Sala, 1998, p. 176).

Another artist many times described who suffered from a neglect is Anton Raeder Scheidt (Wurtz, Goldberg & Robinson, 1982). His self-portraits are known and displayed changes in concordance with his symptoms. Other artists are Lovis Corinth and Otto Dix. These artists, however, were apparently not aware of their deficits; or rather, their awareness level grew in parallel to the improvement of the visual-spatial functions. Therefore, Fellini is in this respect an exception. Artists with neglect and no awareness of it do not complete their artworks, regardless considerable effort (Marshall & Halligan, 1993). Despite Fellini's awareness level of his deficits, it did not help him to overcome them.

Furthermore, evidence of implicit processing of neglected parts of stimuli was observed (Marshall & Halligan, 1988). Cantagallo and Della Sala (1998) postulated that a deficit of the visual-spatial working memory of the visual field, contralateral to the lesion, might be responsible for this phenomenon (Ellis, Delia Sala & Logie, 1996) which, in turn, based on the assumption that the implicit processing takes place by accessing knowledge stored in long-term memory. As a direct consequence, patients suffering from neglect should only be able to process meaningful precepts in the neglected field implicitly, since meaningless contents can probably not be activated

by traces in the long-term memory. Ellis et al. (1996) provided experimental support for this hypothesis. The authors eventually drew the following conclusion:

“It might be postulated that the dissociation between impaired spatial performance coupled with awareness of such deficit shown by FF [Federico Fellini], might be mapped onto the relative impairment of visuo-spatial working memory functions (responsible of the impairments in visuo-spatial tasks) and the intact conceptual awareness, which capitalizes on the good long-term memory functioning” (Cantagallo & Della Sala, 1998, S. 182).

Moreover, Fellini showed a neglect of the left lower quadrant of the visual field at the presentation of a visual stimulus, displayed however no neglect in connection with imaginative tasks. This specific pattern would be indicative of a double dissociation between representation and perception in neglect, which in turn undermines the hypothesis of a common underlying mechanism.

Blanke, Ortigue and Landis (2003) reported on the occurrence of a mainly colour related neglect in a 71-year-old professional educational female artist. A haemorrhage in the right posterior parietal lobe led to an anopsy of the left lower quadrant of the visual field.

Drawings completed during the period of her impairment revealed a mild left-sided graphic neglect, with a particular emphasis on colours. The coloration of the drawings focused on the right side of the picture (the left side projects in the right hemisphere where the lesion was localized).

A similar procedure could not be found in her premorbid works and disappeared six weeks after her brain injury. The observations indicated that parietal damages may not only affect spatial relations but also, in a dominant manner, visual stimulus attributes, such as for example colour.

A neglect may also affect sculptural abilities, as Halligan and Marshall (1997) reported in their case study of a 75-year-old well-known British painter and sculptor. After a brain stroke, the artist displayed a mild left-sided sensory-motoric deficiency, an anopsy of the left lower quadrant and a left-sided visual neglect. Eight years before the brain stroke, the artist lost in an accident the functional ability of his

right dominant hand; however, he succeeded in transferring his artistic abilities to his left hand. Six months after his stroke, the artist was discontent with his sculptural and painting performances, in spite of regaining the capabilities of his left hand. The drawings seemed to be less organized and elaborated than they used to be while the artist was concentrated mainly on his right side. In addition to the left-sided hemi-neglect, some sculptures and drawings demonstrated distorted, exaggerated or deformed figures. Despite the completeness of head and eye movements, the artist was not able for example to complete the left side of a clay face even approximately as well as its right one. He was no longer able to integrate diverse perspectives into a coherent three-dimensional whole. Although the apparent impairments improved within a year, traces of neglect were identifiable in many subsequent drawings and paintings until his death. The artists could however never regain his former smoothness in his sculptural performance.

Finally, the presented case studies demonstrated that even a life-long dedication to artistic creation offers no or only little protection against a sudden decrease in the ability to pay attention to objects in the left visual field.

### **3.7.2 Different forms of Dementia**

Below, various forms of dementia and its impact on artistic and creative work will be discussed. In this context, mainly Alzheimer's disease and the frontal-temporal dementia have been dealt with in the literature. According to Miller and Miller (2011):

“Alzheimer disease and frontal-temporal dementia provide contrasting examples through which focal brain injuries influences artistic production and creativity. Typically, visuo-constructive abilities are lost in early stages of Alzheimer disease, and over time, there is a diminution of color and style. One assumes that prominent and early parietal involvement in Alzheimer disease results in the loss of artistic ability” (p.103).

#### **3.7.2.1 Alzheimer disease and artistic creation**

Alzheimer disease is a degenerative dysfunction of the brain, characterized by cognitive and functional deficits and changes in affect and behavior. Patients

suffering from Alzheimer disease become more passive and show only little inclination to begin and complete projects.

As a result, little-experienced artists rather seem to cease to work creatively (Chatterjee, 2004). Artists who continue to be active, in turn, display a tendency to simplification. Crutch et al. (2001) investigated the correlation between changes in the artistic expression of a professional painter (William Utermohlen) with the stages of his Alzheimer disease.

Neuropsychological studies over several years evidenced a continuous general deterioration of cognitive functions. Mainly affected was his verbal memory, visual-perceptual, visual-spatial and executive abilities. An MRI revealed a generalized bilateral cerebral atrophy.

In the period after the diagnosis at 61 years, the artist's work focused on self-portraits of which some are presented in Figure 18 representing the changes in style and the deterioration of the cognitive status, mainly in terms of visual-perceptual and visual-spatial abilities. While painting A is still a typical image of his premorbid creative work, the later works show that the brushwork became coarser, and the surfaces rougher.

A sense of proportion, perspective and depth and the structural capabilities gradually deteriorated, an abstract background has no longer been implemented. The realistic implementation of the earlier works could no longer be realized by the artist. The self-portraits can also be seen as an expression of the inner status; issues such as anxiety and depression are distinct.





Figure 18: A series of self-portraits by the painter William reflecting the progression of his Alzheimer disease. Painting A was created at the age of 60 years, still unaffected by the illness. Painting B was completed at 62, painting C at 63, painting D at 64, painting E at 66 and painting F at 65 years of age (from: Crutch et al., 2001, p.2131).

An impairment of the ability to process perceptual and spatial information seems to be of particular importance for the artistic changes observed. The investigations carried out have shown, however that the visual memory was not affected, which might have been one of the reasons why the artist was able to continue painting. Motivation, creativity, and artistic, creative urge seem to be unequally affected by neurological insults. Abstraction appears to be another possibility to give expression to artistic intention despite various impairments.

Cummings and Zarit (1987) had already made similar observations in a semi-professionally-working artist. Over a period of two years, they systematically performed behavioral and neuropsychological tests. In correlation to the deterioration of neuropsychological abilities, changes occurred in his artistic output. In the presence of intellectual impairment and a gradual decline in most neuropsychological functions, visual-motoric and constructive abilities were the least affected and demonstrated a marked decline only towards the end of the observation period. A

painting completed at the age of 67 years, when the first symptoms were already manifested, displayed considerable skills in presentation, shading, color, perspective, proportion and balance in the image construction. At the age of 70 years, when Alzheimer disease was diagnosed, the deterioration of artistic skills was manifest. Seven years after onset of the symptoms, a loss of detail, a lack of perspective and a simplification of the color choice were recognizable. A year later, at the age of 75, the artist produced only stereotypical reproductions of earlier paintings in which errors in perspective and proportion became evident. At the age of 76, his paintings demonstrated a complete dissolution of the image construction with a total loss of perspective, intrusion of irrelevant details and a striking perseveration.

The described case study (Cummings & Zarit, 1987) confirms the general tendency to simplification in the artistic creation in the course of Alzheimer disease.

The subjects became simpler, whereas specific contents were detained and earlier works drawn on. A decrease in the richness of details and a minimized coloration, as well as the loss of perspective representation, manifested themselves. Similarly, a decline in motivation became evident.

In the earlier stages of the disease, the authors observed an affection of artistic skills mainly on a motivational, organizational and executive level; later on, however, also the visuomotor skills were affected.

The authors suggested that the visuomotor skills, an important element in artistic expression, were probably genetically and/or by training higher developed and therefore less affected: "Their relative preservation suggests that the intrinsic neurophysiologic organization of this component of his talent may have rendered it less vulnerable to impairment" (p. 2733). Consequently, the correlation between neuropsychological deficits to changes in their artistic production allows insights into the structural functional organization of the brain of a talented individual.

The readiness of the artist William Untermohlen and others to participate in the presented study of Crutch et al. (2001), thus providing the possibility to carry out neuropsychological investigations over a longer period and the use of imaging procedures offer an optimal opportunity to investigate changes in artistic style caused by Alzheimer.

This is however not the case with the well-known representative of abstract expressionism, Willem de Kooning, who also arouse the interest of scientists. However, the assessment of his work is far more problematic on behalf of diagnostic uncertainty.

Kontos (2003) analysed among other the late paintings of the artist de Kooning under the aspect of a progression of his probable Alzheimer disease. Here again, it became evident that the art in particular, as a distinct human experience and expression, may be useful for scientific discourse. The paintings of de Kooning from the 80ths of the last century displayed a decisive change in style. At this time, he experimented with simple paintings, mostly held in red, white, yellow and blue. By means of a projector, he transferred his smaller earlier works on a big canvas and subsequently represented the object in a clear cut and reduced line (Espinel, 1996; Reif, 2001). However, what seemed to astonish the world of art and the world of science likewise was that de Kooning, because of his advanced dementia (presumably of multiple etiologies), should not have been able to do so (Kontos, 2003). Kontos proceeded on the assumption that the resistance to accepting that de Kooning, despite his dementia, had been artistically creative would be based on the biomedical commitment to inextricably link intention and mental capacities.

Kontos claimed "that the body can be a source of inventiveness and creativity, inviting us to understand the body as active, that is, imbued with life force that has its own intentionality" (2003, p. 166). Accordingly, the continuous performance of artistic intention of de Kooning would testify of "the body's potentiality for innovation and creative action" in spite of neural affection (p.167). In any case, the creative work of de Kooning in spite of his progressive disease raises some questions, which may contribute, among other, to broadening the scientific view about a particular illness. Thus, Kontos wrote, „Individuals with this illness must be seen as retaining a sense of self with the persistence of agency despite cognitive impairment“(p. 168). In addition, Espinel (1996) dedicated himself to the work of de Kooning and again, raised the issue as to the healing power of art and to the particular role of art, especially in its abstract form, for the convalescence of de Kooning. Espinel spoke of convalescence, but based his assumption only on the fact that de Kooning had continued to paint.

The case study of the artist Untermohlen (Crutch et al., 2001), as well as the case studies by Cummings and Zarit (1987), investigated artists suffering from dementia. These studies proved a marked deterioration and impairment of their artistic activity. Considering this fact, one may assume that the changes in the style of de Kooning might not have been the expression of artistic intention, but rather of impaired ability. Is it then still possible to speak of art? Does the intention of an artist to create suffice or can you still explicitly speak of intention? Meulenberg (1996) hypothesized that the ability to remember an artistic idea or concept could be so severely disturbed that the artist may no longer be able to compare his idea with the result of his ongoing work on the canvas. At that moment, when an artist can no longer convey a subordinate intellectual content, one may speak at best of “decorative results”, as Gibson did concluding

“[...] that this tragic dementia is such that he [de Koonings] is beyond saying anything significant and this appears to be born out by his paintings. They have become decorative, and their interest lies in the legacy of a successful and original painter” (p. 1838).

De Kooning’s separate living wife Elaine and her brother supported him actively, motivating and encouraging him to paint. Without such support and guidance, his works would hardly have come into existence (Stewart, 2002).

The act of painting might have been of therapeutic value for de Kooning or not. The question would be rather whether a creative act, if consciously or not, has a greater therapeutic value than some other ergo-therapeutic work (e.g. basket weaving). Art therapy seems to have at least a positive impact in the case of dementia (Stewart, 2002). In any case, cognitive impairments do not necessarily result in a decline of artistic style. The works can indeed gain expressional force and eventually appear to be far more interesting than those from premorbid creational periods do.

It is certainly necessary to deepen the understanding of de Koonings later works by an understanding of his disease. De Kooning showed clear parallels in his later work to the described changes in the work of other artists with similar symptoms (Cummings & Zarit, 1987; Crutch et al., 2001). Characteristic features of the above-mentioned case studies were a general simplification of artistic work, the reduction,

and perseveration to subjects, the resorting to earlier works, a loss of richness in detail, a limited choice of colors and a decline in motivation.

As Stewart (2002) wrote:

“When a skill is lost, the whole being must readjust itself. It is the way that a patient readjusts himself to the loss that is fascinating and unpredictable. Do we then view a person by what the disease has robbed them or by what they have preserved and how they have managed to adapt it?” (p. 316).

### **3.7.2.2 Lewy- Body Dementia**

Sahlas (2003) retrospectively described the changes of the British artist and writer Mervyn Peake (1911-1968) in the light of current scientific knowledge. The neurodegenerative disease of the artist had been temporarily described as Alzheimer disease, Parkinson disease or post-encephalitic Parkinsonism. Symptoms and behavioral changes could not be clearly classified in those days. Due to biographical notes, Sahlas assumed that Peake had suffered most likely from Lewy Body Dementia. In his fifth decade of life, the artist showed signs of Parkinsonism and cognitive decline. Visual hallucinations were reflected in his drawings (see Figure 19) and, in addition to paranoid delusions, in his poems. As the deterioration increased, short episodes of pertained insight manifested themselves into drawings of figures with pointy hats and often a worried, anxious expression (see Figure 19).

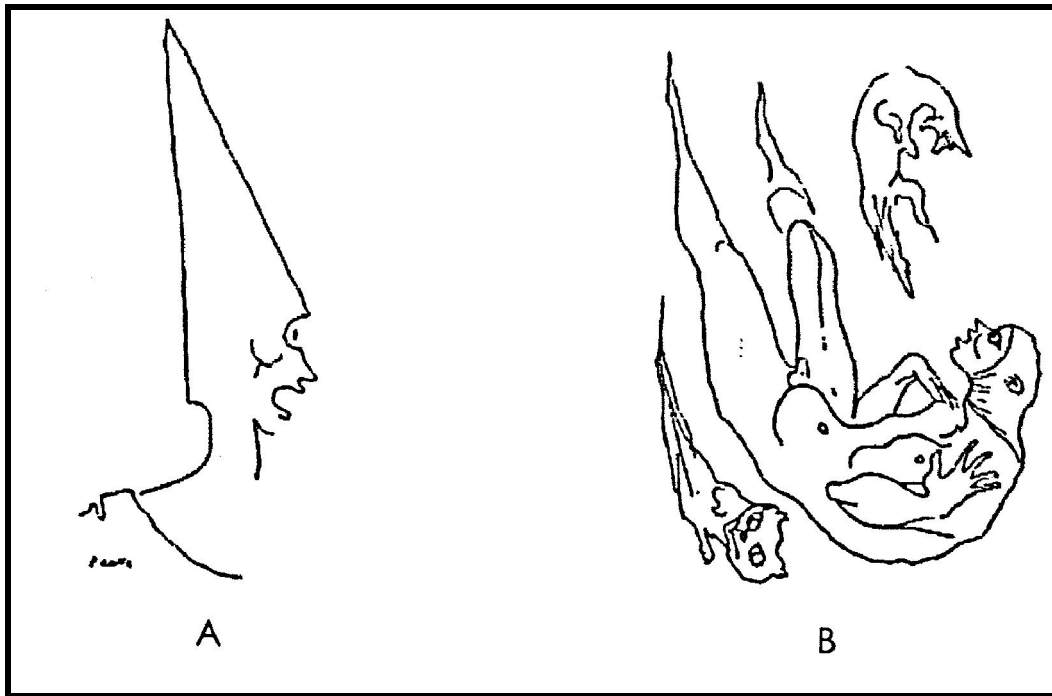


Figure 19: Drawings of the artist Mervyn Peake, completed at a progressive stage of his disease. A shows a motive repeatedly used by the artist; B was drawn when the artists suffered from visual hallucinations (from: Sahlas, 2003, p. 891).

The progressive dementia with Parkinsonism, visual hallucinations and severe cognitive fluctuations suggest a dementia of Levy type. The progressive cognitive decline was noticeable in the late works of the artist. His pronounced difficulties in attention and visual-spatial perception are part of the phenomenon Lewy Body Dementia, whereas memory decay is prevalent in Alzheimer disease. An increasing abstraction up to the point of cartoon-like structures took place in his graphic expression. Similar features were perceivable in the artists Willem de Kooning and William Untermohlen (see Section 3.7.2.1), who could both, in the course of dementia of the Alzheimer type, only produce distinctly abstract works. According to Sahlas (2003), this is a result of deterioration of visual-spatial functions, and probably based on the involvement of posterior isocortical association areas. Peake differed from artists who probably suffered from Alzheimer disease by the recurrence of bright moments, still preserved for a long time, in which he completed drawings.

### **3.7.2.3 Vascular Dementia and artistic expression**

Annoni, Devuyst, Carota, Bruggimann and Bogousslavsky (2005) reported on two case studies. They described significant changes in the artistic style of two artists, mainly as consequences of an ischemic infarct (stroke caused by vascular occlusion) of small extent in the left occipital lobe or the thalamus. The specific influence of focal and limited brain lesions due to executive and affective changes in the artistic style have rarely been studied yet. The induced artistic changes were analysed based on extensive neurological, neuropsychological and psychiatric evaluations. The change in their artistic expression remained initially unnoticed for both patients. They showed mild forms of executive dysfunction, but no general cognitive decline.

Patient I displayed minor visual perceptual difficulties (dyschromatopsia and scotoma in the right upper visual field) due to a suffered infarction in the occipital areas corresponding to the areas VI and V2. In addition, the patient showed increased anxiety and difficulties in emotional control. His artistic style changed towards a more stylized and more symbolic art. In contrast to previous works, a general simplification of forms, a monochromatic choice of color and the use of a background independent from the foreground. Moreover, he incorporated lighting effects in his works triggered by the scotoma.

According to Annoni et al. (2005), the works of the second patient were referred to as 'figurative-impressionistic' before his stroke. After a small left lateral damage in the thalamus, this patient also displayed a slight reduction of emotional control and a change in artistic expression. Patient II, ambidextrous, painted shortly after a stroke with the left hand and subsequently alternately with both hands, a method that he had never previously applied. From his impressionistic mode of painting his style changed to a more realistic form of representation, faithful to detail, the intensity of the colors increased and the organization of the image construction became more structured and geometric. According to the authors, the artist associated his change of style with the use of the left hand. According to the artist, objects completed with the left hand demonstrated a stronger emotional expressiveness and a stronger coloring. Conversely, paintings completed with the right hand would have clearer lines, sharper contours and a clearer perspective. The artist noticed an increased creativity by using his left hand.

The observations by Annoni et al. (2005) are also interesting regarding questions on the hemispheric specialization, a subject further discussed below in connection with creativity (see Section 4.5.2). The use of the left hand probably evokes a stronger connection to the right hemisphere, which in turn is associated with the processing of non-verbal, spatial content and greater involvement in terms of emotional perception. Moreover, increased creativity is associated with a stronger involvement of the right hemisphere.

Annoni et al. (2005) concluded from the results that minor cognitive and affective changes caused by focal posterior brain injury might have a significant impact on the artistic expressiveness. Since both patients did not perceive in themselves any changes at the beginning, it had to be assumed that these changes did not occur because of a personal decision, but were of a neuronal nature. Moreover, in both painters only a change in terms of their creative work was noted and had affected neither other activities nor habits.

Since posterior regions apparently play a particular role in creative thinking (Mölle et al., 1996), it was, to the mind of the authors, not surprising that a minor brain damage in these regions would change artistically creative thoughts and thereby artistic style. The authors concluded that the minor executive dysfunctions, as well as the mild emotional loss of control of both painters, might be at least partly responsible for of the changes in style.

#### **3.7.2.4 Frontotemporal Dementia and artistic creation**

According to Miller and Miller (2013) “frontotemporal dementia<sup>30</sup> is a collection of heterogeneous conditions that have focal onset of disease predominantly in the frontal and temporal lobe, hence the name” (p.100).

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<sup>30</sup> Frontotemporal dementia was described by Arnold Pick around 1900 and therefore also called Pick disease. The disease is characterized by a locally accentuated atrophy of the frontal or temporal lobe which are, among others, a cause for the dementia. They may also result in changes of personality and disturbances of social relations. There is a loss of the ability to work professionally. Norms are no longer respected which may lead to difficulties in the social realm and to criminal actions. A heightened sexual drive and inhibition can also be observed. Patients are not able to acknowledge their disease. The onset of the disease is usually between the 50th and 60th life decade. The onset of the symptoms and the progress of the disease are slow. Sensual functions, memory and special-constructive abilities are hardly affected. Among others, the following three groups of disease are allocated to the pick-complex (approximately 20% of all dementia): the frontotemporal dementia, the primarily progressive aphasia and the semantic dementia. In frontotemporal dementia, the atrophy is predominantly pronounced in the medial, dorsolateral, and orbital frontal lobe. In the primary progredient aphasia, an asymmetric, left frontolateral lobe atrophy is present and the semantic dementia is caused by a left temporal lobe atrophy (see Brun et al., 1994; Navy et al., 1998).



Viskontas and Miller, 2007, as cited in Miller & Miller, 2013) postulate,

“Commensurate with the focal pattern of anatomical disease, patients with frontotemporal dementia develop focal cognitive and behavioral deficits, with sparing of functions in unaffected brain regions” (p.100).

As mentioned before, a neurological change does not necessarily result in a deterioration of artistic expression. Miller et al. (1998) described the clinical, neuropsychological and sculptural characteristics of five patients with frontotemporal dementia who developed artistic abilities in the course of this illness. In frontotemporal dementia, an atrophy of the dorsolateral and orbital frontal lobe is prevalent. Four of these patients displayed the variant of frontotemporal dementia with the anterior temporal lobes involved and the dorsolateral frontal cortex unaffected.

Visual abilities were preserved, whereas lingual and social abilities were severely impaired. The loss of the function of the anterior frontal temporal lobe apparently resulted in an increase of artistic abilities.

After years of intensive creative activity, some of the patients gave painting up again; however, this was not surprising in the face of the progressive process of the disease. The creativity of the patients demonstrated visual but never verbal forms. The paintings, photographs, and sculptures were realistic representations, partly painted out of memory with abstract and symbolic components missing yet. In spite of progressive cognitive and social impairments, the patients showed an increased interest in tiny details of faces, objects, forms and shades of colors. All patients dedicated themselves to their creative work with enormous intensity. Planning, organization, and motivation are influenced by the dorsolateral and medial part of the frontal lobe – areas, which remain unaffected in the temporal variant of frontotemporal dementia. Moreover, most of the patients mainly displayed a dysfunction of the dominant hemisphere. Dysfunctions of the dominant hemisphere may leave drawing skills comparatively unaffected (Kaczmarek, 1991), whereas dysfunctions of the non-dominant hemisphere may also destroy artistic abilities in formerly talented artists (Alajouanine, 1948).

Kapur (1996) coined the term “paradoxical functional facilitation” for the phenomenon of unexpected improvements in the behavior after brain injury, thereby highlighting the two major neural mechanisms, inhibition and compensatory plasticity. Talent, on the one hand, as in art, may be accompanied by dysfunctions in other areas, such as social skills. Miller et al. (1998) concluded that the loss of social skills and inhibitions might have facilitated the artistic output of the patients. The authors postulated that the selective degeneration of the anterior temporal and orbital frontal cortex might have evoked a reduced inhibition of visual systems located further behind and, as a result, an increased artistic ability and interest. The breaking of social conventions, which occurs to a major extent in artists (and by reduced inhibition in the patients), may lead to a more inhibited, creative output.

Similar observations were made previously by Miller et al. (1996) based on three patients who became recognized painters after the onset of frontotemporal dementia. All three patients with the temporal variant of frontotemporal dementia showed artistic improvement during the early and middle stages of the disorder. One of the three patients, who had been a successful businessperson before, was part of the study described above (Miller et al., 1998). At the age of 68, he had been ill for a period of 12 years.

At the age of 56, he began to describe, ‘open’ and ‘closed’ periods of time. In the ‘closed’ state, he appeared agitated and dysphoric; lights and sounds were perceived as extremely intense and painful. In the ‘open’ state, lights and sounds resulted in euphoria, and subsequently to increased creativity. In the following decade, he painted visualized images of the ‘open’ and ‘closed’ states. At 58, he became verbally repetitive, anomic and uninhibited. He changed his clothes in public places and insulted strangers. His increased sensitivity to light remained; moreover, he displayed an increased visual awareness of his environment.

Without any prior interest in art, he began to paint at the age of 56, over time with increased precision and observation of detail. Between 63 and 66, he succeeded in winning some art awards of local art exhibitions. While his creative activity continuously developed in the beginning, a deterioration became manifest at the age of 67. At 68, he drew bizarre puppet-like figures. At this point of time, he was absent

and irritable, but displayed only small facial emotion. His interest in his surroundings increased and he extensively commented on colors and shades.

The mini-mental-state Test<sup>31</sup> resulted in a value of 15 out of 30. A magnetic resonance tomography revealed a bitemporal atrophy. The PET to measure regional blood flow showed a bilateral hypoperfusion, right worse than left, while the frontal perfusion was normal. The highest perfusion was manifested in the right posterior parietal and occipital cortex. Miller et al. (1996) concluded from the results that brain lesions limited to the anterior temporal lobe could be associated with increased artistic output. Therefore, the loss of the functions of the anterior temporal lobes, which are associated with the inhibition of the posterior visual cortex, could have resulted in intense, unfiltered visual experience, including visual memories.

The increased visual experience might have served, in turn, as a motivation for painting. The unimpaired functions of the frontal and parietal lobe, however, may have enabled the planning and performance of the works.

In an extended recent study by Miller et al. (2000), data from multiple investigations of 69 patients diagnosed with frontotemporal dementia were included. Twelve of these patients displayed new or preserved musical and visual skills.

Despite diverse forms of talents, the patients had several features in common. The manifested talents were of musical or visual, but never of a verbal nature. Symbolic and abstract components were missing. The painters of the test group copied or remembered realistic landscapes, animals and persons or perfected visual design.

The processes indicated a retrieval of previously learned information or images. As a result, this information was manipulated because the mediation of language was missing. The patients pursued their work with sometimes considerable obsession and frequent replication, which, in turn, became an important factor in developing the quality of their products.

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<sup>31</sup> The mini- mental-state-test according to Folstein serves as an orienting psychometric test method for diagnostic verification and clarification of psychic performance disturbances and subsequently, for the observation of their course. This test is often applied for a first determination of possible dementia in a person.

While in the case of frontotemporal dementia anterior frontal and temporal degenerations or both occur selectively, in the early stages of Alzheimer disease, entorhinal and posterior parietal and temporal areas are affected.

Because of the reduced function of posterior parietal and temporal regions, areas contributing to visual constructive, linguistic and musical skills, artistic and musical abilities rapidly disappear in patients with Alzheimer.

Patients with frontotemporal dementia preserve, however, visual-constructive abilities, since posterior parietal regions have remained unaffected. However, even in the case of frontotemporal dementia, reduced creativity occurs. The authors concluded that individuals who developed new creative skills or retained former ones displayed a specific form of this disorder.

However, it remains unclear to what extent one can speak of creativity considering the fact that the manipulation of the content appears limited. In most cases, one speaks of copying or painting from memory in the absence of abstraction and symbolism. Also striking is the obsession with which each of a specific activity was pursued. In general, these patients frequently demonstrated compulsive behavior, to which a part of their performances could be traced back.

In the retrospective study (Miller et al., 2000), eight of the patients with musical or visual abilities exhibited the temporal variant of dementia, another three a predominant temporal involvement, though including an affection of the frontal lobe.

In patients without such specific skills or in those no longer practicing their skills, a vast frontal and temporal hypoperfusion was observed. Thus, in contrast to the rest of the patients with a diagnosed frontotemporal dementia, the unifying feature of patients with newly acquired or maintained skills was an involvement of the temporal lobe with relative integrity of the frontal lobe.

The functional efficiency of the working memory and episodic memory is another characteristic of the temporal variant of frontotemporal dementia, which was probably helpful in the visual and musical performances. The organization of a piece of music or a painting requires the working memory, while the retrieval of previous musical or

visual patterns demands the function of the episodic memory. In contrast, the semantic memory, requiring the integrity of the left anterior temporal lobe, was affected.

Most patients in the group with distinctive visual or musical abilities showed an asymmetric left hemispheric degeneration. These findings are consistent with studies suggesting that a lesion of the left hemisphere does not necessarily mean a decimation of musical abilities (Sergent, 1993).

Right hemispherical injuries, in turn, destroy the capacity to copy or to paint, even in previously experienced artists (Schnider, Regard, Benson & Landis, 1993). While cells of the inferior temporal lobe respond to specific visual stimulus properties such as shape, the role of the anterior temporal cortex in the processing of visual and musical information remains unknown. As suggested by Miller et al. (2000), increased artistic abilities in patients with anterior temporal and orbitofrontal degeneration let assume that these regions inhibit dorsolateral frontal and posterior temporal and parietal regions involved in visual and musical processes.

Hereby, the authors postulated, that

„the selective degeneration of left anterior temporal cortex led to decreased inhibition of the more right-sided and posteriorly located visual and musical systems, and dorsolateral frontal regions involved with working memory, thereby enhancing artistic interest and productivity“ (Miller et al. 2000, p. 462).

Moreover, possibly innate brain asymmetries might have led to a predisposition to already existing or developing talents.

While the patients introduced by Miller et al. (1996, 1998, 2000), mostly suffering from semantic dementia (see Footnote 30, p.104) as a subtype of frontotemporal dementia, evidenced no or only slight interest in art before the manifestation of the disease – that is, showed little or no artistic activities until then, did Mell, Howard and Miller (2003) describe the case of a practicing, talented 87-year-old artist, who developed progressive aphasia (see Footnote 30, p.104) in the course of frontotemporal dementia.

With the progressive course of the disease, there occurred a regression of language and executive abilities; her paintings, however, seemed to be less controlled and

more original. According to the authors, the investigation of artistic development in the course of frontotemporal dementia gave therefore reason to assume that language skills would not only be unnecessary, but in certain cases of visual creativity rather inhibitive.

Of course, in the case of a previously artistically active person the question arises, whether changes in art represented a logical and natural artistic development or had arisen secondary, in the course of frontotemporal dementia. The right-handed 59-year-old artist described in the case study produced some of her best works in a period of about two years, during which she had already difficulties with written and spoken language. An MRI revealed a moderate bifrontal atrophy, slightly more pronounced on the left side, as well as a mild left temporal atrophy. In the course of the disease, however, the artistic output deteriorated distinctly. Figures she painted were distorted and less realistic. Overall, the work of this talented artist depicted a remarkable development over a period of 15 years of progressive aphasic syndrome (Mell et al., 2003, p. 1708).

"As language declined, paintings became wilder and freer", did the authors describe the change. They continued: "Release from the constraints of formal workout became clear, and her pieces were no longer realistic, reflecting an intensely emotional and impressionistic style, with less detail" (p. 1709).

The non-dominant posterior, right parietal and temporal cortices - areas usually spared in the case of frontotemporal dementia - appear to be of critical importance to the ability to accurately copy or draw mental images. According to Mell et al. (2003), a detachment of these brain areas from language dominant patterns of thought, organized by the dominant frontal and anterior temporal regions, seems to play a prominent role in the artistic achievements in the course of frontotemporal dementia. The release of the functions of the frontal lobes, associated with social restriction and awareness of rules, may also have been involved in the development of these late paintings. Similar linguistic and social deficits and artistic creativity were observed in autistic artists.

The hitherto presented cases of increased artistic activity demonstrated mostly heightened involvement of the left anterior temporal lobe. Mendez and Perryman

(2003), on the other hand, have documented three artists with a predominant involvement of the right temporal lobe. The neurodegenerative disorder resulted in a reduced empathy and furthermore, in a noticeable modification of the way people were represented. The drawings of faces were partly distorted, seemed threatening, strange or resembled a skeleton (see Figure 20). It was less the artistic skills as such which appeared to be affected, as the drawings of objects and animals appeared unchanged, but rather the representations of human aspects. The patients showed a flattened affect, no insight into their disease, nor did they notice any changes in their artistic output. Their ability to cope with visual-spatial tasks remained unaffected, nor did any problems in the processing of faces occur. A fourth female artist suffered from a frontotemporal lobe atrophy and a bifrontal and bitemporal hypoperfusion without, however, revealing any changes in her artistic creation.

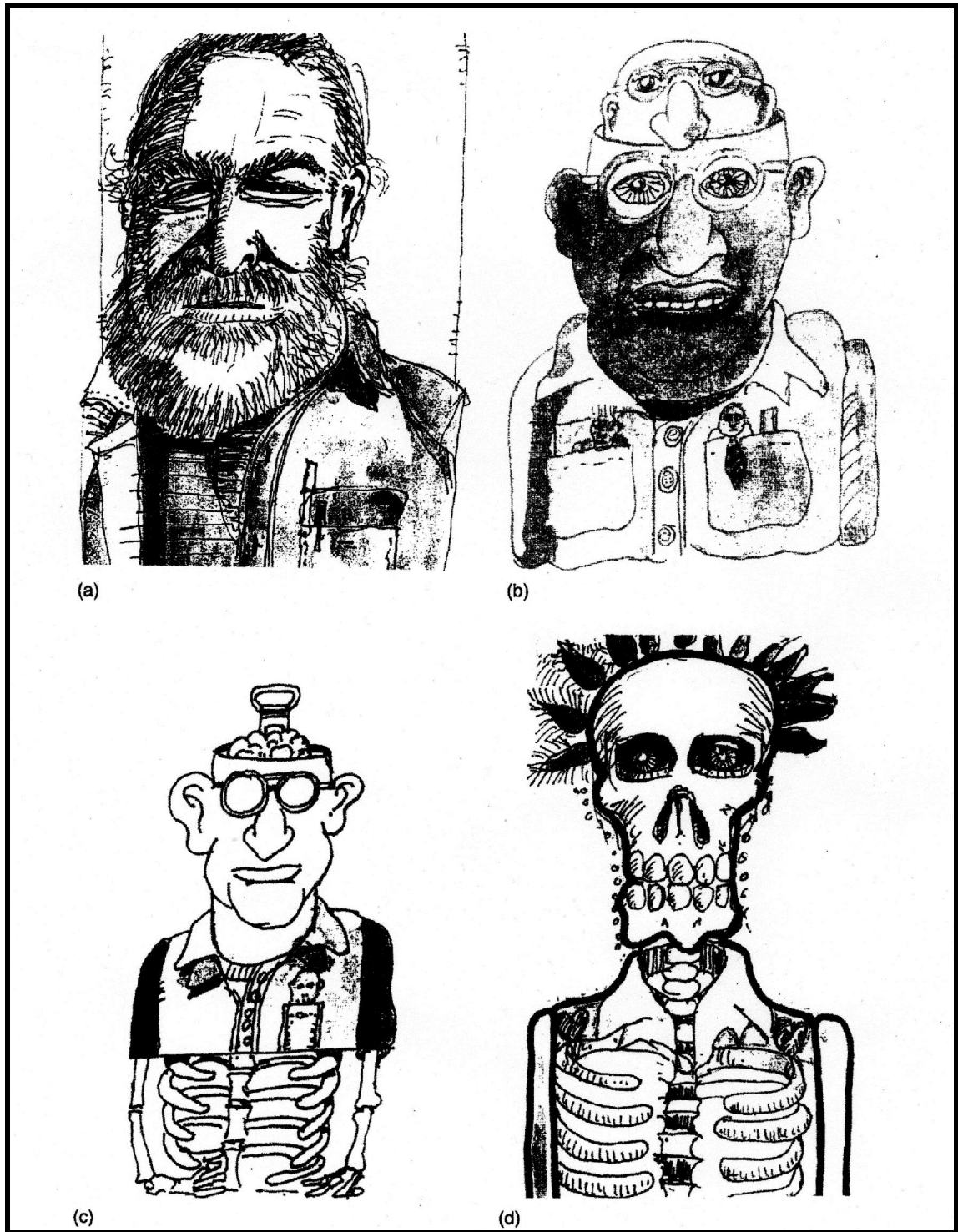


Figure 20: Caricatures of a patient with frontotemporal dementia. Figure A was completed many years before the onset of the disease. Picture B and C were drawn within the first two years of dementia, and picture D at least three years after the onset of the disease (from: Mendez & Perryman, 2003, p. 46).

In contrast to the observed enhancement of the artistic work in some patients with a more prominent left-sided temporal variant of frontotemporal dementia (e.g. Miller et



al., 1998), changes in the drawing of faces seem to be connected with a pronounced involvement of the right temporal lobe.

To the three artists with changed artistic output, both family members and outsiders ascribed a loss of empathy and awareness for the emotions of others.

Although the patients were able to interpret the facial expression of emotions correctly, they were apparently not able to react to them empathically. As their disease progressed, three of the patients drew human beings in an increasingly distorted way.

Mendez and Perryman (2003) concluded, the underlying mechanisms "may be a decreased appreciation of emotional empathy from faces, possibly from greater right temporal involvement" (p. 49).

In addition, Small-Fisman, Black & Lang (2003) described changes in a professional artist. His artistic work reflected characteristics of his cognitive profile, such as disinhibition, apathy, perseveration and left hemi-neglect. A decline in intellectual abilities was recorded, with the performance IQ being stronger affected than the verbal IQ. Significant deficits manifested themselves on the level of attention, initiation, and memory. MRI and SPECT revealed a generalized atrophy, with predominant involvement of the right hemisphere from the cortex to the brainstem and a strong hypoperfusion of the complete right hemisphere and left frontal regions. Corticobasal degeneration was assumed; the pathological findings of the deceased patient revealed however a frontotemporal dementia (Kleiner-Fisman, 2005).

Simultaneously to a decrease of spatial orientation, changes in personality, such as increased irritability, loss of previous interests and a lack of insight into his disease, significant changes in the work of the then 68-year-old artist became apparent.

The premorbid works of the illustrator and portrait painter were realistic representations in reserved tones and delicate shadings (see Figure 21). The change in the style manifested itself in thicker layers of color, a stronger coloration and in a far higher degree of stylization. The more abundant application of the colors was mainly found on the right side of the canvas.

According to the authors, the artist reported dissatisfaction with his work. He undertook repeated changes to improve the distortions he now perceived. For example, he began to make changes in the portrait finished a year ago, paying particular attention to the right-hand side (see Figure 21). Despite repeated modifications, the artist remained dissatisfied with his performance. He had neither been able to articulate the imperfections nor to correct them. In his premorbid state, the artist had never exhibited such an attitude towards his work.

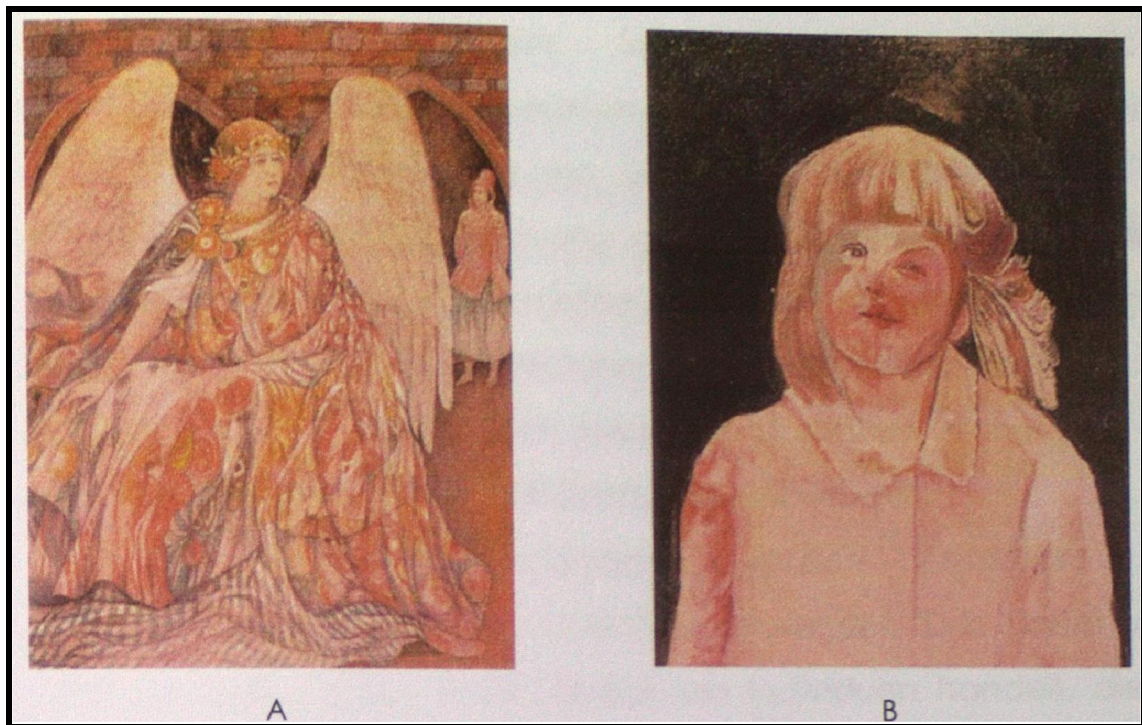


Figure 21: Works by an artist with prefrontal dementia. Painting A shows a work from his premorbid period of work, completed in 1993, with a delicate shading and elaboration. Painting B represents a portrait that was revised one year after its original completion, with increasing distortion of the right side, 1998 (from: Kleiner-Fisman et al., 2003, p. 296).

In contrast to the previous case studies describing the occurrence of frontotemporal dementia associated with artistic creation, the patient in the study by Kleiner-Fisman et al. (2003) displayed right hemispheric a selective involvement of dorsolateral frontal and parietal regions, which play a significant role regarding artistic skills. The authors pointed out that the works of the artist, after manifestation of the disease, reflected both new functional capabilities, the adaptation of perceived distortions by the application of stronger colors and duct, as well as the loss of functions, expressed by the hemi neglect. The later works, after the onset of the degenerative disorder, "reflected a different perceptual approach to interpreting his subject matter" (p. 298).

Two years after the onset of the disease and in the wake of the loss of interest and initiative, the artist discontinued any attempts to be furthermore artistically active. This may, according to the authors, have been associated with the context of the outstanding compromising of the right hemisphere and thus cross with a deep impact on motivation, self-perception, spatial attention and visual constructive capabilities.

At the same time, the orbitofrontal damage might have been a reason for the blunting of his personality and the disinhibition, possibly due to a disruption of the affective limbic inputs. Moreover, the authors emphasized that the increasing abstraction in the work of the artist was accompanied by a growing frustration of the same and reflected, by no means, an expression of a deliberate stylistic intention.

Expressions such as art creators, artists and the like are used to constant discomfort. The discomfort is mainly present when it comes to individuals who have made up to that time little or no effort in this direction. Nevertheless, all these individuals proved to be actively creative out of their initiative. Whether their work may now be considered as art or as degenerative processes, the disorder seems to affect their work massively or, though indirectly, to provide the impetus to do so.

Furthermore, the question may be posed, as alluded above, whether one should continue to speak of art, if formerly recognized artists such as de Kooning obtained a new style in the course of the decrease in their cognitive capabilities or rather of changes in their artistic skills.

In the case of de Kooning, diagnostic uncertainty remains since the neuronal substrate is unknown. If however, the frontal lobes are almost unaffected, as it is the case for example in the temporal variant of a frontotemporal dementia, is it then more justified to speak of art, because one may assume that the planning and remembrance of the works is hardly

Furthermore, the creative factor seems mostly to be missing or significantly reduced. The artists often copy or paint from memory. Depending on the type of the dysfunction, symbolic or abstract elements are missing (in some cases of a frontotemporal dementia) or realistic representations are no longer possible, resulting in an ever-increasing abstraction (for lesions in posterior regions, such as in Alzheimer disease).

Are we then allowed to speak of artistic intention, if the options are limited to such an extent from the beginning? It is not the prominent goal of this research to discuss these issues. Neurodegenerative processes in the course of dementia appear to allow, however, looking at the nature of artistic and creative processes. An interpretation of changes in the style of a creative artist with psychiatric or neurological abnormalities, such as in the case of de Kooning, can, however, not be approached without obtaining and considering more detailed information on the kind of the impairments.

It is, however unknown, under what conditions patients with frontotemporal dementia develop artistic abilities. In some cases, an asymmetric left hemispheric degeneration appears to lead to the release of untapped cognitive skills, in the sense of a "paradoxical functional facilitation" (Kapur, 1996). The obsessive-compulsive symptoms that occur partly as a side effect of such a dementia may likewise play a role. Thus, the release of creativity and originality is an unexpected and not yet sufficiently investigated feature of dementia. However, one should not forget that not necessarily every individual with a dementing disorder develops great creative power. Some of the patients in the study by Miller et al. (2000) were highly intelligent before the appearance of symptoms, so that talents may only occur in selected individuals. However, dementia does not necessarily mean the end of creativity, but may unexpectedly open up doors to interesting and new opportunities in the artistic development (Mell et al., 2003). As Miller et al. (2000) proposed it would however always make sense to promote visual and musical skills in the context of anterior left temporal injuries or dysfunctions.

## **Chapter 4**

### **CREATIVITY**

#### **4.1 Introduction**

The following discussion focuses on the biological and neuropsychological aspects of creative processes; that is on human creative processes and their associated correlations. As introduction, the most important approaches to creativity research will be discussed. For a deeper analysis, refer to the significant articles of well-known scientists in Sternberg (1999).

#### **4.2 Approaches to creativity research**

Creativity research originated in J. P. Guilford's lecture on "Creativity" at the American Psychological Association in 1950. Originating from the USA and induced by the "Sputnik shock" in 1957, when the then Soviet Union shot the first earth satellite into space, the topic has received constant attention. Its primary focus has been the social relevance of creativity and problem solution. However, Sternberg and Lubart (1999) noted that in the time from 1975 until 1994 only 0,5 % of the listed articles in Psychological Abstracts had creativity as subject. Guilford (1970) explored the period from 1928 until 1967. He noted that, except for a short increase around the year 1940 (by less than 0,3 %), only 0,1 % of the listed books and articles in the Psychological Abstracts dealt with creativity, even in the year 1955, "after which things began to happen" (p. 155). A change happened at first around the year 1960. At this time, a sharp increase (by around 0,4 %) could be observed. In 1965, the increase was by 0,7 %, and in 1969 already by 1,4 %.

Up to the present day, the approaches to creativity research vary immensely. Sternberg and Lubart (1999) exemplarily demonstrated the mystical, the psychoanalytic, the pragmatic, the psychometric, the cognitive and the social-personality approaches and added as "seventh the approach of confluence theories." For an explanation and description of the different research methods see Table 3.

The social-personality approach focuses on personality factors, motivational factors and the socio-cultural background as sources of creativity but ignores the underlying mental processes. Part of this approach is also the idea that creative individuals are

characterised by certain personality traits. Sternberg and Lubart (1999) assume furthermore that the still existing adherence to the mystical approach and the view of creativity as a spiritual process would be counterproductive to the scientific approach. In the same way, the authors consider the pragmatic approach as a hindrance in which they criticize the mostly missing empirical testing of the validity of ideas and the lack of a qualified theoretical background. The commercial aspect would come too much into the foreground. Likewise, they unfavorably mention the individual case studies of eminent creative personalities, mostly inherent in psychodynamic approaches and other earlier studies, by which one can hardly obtain generalizations and thus general valid statements.

The uncontrolled situation causes a further problem. Only experiment and therefore the arbitrary manipulation of the variables allow for a conclusion of causal connections. Creativity research tried to clarify the following questions primarily: How does the cognitive process, underlying creativity, work? What are the personal characteristics of creative individuals? How does creativity develop and manifest itself throughout a lifetime? Which social environment is most strongly associated with creative performances (Simonton, 2000)?

Since the access to highly creative persons, who are rather rare within the total population, is complicated, Guilford (1950) suggested a psychometric method by testing “ordinary” probands by means of paper-and-pen-tests. The tests are based on the assumption that the essential mental functions of creative thinkers would be shared to a certain degree by the biggest part of humanity. Thus, divergent brain challenges<sup>32</sup> quickly became the predominant tool for measuring creative thinking; they made it possible to compare people on a standardised ‘creativity scale’. Although these simple, practical tests simplified the scientific procedure, they were considered as too trivial and inadequate for measuring creativity at all. To capture the statistical rareness of an answer in relation to all answers of the reference population objectively is only one of various possibilities to operationalise and measure the construct creativity. Besides, the question was raised, whether measurements within

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<sup>32</sup> In a divergent brain challenge, the test person has to find, for example, as many as possible purposes to use an everyday object like a paper clip.

the standard population would at all be apt to reveal any information about excellent and outstanding creative performances.

Furthermore, the complex phenomenon cannot sufficiently be explained by uni-disciplinary approaches since, as Guilford emphasizes, “creativity is not any one thing; it is many things and takes many forms” (1970, p. 157). In an extreme case, the consequence of the mistaken assumption of understanding creativity as only one variable would result in the danger of trying to deduce from one single experiment the individual creativity level. Policastro and Gardner (1999) suggested distinguishing between at least five various forms of creative behaviour. According to the authors, creative behaviour could manifest itself in the process of problem solution, in theory development or in the creation of a kind of permanent work within a symbolic system (e.g. ‘Guernica’ by Picasso or ‘The Third Symphony’ by Beethoven). Additionally, creative behaviour could appear in the performance of a ritualized work (e.g., the dance of Martha Graham) as well as in a performance characterized by a high uncertainty factor. (That is a performance, where it is impossible to predetermine its details because the reactions of the participants are unknown – such as in political discussions, military fighting operations).

**Table 3: Description of different approaches in creativity research (based on Mayer, 1999, p. 453).**

<b>Research approach and paradigm</b>	<b>Description</b>
<b><i>Psychometric</i></b>	
Description	Development of a test for measurement of creativity
Comparison	Comparison of individuals with high and low measured values of creativity
Reference	Definition of the relations between measured values of creativity and other measured values
<b><i>Psychological</i></b>	
Description	Description of the cognitive process underpinning creative thinking
Comparison	Comparison between cognitive processes of creative and non-creative thinking
Reference	Determining inhibiting and supporting factors of creative thinking

<b>Biographic</b>	
Description	Construction of a qualitative image of a single-case study of a creative person  Carrying out a quantitative analysis of a single-case study of a creative person
Comparison	Construction of a qualitative description of common features in individual single-case studies of creative persons  Carrying out a quantitative analysis of common features in individual single-case studies of creative persons
Reference	Identification of significant life events favouring the development of a creative person  Construction of a quantitative analysis of important life events which support the development of a creative person
<b>Biological</b>	
Description	Description of biological correlates of creative thinking
Comparison	Comparison of biological characteristics between creative and non-creative individuals
Reference	Defining the effect of biological impairments on creativity
<b>Computational</b>	
Description	Construction of computer codes simulating creative productions
Comparison	Comparison of creative thinking and computer programs
Reference	Determining how changes within a program change the creative output
<b>Contextual</b>	
Description	Description of creativity in social and cultural contexts
Comparison	Description of the understanding of creativity in different cultures
Reference	Identification of techniques that may contribute to overcoming creativity barriers within a social context  Identification of the evolution process of the design of human creativity



Another long-time discussed question is: Are the attributes (both internal and external) resulting in creative expressions within a particular domain the same as the ones evoking creative expressions within another domain? Is creativity, therefore, division-specific or a generalized attribute, as implied by psychometric creativity tests? Knowledge is an important factor in the realization of creative expressions. However, knowledge is division-specific and not easily to be transferred to other sections.

At the same time, however, creative individuals display augmented particular personality and motivational characteristics of general importance. One may find relevant indications for both views. However, it may be assumed that creativity has both specific and general components. For further insight into this subject, refer to Sternberg, Grigorenko and Singer (2004).

A question often arises that will only be briefly outlined here: Does a correlation between creativity and personality characteristics exist (see Section 4.4.3)? Creative people are often attributed various particular personality characteristics. Among other, parallels are drawn to pathological behaviour patterns (Eysenck, 1995). Eysenck postulated as described below (see Section 4.4.3), a direct correlation between his P-scale and creativity (Eysenck, 1995). Schizotypy (see Section 4.4.3) is, *inter alia*, associated with magical thinking and extraordinary perception experiences, but also with increased scores in correlation to creativity and right hemispheric activity (Fisher et al., 2004). This observation may raise the question whether creativity, in association with certain emotional, cognitive and personality characteristics may also cause a predisposition to psychical disorders.

However, it is far more likely, that creativity as an expression of a personality dimension, which means as a characteristic (possibly as a predisposition to mental disorders as shown by the P-Scala of Eysenck), will only under certain personality characteristics (as those above-listed) evoke creative performance.

Feist (1999) offers a review about the correlations between personality and creativity in arts and sciences. According to the author, artists exhibit in comparison to non-artists more often particular personality traits. The following may serve as an example: open-mindedness to new experiences, phantasy and imagination,

impulsivity and a relative low level of diligence, comparatively higher levels of anxiety, introversion, affective disorders, emotional sensitivity, nonconformity, autonomy, independence and irregularity, ambition, an urge to work, hostility, social incompatibility and social withdrawal.

The investigation encompassed 113 artists and 181 scientists born between 1850 and 1900 (among them only two females) of the German language area.

4,8 % of the artists and 4 % of the scientists were affected by functional psychoses. Schizophrenic disorders were found only in artists (2,8 %) and manic-depressive disorders only in scientists. The danger of schizophrenia is, according to the author, three times higher for artists than for the normal population, whereas the danger of manic-depressive psychosis is ten times higher for scientists. 63, 7% of the artists and 75, 7% of the scientists showed completely inconspicuous findings.

Juda (1953) concluded therefore “a psychic abnormality is not a premise for the mentioned exceptional performances” (p. 77). However, a “positive relation between psychic anomalies and greater talent [...] might be feasible, at least to a certain degree” (p. 80).

Post (1994) determined the lifetime prevalence for several psychopathologies of extraordinarily creative individuals retrospectively. He included in his study the biographies of 291 male scientists, among them composers, visual artists, writers, thinkers and politicians. (Females were excluded because of a lack of suitable biographies).

If appropriate, the collected data were transformed into diagnoses by DSM-III-R criteria. Post (1994) concluded that most investigated individuals showed extraordinary but not pathological personality traits and slightly neurotic anomalies would likely show up more often than in the normal population. An increased number of severe personality anomalies was only notable in visual artists and writers. According to the author, functional psychoses were even less frequently present (1, 7 %) than could be assumed by epidemiological studies. In addition, these were limited to affective variants and schizophrenic disorders were not presented at all in this sample.

According to Post (1994), creative performance, persistence, diligence and accuracy was common in all cases. Post concluded from his research results “certain pathological personality characteristics, as well as tendencies towards depression and alcoholism, are causally linked to some kinds of valuable creativity“(p. 22). However, it remains questionable whether one may speak of any causal correlations.

#### **4.3 Definition of creative performance**

Creativity, like a latent personality characteristic, can only be defined by creative achievements. Eysenck (1995) distinguishes “creativity as trait and as achievement”. He considers it a paradox that “creativity as a psychological trait is apparent in all people, to varying degrees, while creativity in the sense of great achievement seems confined to singularly few” (p. 36). In order to avoid the use of creativity in several meanings, he suggested using the term ‘originality’ instead of ‘creativity as a trait’.

Thus, the question arises of which criteria a creative achievement consists and what factors promote or inhibit creative performances.

Creativity is commonly defined as “ability to act extraordinarily (originally) but appropriately” (Zimbardo, 1999, p. 574) and is both of individual and social significance. For further definitions of creativity, see Pimmer (1995). Therefore, a performance can only be classified as creative if it is original (or infrequent) and at the same time adequate for solving a problem.  $K = O \times A$  ( $K$  = creativity;  $O$  = originality;  $A$  = adequacy). If one of both multipliers equals zero, it is not a creative performance.

The majority of studies for determining creativity bases on this assumption and measures the individual at a correlating norm population. Judging by the appropriateness of the act, activities are distinguished as creative, senseless or even psychotic. However, the verdict always underlies a value judgement based on the respective cultural and temporal context. The problem about creativity tests is their low, but essentially constitute reliability. (Reliability is tested by repeated measurement and only satisfactory if the results are consistent under possibly equal conditions). Subsequently, there are very broad confidence intervals that strongly decrease the significance.

Guilford saw creativity in the domain of intelligence and wrote "one of the most important aspects of intelligence is creative-thinking ability" (1970, p. 150). Within his expandable "Structure-of-Intellect Model," Guilford (1956, 1966) suggested three basic dimensions of intelligence, which together form a cube and give by their combination 120 factors. These three dimensions divide themselves in operations (cognition, memory, divergent production, convergent production, and evaluation), products (units, classes, relations, systems, transformations, implications) and contents (figural, symbolic, semantic, and behavioural). The ability of divergent thinking relevant to creativity constitutes one of the five operations and therefore may be understood as an integral part of intelligence. For the question, whether creativity is a part of intelligence and vice versa, refers to the review by Sternberg and O'Hara (1999).

The research team, led by Guilford, found four key features of creative behaviour:

- Sensitivity to problems
- Fluency of ideas
- Flexibility
- Originality

Wagner (2000) defined the following parameters as central characteristics of creativity:

- Fluctuation

correlates with Guilford's fluency of ideas and characterizes the ability to create as many ideas as possible to one topic or to link one idea to as many as possible topics. Usually, this ability is tested by word association tests.

- Flexibility

characterises the ability to switch without difficulty between different topics.

- Originality

is understood as “novelty for oneself and remaining by oneself” (Wagner, p. 50) despite possible aversive circumstances.

- Sensitivity

Guilford understands sensitivity as sensitivity to problems. Wagner (p. 53) describes sensitivity about art as the “ability to perceive, react to and express adequately the social changes, trends, fashions and currents that are in the air.”

- Complexity preference

is characterized by Wagner (p. 56) as “all conjunctions within the world”.

- Elaboration skills

describe the ability to arrive from a concept to a concrete plan.

Creativity also implies a synthesis, in the sense of associating contents that are not necessarily associated a priori. At the same time, Guilford compared simple linear (convergent) thinking with divergent thinking. Intelligence tests primarily measure convergent thinking. Tests for the measurement of creativity were deduced, inter alia, from projective methods (e.g. Rorschach-test, see Figure 22). At projective methods, the individual has to respond freely to a particular material and describe emerging associations that are judged neither as right nor wrong. From the reactions and statements, one tries to deduce the underlying motivation and personality structures.

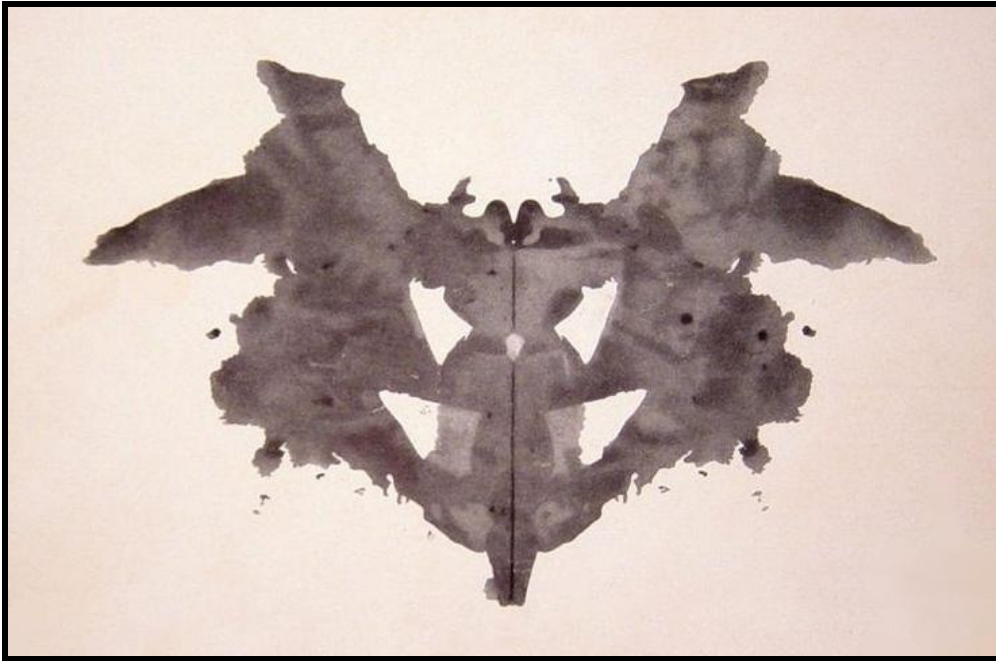


Figure 22: Rorschach symbol I

In relation to problem-solving skills, a divergent production means that as many solutions as possible should be produced. On the contrary, a convergent production requires only one right solution. Therefore, the solutions in a creativity test are not only right or wrong, but also more or less creative, measurable by the above-mentioned characteristics. In terms of quantity, it means the extent of originality (infrequency) and fluctuality, in terms of quality, the extent of flexibility and elaboration.

As aforementioned, knowledge provides an additional important aspect enabling creative performances (Weisberg, 1999) and therefore also memory and motivation (Collins & Amabile, 1999). In combination with the traits described by Wagner (2000), creative performances become possible (Wagner, 2000).

Eysenck (1995) described creative performances as a multiplicative function of cognitive, environment-related and personality variables (see Figure 23).

Cognitive Variables	Intelligence Knowledge Technical abilities Specific talent	}	
Environment-Related Variables	Political-religious factors Cultural factors Socio-Economic and Educative factors	}	Creative Performance
Personality-Related Variables	Intrinsic Motivation Confidence Non-Conformity	}	

Figure 23: Creative performance as a multiplicative function of cognitive, environment-related and personality variables (Eysenck, 1995, p. 39).

#### 4.4 Biological aspects of creativity

“Creativity is a rare trait”, wrote Martindale (1999, p. 137). He reasoned that creativity requires the simultaneous occurrence of multiple characteristics (e.g. intelligence, perseverance, unconventionality, the ability to think in a certain way). None of these characteristics would be rare for itself, but rather their co-occurrence in one person<sup>33</sup>. Therefore, one may also assume that all these characteristics have a biological basis.

Access to creativity is mostly descriptive and rarely explanatory. It remains doubtful how the underpinning processes, foremost the biological and neuropsychological aspects, are designed. However, the genetic approach, although of biological nature, shall be ignored in the following observations. Galton has early dealt with this issue in his work ‘Hereditary Genius’ (1869). Genes influence behaviour only indirectly by the gene expression. In addition to genetic factors, environmental factors are usually of great importance as well. It is hardly possible to separate the relevant factors from each other completely. Furthermore, the so-called regression to the mean<sup>34</sup> plays a role in heritable mental and physical characteristics. However, the level of activation

<sup>33</sup> For the distinction between “creativity as trait and as achievement” (Eysenck, 1995), see Section 4.3.

<sup>34</sup>Regression as a statistical expression means that the estimated standard values of the dependent variable are closer to the sample medium value than the related sample medium values of the independent variable. Illustrated by the example of the body size, this would mean that very tall or very small parents mostly beget descendants, which are slightly smaller in the first case or somewhat taller in the second instance.

seems to be of central importance in creative performance. Kris (1952 / 1977) spoke in the proper sense also of various forms of the activation level by comparing both forms of psychic energy: the primary process and the secondary process.

#### **4.4.1 Primary process related and secondary process related cognition**

Firmly committed to the psychodynamic approach, Kris (1952/1977) focused on the psychic energy and the relationship between the Ego and Id<sup>35</sup>.

This relationship of Id and Ego would also encompass the relationship between the primary and secondary process.

This distinction of forms of psychic energy, attributed to Freud, bases on the assumption that in its first form the energy is free and unconstrained and in its second form controlled by the Ego. Kris hypothesized that creative individuals switch more easily between primary and secondary process related thinking.

“The ability of easily gaining access to the material of the Id without being overwhelmed by it, of maintaining the control over the primary process, as well as probably especially the ability of going through a quick or at least adequately quick change between the levels of the psychic function, indicate psychological characteristics of particular, yet complicated form” (Kris, 1977, p. 23).

Primary process related thinking is characterized by a reduced consciousness level, as, for example, in dreams and fantasies; it works rather imaginatively and associatively and is linked to the unconsciousness, the Id, and the pleasure principle. Secondary process thinking in turn is conscious, verbal and realistic, subject to the Ego and the reality principle. Therefore, the regression to an associative primary process related state would facilitate the discovery of new combinations of mental elements. Kris attributed this phenomenon to an Ego-Regression.

“Typically we encounter the Ego-Regression – the regression of the Ego-function to a primitive stage – not only when the Ego is weakened - as when we sleep or are falling asleep, in phantasy, in an ecstasy or psychoses – but also in creative processes of various kinds” (Kris, 1977, p. 187). In contrast, creative elaboration

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<sup>35</sup> According to Freud, personality is divided into the Id, the Ego, and the Super- Ego.



requires returning to a secondary process related state. As a side note, Kris was convinced “scientific thinking never can strictly be separated from the realm of the unconscious”. He also believed “there exists an intimate relation between these higher functions of the spirit and unconscious wishes and desires including their early childhood roots” (1977, p. 168). Therefore, Kris underlined the “Id-aspect of scientific thinking” (p. 169). Besides, he assumed that the excitement, partly connected with productive thinking, was of libidinous nature. Freud believed that the pleasure principle was most likely overcome in science “that also offers intellectual pleasure within the work and promises limited practical benefit” (1911 / 1943, p. 236). Finally, Freud wrote:

“Art accomplishes in a peculiar way a reconciliation of both principles [the pleasure principle and the reality principle]. The artist is primarily an individual, who turns away from reality, because he is not able to befriend its request to renounce one’s drive for satisfaction initially, and thus, he allows his erotic and ambitious desires fulfilment in fantasy life. But due to his unique gifts, he finds his way back from this fantasy world into reality by creating his fantasies into new kinds of realities which other people approve as valuable portrayals of reality” (1911 / 1943, p. 236).

Thus, Freud described – as also postulated by Kris – the ability, inherent in artists or creative individuals like scientists, to switch with greater flexibility between primary and secondary process related processes.

Martindale and Dailey (1996) emphasized the necessity to release the theory of Kris from an excessive psychoanalytic burden and to perceive the continuum between primary process and secondary process not as a psychoanalytic construct, but as purely descriptive, as a form of conscious thinking. The authors investigated on one hand the relationship between creativity and primary process related thinking and on the other hand, the relationship between psychoticism, openness to new experiences and creativity, as well as primary process related thinking<sup>36</sup>. The subjects of the study had to construct a story whose primary process-related content was determined by a system for content analyses (Regressive Imagery Dictionary), created by Martindale.

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<sup>36</sup> Conspicuous manifestations of primary processual operations are associated with clinically conspicuous behaviour, such as with schizotypal and resident disorders that cause a loss of reality. McCrea (1987) in turn recognizes a connection between the personal characteristic of openness to new experiences and creativity.

The creative potential of the subjects was measured by various tests: a word association test, a test for measuring deductive thinking, and the assessment of the creativity level of a written story by two independent reviewers. In addition, Martindale and Dailey (1996) used personality tests. The different measurements of creativity correlated positively but not significantly, (which, in fact, casts doubt on the construct validity of such tests). The correlations between the creativity measurements, the primary process-related content and the personality tests revealed a positive and significant correlation between creativity measurement results and the primary process-related content. The more creative a test person was rated, the more primary process related contents reflected his or her narration. The correlations between the individual creativity measurement results and psychoticism were partly positive but not significant. However, significant was the positive correlation of the measurement results with extraversion (at Eysenck's Personality Questionnaire, Eysenck & Eysenck, 1975, however, not at the NEO Personality Inventory by Costa & McCrae, 1985). No correlation between the creativity measurement results and an openness to new experiences could be observed.

An exploratory factor analysis led to an extraction of two unrotated factors. Their loadings showed that the creativity measurements, the primary process-related content, psychoticism and extraversion formed a cluster by high loadings on one factor and low ones on the other. Disinhibition is instanced as a probable connecting moment of these characteristics. On behalf of the relatively low number of random sampling (N = 37), the authors themselves, suggested to interpret these results rather as indicative.

#### **4.4.2 The importance of the activation level**

Between arousal and performance exists a retrograde u-shaped relation. The relationship between arousal level, complexity factor and performance describes the Yerkes-Dodson law (1908). According to this law, the performance level decreases during difficult tasks as soon as the arousal level increases. On the contrary, the performance level increases during simple tasks when the arousal level increases. In this respect, there exists an optimal activation level for every task. Individuals differ in their habitual activation level. At the same time, there exists a correlation between

the cortical activation, measured by EEG, and the state of consciousness (see Section 1.9.1) as wave amplitude and frequency of the waves are changing. The occurrence of slow and high waves is characteristic for a low activation level, the presence of faster and smaller ones for an increasing activation level. Martindale (1999) concluded, when creative individuals showed a larger variability on the primary-secondary-process-continuum (see Section 4.4.1), they would also demonstrate this variability at the activation continuum. Martindale postulated that an average activation level is optimal for secondary process-related states while both a high and a low activation level associate with primary process-related states. According to Martindale (1999), a lower activation level would be associated with primary process-related processes and, as a result, promote more extensive associations, and thus creative performance.

Hull (1943) was able to show that at a progressive increase of the actual activation level, the behavioural variability – a prerequisite for creative performance- decreases. This phenomenon is readily comprehensible since one is hardly prepared to try out new solutions in stressful situations, but rather resorts to proven patterns of behaviour. However, it renders speed components of some tests problematic. Time pressure is not conducive to creative expression.

Mendelsohn (1976) postulated that creative individuals possess a wider attention span, thus being able to pay attention to several elements at the same time (defocused attention), which in turn facilitates combining various previously uncorrelated elements. Ansburg and Hill (2003) proved that creative thinkers used peripherally presented stimuli more efficiently than analytic thinkers did. A diffuse, defocused attention increases the probability of perceiving unexpected stimuli and thus the access to distant associations.

Defocused attention is at the same time a characteristic of primary process-related cognition. As described above, it is associated with a reduced cortical activation.

Correlations between activation level (measured, for example, by PGR – psychogalvanic reflex) and psychometric creativity performances turn out most of the time highly positive because a higher habitual activation level associates with an increased attention span. In a study on vigilance performance, in which the attention span plays inherently a central role (Gange, Green & Harkins, 1979), introverted

persons proved to have an advantage over extroverted. The result was partly attributed to the fact that introverts produce mostly more orientation reactions than extroverts do. Eysenck (1967) postulated that introverted persons in contrast to extroverted individuals are characterised by a higher cortical arousal level.

Martindale, Anderson, Moore and West (1996) pursued the hypothesis that creative individuals possessed a lower habituation level<sup>37</sup> than less creative individuals. The persistence in pursuing their goals attributed to creative persons is associated with this lower habituation level. Tests measured the creative potential of 24 subjects. Subsequently, their skin resistance was measured at the presentation of sequences of white noise of 60 dB. The more creative test persons demonstrated a significantly higher amplitude of skin resistance and a lower habituation rate. Consequently, the creative individuals reacted physiologically stronger to the stimulus. Within the group of highly creative individuals, the positive amplitude increased during the presentation sequences, whereas it decreased in the less creative group. The lower habituation rate was interpreted in the light of Sokolov's (1963) habituation theory,<sup>38</sup> according to which a longer period would be needed to form and test a neuronal model. The authors conclude that if the positive amplitude is to be understood as orientation reaction, the increase over the sequences in the highly creative group could be interpreted as a sign that in this case the attention to incoming stimuli was also maintained after the formation of a neuronal model. The authors further concluded that creative individuals are rather motivated to look for new stimuli than to avoid repetition. However, one could not assume that this was the opposite pole of a continuum. A slower habituation rate could also repeatedly be observed in schizophrenics (Akdag et. al., 2003) and introverts (Eysenck & Eysenck, 1987).

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<sup>37</sup>The habituation to an unchanging stimulus by a decrease of attention.

<sup>38</sup> According to Sokolov's theory of habituation, the reaction eliciting feature of a stimulus is stored in the form of a neural model; newly incoming stimuli are compared with the stored models of the stimulus; the extent of the deviation then determines the orientation reaction. The neural model is continuously adjusted to the stimulus.

#### 4.4.3 P-Scale of Eysenck, cognitive inhibition and schizotypy

Eysenck (1995) postulated a close relationship between creativity and psychoticism<sup>39</sup> and wrote, "Creativity is not an ability, but a cognitive style closely related with psychoticism" (1995, p. 279). Eysenck suggested in his P-E-N model, additionally to neuroticism (N) and introversion-extroversion (E), the so-called psychoticism (P) as a third fundamental personality dimension, "which is a dispositional variable or trait predisposing people to functional psychotic disorders of all types" (1995, p. 203). It must be distinguished from psychosis in the psychiatric sense, which is opposed to creative output. "It appears to be psychoticism in the absence of psychosis that is the vital element in translating the *trait*<sup>40</sup> of creativity (originality) from potential into actual achievement" (p. 236). The P-Scale of Eysenck was developed to measure psychoticism in healthy subjects, such as non-psychotic groups.

Both creativity and psychoticism were based on a cognitive style, which he called 'over-inclusiveness', correlated with a low association gradient that allowed a broad range of interpretation of relevance with regard to stimuli. The 'over-inclusiveness' could be traced back to a lack of inhibition, which in turn is characteristic of psychotics, individuals with a high P-value, creative persons and geniuses. A part of this would be, for example, the loosening of thought associated inter alia with schizophrenia, but also with creativity (inter alia relevant in word association tests and deductive brain challenges). Further characteristics of the cognitive system would cause the distinction between a psychotic patient and a genius, for example, the ability to reject too remote and inadequate answers (see Figure 23, p. 124). Thus, Eysenck (1995) interpreted creativity as a disinhibition syndrome that is associated with a weakening of the frontal cortex function (the moderator function) and at the same time a relative enhancement of subcortical activities. Consequently, arising action stimuli are not inhibited (e.g. aggressiveness, egocentric interests) whereby Eysenck postulated a positive correlation between creativity and his P-scale again.

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<sup>39</sup> Psychoticism (P) is described by the following features: delusions, hallucinations, delusion of reference, sudden mood swings, thinking and memory disorders, increased suicide impulses, lack of social contact, fundamental distrust towards the world, and others.

<sup>40</sup> See Footnote 33, p.126.

Cognitive inhibition plays a significant role in information processing. Irrelevant information is selectively excluded. One assumes that this process bases on processes facilitating balance in terms of task-relevant stimuli and the inhibition of task-irrelevant stimuli. This process of attention control correlates inter alia with the activation level. Cognitive inhibition may be measured experimentally, for example, by negative priming<sup>41</sup>.

A schizophrenic disorder causes a weakening of the inhibitory selection mechanisms and characteristic disturbances in thinking and perception, whereby the clarity of the consciousness and intellectual abilities are mostly not affected.

“In the typical schizophrenic thought disorder, secondary and unimportant aspects of an overall concept are prioritized, that play only a minor role in normal psychical activities; they are used in the place of important, situational appropriate elements” (International Classification of Psychiatric Diseases, ICD-10, p. 104).

According to Eysenck (1995), a small association gradient may result from a lack of cognitive inhibition as measured by negative priming. Eysenck recognizes an indirect evidence for his theory in some research findings (cf. Eysenck, 1995). They have shown that individuals with a high P-value are creative, had a small association gradient and low negative priming values.

“This, of course, is precisely what is characteristic of the mechanism needed to explain the overinclusiveness of schizophrenics and high- P scorers; the failure of negative priming and/or latent inhibition to limit associational spreading (flat associational gradient) would appear to account for the prominent symptoms of psychotic cognition and the major feature of creativity” (Eysenck, 1995, p. 252).

Thereby, the correlation between psychopathology and genius may be explained. As aforementioned, a low association gradient, caused by a lack of inhibition, is not in

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<sup>41</sup> Typically, negative priming is realized in an experiment by the “Stroop Colour Naming” task (colour-word-interference). A colour word (for example red) is presented in another colour (for instance written in green). If the font colour is to be named, normal subjects show a slowed reaction. If the task is defined as ignoring the word and only naming the colour of the font, and if the next word is written in red, the reaction is also slowed down. At priming, sequence elements are pre-activated. If a word is to be ignored, it gains negative attention that inhibits correlating cognitions. Thus, the irrelevant stimulus acts as a prime in terms of later recognition and importance, but in a negative sense, which partly inhibits such a reaction. Individuals with schizophrenic or schizotypal disorders (see Footnote 46, p. 138) demonstrate no retarded answer latency, what is interpreted as a sign of a reduced cognitive inhibition.

itself sufficient to produce a creative performance. Other components also play a significant role in this process (see Figure 23, p. 124).

Carson, Higgins and Peterson (2003) analysed how a high intelligence quotient in correlation with reduced latent inhibition influences creative output. A meta-analysis carried out on a young random sample with high intelligence quotients demonstrated that subjects with permanent highly creative performances displayed significantly lower latent inhibition values than subjects with comparatively little creative performances. Subjects with extraordinary creative performances in a certain field in turn showed lower latent inhibition values with a seven times higher probability than a less creative control group<sup>42</sup>.

If one assumed the existence of both quantitative and qualitative differences in the cognitive processes among individuals with highly creative performances in a particular domain and other intelligent thinkers, the relative decrease of the latent inhibition would be a potential source of these qualitative differences. This decrease in turn could increase the amount of available mental elements as a part of the process of creative discovery. Highly creative individuals apparently do not pre-categorize stimuli, in the same way, as less creative individuals do.

Since several studies have pointed out that a reduced latent inhibition is, on one hand, a predisposing factor for psychosis and, on the other hand, for creativity, the question arises what differentiates a psychotic from, for example, a poet? Carson et al. (2003) postulated in this context that some psychological phenomena "might be pathogenic in the presence of decreased intelligence, psychometrically defined, but normative or even abnormally useful in the presence of increased intelligence" (p. 500). Studies have shown that the correlation between creativity and intelligence is no longer significant from an intelligence quotient of about 120 onward (cf. as a review Sternberg & O'Hara, 1999). This threshold theory indicates that an intelligence quotient of about 120 is probably necessary but not sufficient for creative performance. - Or, to put it in another way, highly creative individuals often have a

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<sup>42</sup> The creativity was measured with the following scales. *Creative Achievement Questionnaire*, a questionnaire, developed by the authors, regarding lifelong creative performances in a certain field. (Sample question: My work has won a prize or prizes at a juried art show): a test to analyse divergent thinking (Torrance, 1968) as well as a personality questionnaire, *Creative Personality Scale* (Gough, 1979).

high intelligence, but highly intelligent individuals are not necessarily highly creative. The eminently creative participants of the study by Carson et al. (2003) had an average intelligence quotient above this threshold ( $M = 128.6$ ,  $SD = 8.3$ ). On the contrary, the control group had an intelligence quotient under this limit ( $M = 118.3$ ,  $SD = 11.9$ ). A regression analysis demonstrated that negative latent inhibition values and positive IQ values explained a third of the variance of the creative performance values. This result would in turn support the theory that both qualitative differences (for example, the lack of the ability to filter out irrelevant stimuli) and quantitative differences (for example a high intelligence quotient) underlie creative versus ordinary cognition. The interaction between latent inhibitions and the intelligence quotient was highly significant. Therefore, the intelligence quotient could be a moderating variable and overcome a 'deficit' in earlier, selective attention processes with a highly effective mechanism on a later, controlled level of selective processing. Presumably, an extremely creative individual was privileged in as much as he or she had a greater amount of unfiltered stimuli available that heightened the number of original new combinations. Therefore, Carson et al. (2003) conclude "a deficit that is generally associated with pathology may well impart a creative advantage in the presence of other cognitive strengths such as high IQ" (S. 505).

Cognitive inhibition and negative priming have by their nature a biological basis that is possibly related to dopaminergic transmitters. For example, the neurobiological reasons for the schizophrenic disorder become apparent in a hyperactive mesolimbic dopamine system and, furthermore, in a disorder of the medial temporal and prefrontal cortex regions (Birbaumer & Schmidt, 1999). Serotonin in turn often has inhibitory effects on the central nervous system and thereby possibly a reducing effect on creative performances. As a summary, see the model of a causal theory of creativity by Eysenck in Figure 24.



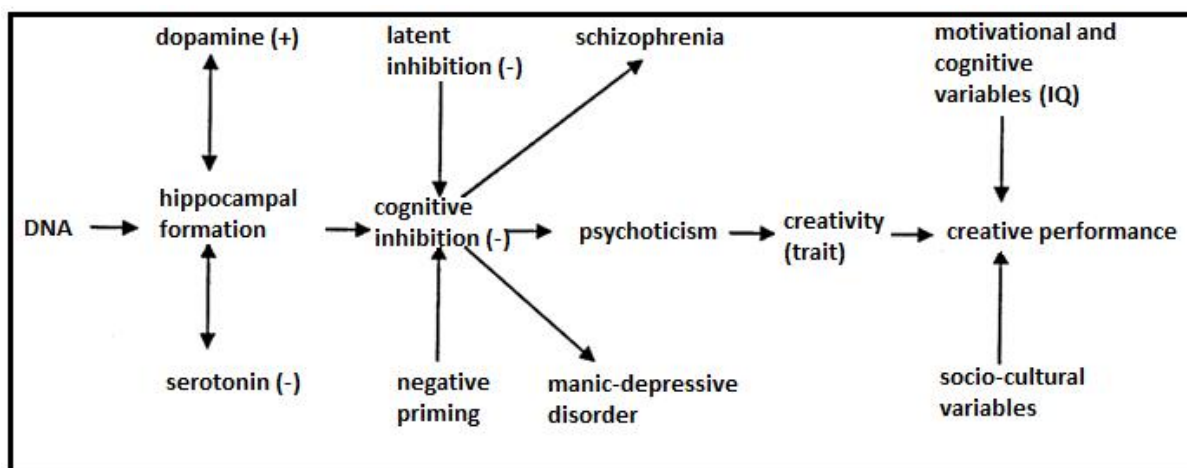


Figure 24: Eysenck's causal theory of creativity (by Eysenck, 1995, p. 280)

The research results of Merten and Fischer (1999) support Eysenck's theory of a positive correlation between psychoticism (high P-value), creativity and behaviour in the word association test. 40 writers and actors, postulated as creative, were tested in a word association test under several conditions<sup>43</sup>.

The control group consisted of 40 individuals with schizophrenic disorder and 40 subjects from a 'normal group'. In the Eysenck Personality Questionnaire EPQ (Eysenck & Eysenck, 1975), the creative individuals had an increased P-value in relation to the normal group. At the same time, their answers were more original in the free response condition than those of the normal group were. In contrast to the group of schizophrenics, the group of creative individuals produced the most original associations in the individual response condition. This result confirms the ability of creative individuals in comparison to psychotics to reject inadequate answers as postulated by Eysenck.

A study (Abraham, Windmann, Daum & Güntürkin, 2005) analysed the specific creative cognitive processes in the context of important dimensions for creative performances – such as originality and adequacy – and compared them to psychoticism. The researchers assumed that a higher level of psychoticism would

<sup>43</sup> In contrast to traditional word association tests, they collected not only free associations (free-single-word-association), but added a common response condition. The participants had to find associations, which were as conventional as possible and, in the opinion of the individuals used by a majority of people. In the individual response condition, the test persons were supposed to convey associations in response to the stimulus, which, in the opinion of the individual, nobody else would think of.

result in a higher dimension of conceptual expansion (expressed as a wider association gradient by Eysenck) but would be completely unrelated to the adequacy of the idea. The authors postulated a correlation between psychoticism and creativity based on associative thinking and broader, but weaker top-down controlled activation patterns. They expected that a higher extent of psychoticism led to a higher performance in a test measuring the conceptual expansion and to a higher degree of originality in a creative imagination task, but not necessarily to a higher degree of practicability (adequacy) within the creative imagination task<sup>44</sup>. Eighty subjects were presented with Eysenck's Personality Questionnaire in a revised form (EPQ-R; Eysenck & Eysenck, 1991). By means of a median split, the sample was divided into a group with low and a group with high P-value. The conceptual expansion was analysed by the Ward (1994) 'animal-task'<sup>45</sup>. The proband group with a higher P-value reached significantly higher values ( $p = 0.22$ ) regarding conceptual expansion than the group with lower P-values. They also displayed significantly higher values ( $p = 0.45$ ) regarding originality in the imagination task. However, no significant differences could be observed between the two groups regarding the practicability-value ( $p = .88$ ) and the total value in the creative imagination task ( $p = .297$ ). A low but significant correlation was found between the total value "conceptual expansion" and psychoticism ( $r = .285$ ,  $p = .01$ ). One may interpret this result as follows: The higher the P-value, the higher the conceptual expansion. Regarding psychoticism, the total value, and the practicability-value of the imagination task, no significant correlations were found. Likewise, regarding psychoticism and the originality scale in the imagination task, only a low but significant correlation ( $r = .234$ ,  $p = .037$ ) could be reported.

To that extent, the original assumptions could be verified, but its effects were not too robust. Similar to Eysenck's idea, individuals with a higher P-value seemed to be able to develop broader concepts due to a broader association gradient. At the same time, they were able to generate more original ideas than individuals with a lower P-value did. Abraham et al. (2005) associated this result with a more diffuse top-down

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<sup>44</sup> In the imaginative task (Finke, 1990) predefined elements had to be put together to an object that had to correspond to a predefined function.

<sup>45</sup> In the 'animal task', the test persons are asked to imagine and draw animals that live on a planet completely different from the earth. The task is evaluated by the fact in how far fundamental characteristics of usual animals were applied or rather *not* (= creative).

managed control. Probably, psychoticism increases only the originality aspect of creative cognition, whereas the aspect of adequacy or functionality remains unaffected. However, as mentioned above, a high originality degree is not to be equated with a high creativity degree. The solution of the imagination task seems rather be associated with processes corresponding to a scientific concept of creativity, demanding both originality and functionality. The task of conceptual expansion requires less than the imagination task in terms of functionality. Therefore, it may rather comply with an artistic understanding of creativity.

Recent studies are dedicated, inter alia, to individual differences within the normal population regarding schizotypy<sup>46</sup>, a personality construct related to psychoticism, and creativity.

Green and Williams (1999) investigated the hypothesis that increased creativity of individuals with a higher level of schizotypy might be explained by reduced cognitive inhibition. They presented 72 non-clinical probands with a test battery for measuring their degree of schizotypy (Schizotypal Traits Questionnaire, STA, by Claridge & Broks, 1984) as well as measuring divergent thinking. Besides, they received a negative priming task<sup>47</sup> in order to measure their cognitive inhibition.

The researchers found a significant but rather low positive correlation between schizotypy values and the number of extraordinarily original answers to the divergent brain challenges. In contrast to the results of other studies, it was not possible to verify the association between decreased cognitive inhibition, detected by the negative priming task, and schizotypy. These findings may be related to problems with the negative priming task (for example, to recognise the connection between stimuli presented before and afterwards), or with special characteristics of schizotypal manifestations. Therefore, cognitive factors might have played a less important role than motivational ones.

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<sup>46</sup> One may understand schizotypy both as a hypothetic, not directly observable, multidimensional construct that includes an underlying personality organisation with a tendency to develop psychoses, or as a phenotypical manifestation, a specific personality organisation (see Daneluzzo, Stratta & Rossi, 2005). In the latter case, both a pathological and a 'normal' manifestation are possible. A schizotypal disorder, that means as pathological manifestation, designates "a disorder with eccentric behaviour and anomalies of thinking and mood that seem to be schizophrenic, although there never occurred any clearly characteristic schizophrenic symptoms." (ICD-10, p. 113).

<sup>47</sup> See Footnote 41, p. 133.

Likewise, in the study by O'Reilly, Dunbar and Bental (2001), a correlation of schizotypal dimensions and divergent brain challenges became only apparent when comparing a group of students from the humanistic with a group of students from the artistic field (N=100). The authors could not observe such a correlation within the group of students from the same field of study.

Subsequently, schizotypal characteristics play possibly only an important role in deciding to choose creative ways, but do not directly contribute to divergent thinking. Although Merten and Fischer (1999) were able to prove a higher P-value in creative individuals than in the normal group, they were not able to observe any direct relation between a high P-value and a high originality value within the group of creative individuals.

There exists no conclusive evidence about any correlations between creative expressions with certain personality traits or a specific cognitive style. Eysenck (1995) himself points out that his conclusions have only indirectly been verified and that further studies are required. However, I will not go into further details of this issue but rather focus on the main subject of this research paper, the neuropsychological correlations of creative performances.

#### **4.5 Neuropsychological correlates of creative performances**

Creativity as a fundamental activity of human information processing is based – as is to be assumed - on normal mental processes (see Ward, Smith & Finke, 1999). It is, therefore, a part of cognitive science and, in a closer sense, of neuroscience. The integration of today's understanding of brain functions and theories of creativity is, therefore, a necessity. Neuroscientific attempts to explain creative performance focus on hemispheric asymmetries, gender differences and the comparison between high creative and less creative individuals. These theories shall be discussed in the following section. Dietrich (2004) presented a frame theory of creativity, which includes psychological, cognitive and neuroscientific studies.

#### **4.5.1 Different forms of creative insight and the importance of prefrontal cortex functions**

Dietrich (2004) postulated four different kinds of creative insight, each attributable to different neuronal circuits. By definition, creative insight takes place in a state of consciousness. Based on the assumption that the working memory provides the content of what is accessible to the consciousness, each of the four different circuits would end there. The location of the working memory in turn associates with the prefrontal cortex.

As suggested above, an essential assumption of this frame theory is that “neural circuits, that process specific information to yield non-creative combinations of that information, are the same neural circuits that generate creative or novel combinations of that information” (Dietrich. 2004, p. 1011). The author underlined the importance of the prefrontal cortex. One should however not understand it as “the location of creativity” but as something that “contributes highly integrative computations to the conscious experience, which enables novel combination of information to be recognized as such and then appropriately applied to works of art and science” (p. 1012).

Information processing is understood as a hierarchically structured process; at its top is the prefrontal cortex, the neuronal base for higher cognitive functions (e.g., Frith & Dolan, 1996). Theories on neuronal correlates of consciousness similarly emphasize the importance of the functions of the frontal, and in a narrower sense, the prefrontal cortex for higher attributions (e.g., Crick & Koch, 1998). Two different neuronal systems extract various types of information from the environment. The emotional brain adds an assessment of the incoming information that allows the evaluation of a certain event regarding its biologic importance. A detailed characteristic analysis proceeds separately and parallel and creates the basis of cognitive processing. Both forms of information processing base on a functional hierarchy; within its structures of increasingly higher order, increasingly demanding computations take place. These two functional systems may be differentiated both by anatomical differences and probably also by their form of information processing. The processing of affective contents takes mainly place within the limbic structures, starting with the amygdala,

proceeding to the cingulate cortex until it reaches the ventromedial prefrontal cortex. Within these structures, complex feelings develop, and furthermore, complex social situations are assessed. Cognitive processing involves another part of the limbic structure, mainly the hippocampal formation and the temporal-, parietal- and occipital cortex. The selective attention that is necessary for information processing is also supported by these structures. Between these two information-processing systems, diverse connections occur repeatedly and on several levels. However, it seems that the complete integration of emotional and cognitive information occurs within the dorsolateral prefrontal cortex. This region plays a significant role in executive functions. Information, which has already been processed on a high level, is integrated. Action planning takes place here inter alia and is initiated (neuronal structures can activate the motoric system on each level of the functional hierarchy) while the primary output is the motor cortex.

The prefrontal cortex, separated by the central sulcus from the temporal-, parietal- and occipital lobes, does not receive any direct sensory input but has high integrative function. It is involved in short-term memory, time integration and the maintenance and direction of attention. The prefrontal cortex functionally separates in the ventromedial and dorsolateral cortex (e.g. Fuster, 2002). The dorsolateral prefrontal cortex is strongly linked with the regions of the temporal-, parietal- and occipital lobe whereas the ventromedial prefrontal cortex strongly ties with the amygdala and cingulate cortex. Lesion studies indicate that the ventromedial prefrontal cortex plays a significant role in the integration of values and social standards of an individual culture. The links to the limbic system may be vital in the assessment of personal consequences of one's behaviour, and the resulting feelings may provide an essential precondition for logical and rational decisions. Dietrich (2004) concluded

"given that creativity is both novel and appropriate, it would appear that the ability of the prefrontal cortex to evaluate propriety must be critical to assessing whether a particular new idea is creative as opposed to merely new" (p. 1013).

In her frame model of creativity, Dietrich (2004) suggested two different processing modes from which creative thoughts may arise: rational or deliberate, as well as spontaneous. Creativity may be the result of defocused attention (see Martindale, 1999 and Section 4.4.2). However, according to the author, the ability to pay rational,

controlled attention to adequate information has to be a precondition of creative thinking and a result of an intentional, constructive problem-solving process. Consequently, targeted aesthetic or scientific behaviour depends on the prefrontal activity. Dietrich (2004) concluded that creativity required cognitive abilities, such as “working memory, sustained attention, cognitive flexibility, and judgment of propriety) that are typically ascribed to the prefrontal cortex “(p.1014). The central role of the prefrontal cortex regarding creative thinking was also confirmed by the studies which will be subsequently described.

Dietrich (2004) postulated four basic types of creativity:

”Novelty production can occur in emotional structures or in cognitive structures, and crossing the type of information with the two modes of processing (deliberate or spontaneous) yields the four basic types” (p. 1015).

However, this was not meant to signify that a creative act presented the manifestation of one of these kinds in a pure form. These four types of creativity rather represented essential elements of information processing, and creative behaviour was ultimately the result of a combination of these basic psychological processes. After the generation of a new combination, a value assessment had to take place in the prefrontal cortex in order to form a creative idea. Thus, all four types of creativity would share a “final common pathway”, independent of the circuit, from where the generation of the novelty arose. The author saw the role of the prefrontal cortex within the creative process as tripartite. First, the prefrontal cortex was involved in allocating the working memory’s buffer in the realising process of the creative idea. Information not represented in the working memory is not consciously perceived and can therefore neither be reflected nor reported on (e.g. Gazzaniga, Ivry & Mangun, 1998). Unconscious new combinations might result in a new behaviour, because – as mentioned above– neuronal structures can activate the motoric system at each functional level. However, creatively more sophisticated behaviour was based on the prefrontal integration, by the manifestation of unconscious new thoughts in the consciousness. Secondly, the prefrontal cortex was involved in the assessment of ideas that had become conscious. It selects what ideas to reject or pursue. Thirdly, the prefrontal cortex was responsible for the

implementation of the expression of the creative insight by adjusting the action planning to inner goals.

As already described, Dietrich (2004) proceeded from two different processing modes, deliberate and spontaneous, which enabled creative insights. In general, one assumes that attention is the result of a limited capacity for information processing. Mental states, such as a defocused attention or mental absent-mindedness might simply be the unavoidable result of constant demands on the attentional system to process information selectively. In parallel to the conscious processing an unconscious processing seems to take place (e.g. Gazzaniga et al., 1998), generating permanently new information combinations, independent of the status of attention control. Proceeding from the assumption that the attentional network of the prefrontal cortex is the mechanism that selects and limits the conscious content, Dietrich postulated (2004):

“[...] that the main difference between deliberate and spontaneous modes of processing is the method used to represent the unconscious novel information in working memory. While deliberate searches for insights are instigated by circuits in the prefrontal cortex and thus tend to be structured, rational, and conforming to internalized values and belief systems, spontaneous insights occur when the attentional system does not actively select the content of consciousness, allowing unconscious thoughts that are comparatively more random, unfiltered, and bizarre to be represented in working memory” (p. 1016).

The prefrontal cortex and, in particular, the dorsolateral prefrontal cortex seem to play a decisive role in retrieving information from the long-term memory within the temporal-, parietal- and occipital cortices (see reviews by Cabeza & Nyberg, 2000; Hasegawa, Hayashi & Miyashita, 1999). Thereby, the prefrontal cortex had the function of a search engine that extracts information from the long-term memory in order to represent it temporarily in the buffer of the working memory. This information could give rise to new combinations, which would however probably be consistent with the foresight and former experiences of the respective individual; this, in turn, might have an adverse impact on the problem-solving process. Although the method of considered, deliberate processing allowed concentrating the attention on a particular problem, it limits the solution area because the possibility of creating new



associations is confined to the limited capacity of the working memory. Creativity based on spontaneous insight differed from this qualitatively because the initiation does not take place in the prefrontal ‘search engine’, subject to qualitative (due to existing mental paradigms) as well as quantitative limits (due to the confined capacity). In moments of the down-regulation of the attentional system, thoughts unlimited by social standards and filters of conventional rationality can manifest themselves within the working memory (Dietrich, 2004). In such mental states, conscious thinking would be characterized by an unsystematic drifting; furthermore, the thought sequences manifested themselves within the consciousness in a disordered way; this in turn allowed the emergence of loose associations. The assumption would be consistent with the idea that creativity might be a stochastic combinatorial process (Simonton, 2003). However, the fact that long-term memories are stored in associative networks was not to signify that these thoughts were completely irrational and random.

Consequently, according to Dietrich (2004), a deliberate or spontaneous processing mode or both together may determine the consciousness content. Both of these modes can perform computations in both cognitive and emotional structures. See a schematic diagram referring to the resulting creativity types in Figure 25.

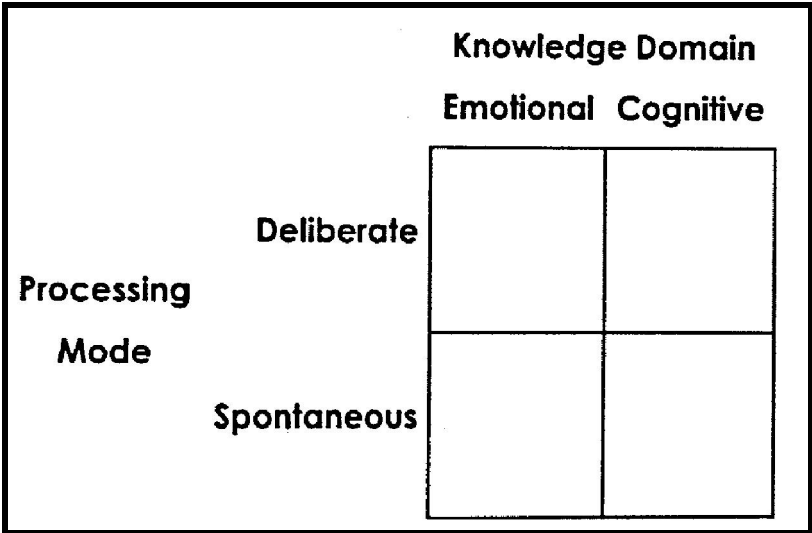


Figure 25: Illustration of the four basic types of creative insight; each managed by a different neuronal circuit. Creative insights can originate by two processing modes, deliberate or spontaneous. These modes can in turn each implement neuronal computations in structures contributing to emotional contents or implement a cognitive analysis. The crossing of the two processing modes with the information types provides the four basic types of creativity (from Dietrich, 2004, p. 1018).

Dietrich (2004) underlined that it is not to be assumed that creative insights would be of only one particular type. These four types had rather to be understood as extremes of two dimensions, 'deliberate / spontaneous' and 'cognitive / emotional'. Creative performances resulted from a mixture of these four essential components.

The association of "deliberate mode-cognitive structures" meant neuro-anatomically that the prefrontal cortex stimulated insights of this type. The frontal attentional network was involved in the search for task-relevant information within the structures of the temporal-, parietal- and occipital cortex. In turn, these activations were put at the disposal of the working memory, so that a manipulation of this information by prefrontal circuits, enabling several other higher cognitive functions, could follow. Furthermore, it one might assume that the hippocampal formation played a role in retrieving information from the memory. As a prototype of this creativity form, Dietrich (2004) instanced the methodical approach, which led to the discovery of the DNA double helix structure and the systematic approach in Thomas Edison's inventions. The quality of this type of creative insight closely associates with two factors. One precondition for this type of creativity is the availability of domain-specific knowledge. Expertise play a considerable role. However, expertise alone does not suffice to enable creative performances; therefore, the 'flexibility' of the prefrontal cortex was decisive. This factor would constitute the domain-independent characteristic of creativity.

The frontal attentional network stimulated the combination of the "deliberate mode – emotional structures". However, it would not look for relevant information within the structures of the temporal, parietal and occipital cortex, the attentional resources were rather directed to affective memory contents in emotional structures. Although the amygdala massively projects into the ventromedial prefrontal cortex, the same does not apply vice versa (Dietrich, 2004). Therefore, it was improbable that insights based on fundamental emotions could be gained deliberately or purposefully. However, neuroanatomical limits are not present in the case of insights based on complex social emotions, since the dorsolateral prefrontal cortex has abundant links with both the ventromedial prefrontal cortex and the cingulate cortex. A prototypical example of this type of creativity is the insight obtained during psychotherapy.

During associative unconscious thoughts in turn, the neuro-anatomic origins of the combination “spontaneous mode – cognitive structures” would be located in the structures of the temporal, parietal and occipital cortices. Based on the periodic down-regulation of the frontal attentional system it is possible that such thoughts became conscious on behalf of the spontaneous representation in the working memory. Since, in general, no apparent effort or intention is associated with these intuitive insights, one often describes them as mysterious. Proverbs like “light dawned on me” or similar phrases symbolize this state. The stagnation often experienced during a problem-solving process, may be solved by dealing with other things. During that time, an incubation phase occurs, whereby the solution often appears spontaneously in the consciousness. It is plausible that this incubation initiates a spontaneous processing mode. The way August Kekulé (1829 – 1896) discovered the meaning of the benzene ring may serve as an illustration. He sunk in a half dream and suddenly saw the solution to the problem in front of him, namely in the form of a snake that bites itself in the tail. This type of creative insight or the creative brainwave also depends on the expertise, because only relevant information stored in the memory can appear in the working memory during moments of defocused attention.

The link “spontaneous mode – emotional structures” is activated when the neuronal activity of structures, processing emotional information, is spontaneously represented in the working memory. Since, as already mentioned, the conscious information processing is subject to strong confinements regarding time and capacity, one assumes that neuronal structures “contend” with one another for access to the consciousness. Emotions representing significant biological events send particularly “loud” signals. In this respect, it seems hardly surprising that intense emotional experiences may evoke a strong desire for creative expression. Artistic expression is a prototype of this combination. Dietrich (2004) cited as an example Picasso’s “Guernica”. The experience of a sudden awareness of a spontaneously generated emotional information could probably evoke a radical effect. This mechanism possibly causes revelations, epiphanies and other religious experiences. “While the emotional nature of the insight certifies its importance, the unintentional nature of the insight adds to the conviction that such experiences must contain “universal truth“, writes the author (p. 1020). Since emotions did not require specific knowledge, were these

insights, based on emotional processing, not domain specific. However, the adequate implementation of these insights may require peculiar abilities.

Dietrich's frame theory can contribute to the clarification of the correlation between creativity and knowledge. According to her theory, creativity and knowledge activate different circuits. While knowledge is primarily stored within structures of the temporal, parietal- and occipital cortex, creativity is facilitated by cognitive abilities that, in turn, are mainly determined by the dorsolateral prefrontal cortex. Subtle modifications in the function of such circuits would probably be responsible for the different manifestations of cognitive abilities and talents in the standard population. An optimal creative output in a knowledge-based field would thus require extraordinarily competent circuits, both within the prefrontal cortex and within the temporal-, parietal- and occipital cortex.

A further correlation results from the above-described relation of age and creativity. The prefrontal cortex is the part that has developed or is developing the last, in both its phylogenetic and ontogenetic functions. In human beings, for example, its complete maturity takes approximately until the early twenties. At the same time, it seems that prefrontal functions are one of the first to deteriorate in later age (Dietrich, 2004). For example, the ability of adjusting to changed rules<sup>48</sup> declines after mid-life in a linear function to the age (Axelrod, Jiron & Henri, 1993). Elderly individuals, therefore, seem to be less able to inhibit taught-in rules. They are less independent regarding direct stimuli from the environment or memory contents stored in the structures of the temporal, parietal and occipital cortex than younger ones. Therefore, Dietrich (2004) states, "one would expect creative achievement to peak in mid-life at the height of prefrontal capacity" (p. 1021). Historiometric analyses prove to be consistent with this pattern (Simonton, 1999). A further, probably complicating factor resulted from the fact that mental states enabling the spontaneous processing mode - such as daydreams - are strongly decreasing with increasing age (Singer, 1975). "Thus, in addition to perseveration, the deliberate processing mode, which favors solutions that tend to be consistent with a person's belief system, becomes the more dominant problem solving mode of thought" (p. 1022), the author concluded.

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<sup>48</sup> Measured by the Wisconsin Card Sorting Test.

Dietrich provided a frame theory of creativity that associated the currently prevalent understanding regarding the functional neuroanatomical foundations of normative information processing with the results of creativity research. In summary, she postulated that creativity was the outcome of a factorial combination of four different mechanisms. According to her findings, neuronal circuits evoking the generation of new combinations can occur during two separate kinds of thoughts (deliberate and spontaneous) and two types of information (emotional and cognitive). Independent of their origin, neuronal circuits in the prefrontal cortex would be responsible both for the process of realizing and evaluating a novelty and for its implementation into creative behaviour.

#### **4.5.2 Creativity, hemispheric specialisation and gender specific differences**

It has been often postulated that creativity is primarily linked with right hemispheric activity. The left hemisphere is generally associated with sequential, verbal and analytical processing, the right one with holistic, non-verbal and parallel processing. This observation is not to signify, however that only one of each hemisphere was active. Most of the time, both hemispheres are interacting, although both can work independently from one another. For instance, the interaction is interrupted if the corpus callosum in split-brain patients has been split or by a temporary anaesthesia of one hemisphere when a barbiturate is injected into the contralateral arteria carotid for experimental purposes (Wada-test). Therefore, the latter would be possibly a significant method for understanding the pattern of the allocation of cognitive performances in the hemispheres, both in artists and in (non-artistic) creative individuals. Concluding from the chirality alone to the organizational pattern of both brain regions is not sufficient. In order to determinate the hemispheric dominance, one also applies the method of dichotic listening (see further below).

Among others, Petsche (1996) and Jausovec (2000) researched the neuropsychological underpinnings of creativity by means of coherence analyses. In this context, they also investigated the issue of the hemisphere specialization.

The authors described correlations between various EEG-parameters and creativity components, examining the data for all possible pairs of electrodes statistically.

Weinstein and Graves (2001, 2002) investigated the correlation between hemispheric dominance, creativity and schizotypy. They determined the hemispheric dominance by a dichotic listening task combined with the signal detection theory. Razumnikova (2004) in turn analysed gender specific differences during a divergent brain challenge.

Petsche (1996) was able to demonstrate that creative thinking, independent whether verbal, visual or musical, is characterised by an increased coherence between occipital and front polar electrode positions in relation to the resting-EEG, both ipsi- and contralateral. His findings proved an increased functional cooperation between these two regions.

In his investigation, Petsche presented the verbal task of creating a short story with ten selected and memorized words. In both genders, (10 female, 20 male, all right-handers), the left hemisphere was more strongly involved. However, verballity is clearly located in the left hemisphere in right-handed persons, to which the result of the test may probably partly be due. Right temporal regions were also significantly involved, more largely in female than male probands and more in the delta band than in the theta band.

The visual task consisted, among other, in creating an imaginative picture. The given task, in which 38 probands (half of them female painters) participated, was identical to the one in the study by Kaplan (1998; see Section 3.6). In that case, the above-mentioned increase of coherence between occipital and frontal areas had been observed in all frequency bands.

The third task (fulfilled by seven male composers) was to compose a short piece of music imaginatively. During its implementation, cooperation between distant brain regions (mainly parietal and frontal) in both hemispheres, however asymmetrical, was observed. Composing a musical piece evoked a far stronger coherence increase than listening to one.

By means of functional magnetic resonance tomography, Zhang, Goel and van den Broek (2006) evidenced that activations occur within the right inferior frontal gyrus (BA 47) in the generation of creative mental imaginations. The probands were

supposed to create meaningful mental imaginations to different statements. They were allowed to attribute equal or similar characteristics (e.g. "a flower that is a rose"= regular condition) or entirely different characteristics (e.g. "a cleaner that is a chair"= creative condition) to respective terms. The evoked activation of both conditions and the baseline (rest condition) were compared with one another. The creative condition showed, in comparison to the baseline, a strong activation in the right inferior frontal gyrus (BA 47), in the right medial frontal gyrus and an involvement of the occipital cortex. A strong activation of the right superior frontal gyrus and the right medial frontal gyrus, as well as an involvement of the occipital cortex, could be observed in the regular condition, deducting the baseline. At the comparison of the creative condition with the regular one, the right inferior frontal gyrus demonstrated significantly higher activations, also under consideration of different reaction times and different conditions.

Razumnikova (2004) investigated gender-specific differences in the activation pattern during a divergent brain challenge by means of EEG. A different hemispheric organisation could be observed in women and men. The data of 16 cortex electrodes of 63 right-handed probands (27 female) were analysed by means of spectral- and coherence analysis of the six frequency bands (theta1, 4 – 6 Hz; theta2, 6 – 8 Hz; alpha1, 8 – 10 Hz; alpha2, 10 – 13 Hz, beta1, 13 – 20 Hz; beta2, 20 – 30 Hz). Razumnikova divided both genders into two sub-groups, depending on whether they could master the task ("There are hundreds of poisonous snakes in the zoo. How will it be possible to measure the length of each snake? "). Task-induced differences in the EEG-data appeared exclusively within the alpha-1 and beta-2 bands. The creative male probands showed a strong increase in the amplitude and interhemispheric coherence in the beta-2 band, while the female creative probands demonstrated higher local increase regarding the beta-2 band and coherence. Furthermore, the creative female probands showed a topographically more extensive task-induced desynchronization of the alpha-1-rhythm than the creative male probands who exhibited stronger inter-hemispheric coherence.

Weinstein and Graves (2002) proceeded from the theoretical assumption that more active involvement of the right hemisphere, analysed by dichotic listening<sup>49</sup> tasks and a lateralised lexical decision task<sup>50</sup> in connection with signal detection theory<sup>51</sup>, would cause higher creativity- and schizotypy-values. Based on a previous study (Weinstein & Graves, 2001), 60 test persons were presented with several scales for measuring creativity and schizotypy as well as with a lateralized lexical decision task and a dichotic listening task. For distinguishing the perception performance about stimulus sensitivity and response criterion, they applied the signal detection theory. The often propagated correlation between creativity, schizotypy and right hemispheric activity has already been pointed out in Section 4.4.3. Weinstein & Graves (2001) postulated, among other things that the common factor, which could explain individual variations of these three variables, might be differences in the semantic processing. For example, associations, which are further distant or more global, might be favoured, possibly due to a relaxation of the response criterion and the subsequent disinhibition of weaker associations.

According to this assumption, a higher accessibility of more distant or less frequent semantic associations may result both in higher creativity values of certain tests (such as the Remote Associates Test by Mednick, 1959) and in higher values of a positive symptomatic of schizotypy (e.g. magic thinking and unusual perceptual experiences). The underlying neuropsychological base would then relate to a pattern of cerebral activity, by which the left hemispheric dominance would be relatively weakened, and the accessibility to the right hemispheric processing strengthened.

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<sup>49</sup> In the method of dichotic listening, a proband receives over the headphone simultaneously differing information in each ear. In the presented test, consonant-vowel-combinations were performed for 300 ms each. In total 30 dichotic pairs, based on six different consonant-vowel-pairs (ba, pa, ga, ta, da, ka) were each presented three times, each time with another visual cue stimulus. The cue stimuli were the original consonant-vowel-pairs. The probands were supposed to indicate whether a cue stimulus was identical with a perceived acoustic stimulus and if so, on which ear it has been perceived.

<sup>50</sup> Regarding the lateralised lexical decision task, the stimulus material consisted of 15 English words with four characters and 45 meaningless word, also consisting of four characters. Per testing, one word each was presented from the right and from the left of the fixation point simultaneously for 150 ms. In one half of the testings, a combination of a real and a meaningless word, in the other half of the rounds two meaningless words were shown. Each word appeared both within the right and within the left visual field in randomized order. The task consisted in deciding whether a real word was presented right or left or whether no real word was presented at all.

<sup>51</sup> The signal detection theory by Green & Swets (1966) focuses on the process of the assessment of the presence (hit or mistake) or absence (wrong alarm or correct rejection) of a stimulus. From this result two processes of signal detection, on the one hand a sensory process that shows the sensitivity of an individual regarding the stimulus strength and on the other hand the following decision process (criterion) that provides information about the answer tendency of the each individual, based on a combination of the percent values of the hits and the wrong alarms. The presence of a stimulus causes the firing of some neurons. The decision would be based, in a certain way, on a comparison of the neuronal activity. An individually determined response criterion would be decisive. Depending whether the activation transcends (by a yes) or undercuts (by a no) the threshold, a specific answer results.



The nature of the individual differences could, therefore, either be neuroanatomical or functional, as in the response criterion of the signal detection theory or a combination of both. Thus, the results of the previous study (Weinstein & Graves, 2001) indicate that individuals with an increased creativity value have a lower response criterion to stimuli presented to the left visual field (right hemisphere) than to stimuli presented to the right visual field (left hemisphere).

One might have to assume that the mechanism, which increases the accessibility to the right hemispheric processing, is at least partly involved in the decrease of the criterion regarding the acceptance of the right hemispheric information.

A meta-analysis of both studies (Weinstein & Graves, 2001, 2002) confirmed a correlation between schizotypy and creativity. Although the study from the year 2001 demonstrated a correlation between schizotypy and laterality, such a correlation did not reach statistical significance in the more recent study (Weinstein & Graves, 2002). However, the meta-analysis demonstrated a significant correlation between these two variables again. It was possible to verify the assumption that creativity is related to an increased right hemispheric sensitivity or, respectively, to a heightened 'attention' to the hemispheric information.

The results of dichotic listening showed a high correlation between a better right hemispheric localization ability (an increased sensory sensitivity when music is played to the left ear) and creativity. A general weak answer criterion, independent of laterality, showed a significant correlation with increased schizotypy.

Probably due to the degree of difficulty of the dichotic listening task, half of the probands had to be excluded because of a too small number of hits regarding the localisation of the stimuli. As a result, the sample turned out to be relatively small. A dichotic listening task had not been conducted in the previous study (Weinstein & Graves, 2001). The answer criterion, analysed by the signal detection theory, proved to be an important variable. The correlation between a different laterality in the lexical decision task, response criterion and creativity (in the Remote Associates Test) was significant in both studies. The meta-analysis of both studies also demonstrated an important correlation between criterion and schizotypy. As just described, the test for

dichotic listening also showed significant results with regard to the criterion and schizotypy. Consequently, these findings imply an important correlation between positive symptoms of schizotypy (magical thinking and unusual perceptual experiences) and the response criterion, namely regarding different sensory modalities (visual and acoustic). Accordingly, the personality variable schizotypy was possibly rather connected with functional (strategy) than structural (ability) individual differences. The negative symptoms of schizotypy (social anhedonia) did not correlate significantly with any of the other variables. It appears therefore that individuals with a generally lower response criterion, particularly with a lower criterion for right hemispheric processes, exhibit higher positive schizotypy values, which are reflected in a stronger tendency to magical thinking, more distinctive unusual perceptual experiences and furthermore, in greater creativity of finding further remote associations. This lower criterion could now be useful to find actual connections between concepts, but it may also lead to wrong causal attributions and hallucinatory perceptual experiences.

The authors concluded that individual differences regarding the extent of schizotypy and creativity would possibly reflect differences in conscious and attention focused processing versus a predisposition to unconscious and defocused processing. The cognitive differences would partly be based on a functional reduction of the left hemispheric consciousness system. Therefore, one should not speak of a dominance of the right hemisphere, but rather of a less pronounced dominance of the left hemisphere facilitating the access to unconscious processes.

Dijksterhuis and Meurs (2005) also claim to have observed a connection between unconscious processes and increased creative performance in a semantic task. They assumed that after the specification of the instruction and a following distraction, unconscious processes would occur. The implementation of the task followed in the conscious condition, directly after the instruction or after some minutes of time for a conscious reflection. Since unconscious processes are rather associated with right hemispheric activity, one might indirectly conclude a stronger access to the right hemispheric information. Unconscious processes in turn are attributed to primary process-related thinking (see Section 4.4.1). If Kris (1952/1977) proceeded from the

assumption that creative individuals can switch easily between primary and secondary process-related thinking, it might be reflected in their ability to have a stronger access either to the right or left hemispheric information or to both, as a respective task demands. Evidence could be gained by studies that analyse different stages of a creative process under reversible inactivation of one hemisphere.

Shemyakina and Dan`ko (2004) examined as described below (see Section 4.5.5), differences in the local and spatial EEG-synchronisation during the performance of a verbal creative task in connection with induced emotions. The differences regarding a complex task versus a simple creative task were caused without emotional induction mainly by activations within the medial and posterior temporal regions of both hemispheres. On the whole, the distribution of the spatial interactions and the strengthening of a large amount of inter-hemispheric functional connections during the performance of the creative tasks under emotional induction corresponded to an involvement of both hemispheres.

Both hemispheres are interacting as already mentioned, under normal conditions during the majority of higher cognitive functions. The question, whether creativity is mainly associated with right hemispheric activity, is yet to be answered. Presumably, the task-relevant kind of creative activity will also play a role in this process. In verbal creativity tests, a stronger right hemispheric activation is less probable than in nonverbal tests because verbal expression is left located in most right-handers. Besides, the question arises in which phase of the creative process, does the hemispheric dominance play a role, during the inspiration phase or the elaboration phase? Martindale, Hines, Mitchell and Covello (1984) pursued this question. They were able to observe a higher level of right hemispheric activity, both with regard to creative inspiration and creative elaboration.

#### **4.5.3 Activation patterns of differently pronounced creativity degrees**

Jasouvec (2000) analysed differences in cognitive processing during problem-solution processes in the context of creativity and intelligence. By means of EEG, coherence- and amplitude dimensions of the lower (8.3 – 10.3 Hz) and upper (10.3 – 12.3 Hz) alpha band were measured in more and respectively in less intelligent

creative individuals. Studies indicate that the lower alpha band is connected with attention processes and the upper alpha band with semantic memory processes (see Klimesch, 1999). An alpha desynchronization is associated with higher mental activity. The allocation of the respective group was conducted with the help of intelligence- (WAIS) and creativity tests (Torrance, 1974). The probands (students) were subdivided into four groups: the so-called talented group had high intelligence and high creativity values; the creative group had high creativity values, but only average intelligence values; the so-called intelligent group had high intelligence, but only average creativity values; and finally, there was the average group, which showed the same values in both tests. One proceeded from the assumption that a different level of intelligence and creativity would be reflected in the kind of solutions to open and closed problems and eventually in the EEG-pattern.

Two experiments characterized by various types of problems (well defined or poorly defined) were carried out<sup>52</sup>. Experiment 1 included well-defined problems of different complexity, which implied the use of a gradual problem-solving process. The complexity was determined by the amount of elements within the problem space. Therefore, it was assumed that differences in the EEG-pattern would mainly become manifest in relation to intelligence and were less determined by the degree of creativity. The probands (N = 49) were divided into respective groups on the basis of their test results. The statistical analysis of the behavioural data showed a significant group effect regarding the intelligence level and confirmed the above assumption. The highly intelligent probands exhibited significantly better values in comparison to the average intelligence probands; the degree of creativity had no influence. The EEG-patterns reflected the results of the behavioural data, although the effects were not equally robust. The differences were primarily determined by the intelligence degree. Talented and intelligent individuals had higher alpha-power values<sup>53</sup> than the average and creative group. The coherence measurements showed for the highly intelligent group, in comparison to the average intelligent group, stronger cooperation between brain regions, mainly within the right hemisphere. The differences in the

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<sup>52</sup> In a well-defined problem the initial state, the target state and the allowed operations in order pass from one to the other, are clearly explained. In a bad defined problem, in turn, the initial state, target state and / or the necessary operations are not clearly determined. The factors initial state, target state as well as the allowed operations define the problem space.

<sup>53</sup> See Footnote 4, p.14.

creative group were far less pronounced, but they had a larger amount of couplings between brain areas, primarily in the frontal brain areas.

Experiment 2 focused on creative problem solution. It was assumed that average creative probands in comparison to the creative proband group evidenced a lower alpha activity. The division of the sample (students,  $N = 48$ ) was carried out according to experiment 1. During the EEG-registration, the probands had to work on four tasks of two different problem types. Within the 'dialectic problem', both problem- and solution space were open. The 'divergent problem' in turn had a more defined problem space but left the solution possibilities open. It corresponded with the divergent brain challenges of creativity tests. The answers had only to be thought of. Gifted (highly creative and highly intelligent) and creative individuals had in the lower alpha band higher power-values than the average and the intelligent group, whereby the talented group had the highest alpha-power-values. Highly significant results were also observed for all 19 electrode positions for both kinds of problems. Similar results could be recorded for the upper alpha-band.

Experiment 2 showed about the coherence measurements within the lower alpha-band, that both of the highly creative groups in comparison to both of the average creative groups exhibited, in general, higher inter- and intra-hemispheric cooperation between brain areas. During the solution of dialectical problems, the manifestation was particularly evident within frontal regions and between frontopolar and parietal, temporal as well as occipital areas. The highly intelligent group in turn showed the largest amount of decouplings, mainly in the left hemisphere, while the creative group presented the most pronounced cooperation of brain areas between the middle parietal (Pz) and both frontopolar regions. A similar coherence pattern could be registered within the upper alpha-band. In general, the dialectical problems required the highest degree of creativity and caused at the same time the highest amount of group differences within both alpha-bands.

In total, Jausovec (2000) could observe that during an EEG-registration, highly creative probands showed lower mental activity during the solution of various creative tasks than the average creative probands. Similar observations could also be made within the highly intelligent group while solving well-defined problems that required convergent thinking. As expected, the degree of creativity played only a minor role in

that case. This result is again an indication of the fact that intelligence and creativity symbolize different abilities, which is also reflected by the neurobiological activity. At the same time, in both cases a lower mental activity is connected with a higher degree of intelligence or creativity or both. The negative association between expertise, ability or intelligence and brain activity at the solution of thematically relevant tasks could already be observed several times (e.g. Petsche, Kaplan, von Stein & Filz, 1997) and represents in the sense of the neuronal efficiency<sup>54</sup> no novelty.

Additionally, the highly creative probands exhibited a stronger cooperation between different and also distant brain areas, namely mainly in the lower alpha-band, while in the upper alpha-band more decouplings were observed. During the solution of divergent problems that required a higher degree of creativity, the highly intelligent probands evidenced in turn more decouplings in the lower alpha band as well as extended coherences in the upper alpha band, while an intensified decoupling of brain areas in the lower alpha-band was registered. Assuming, as already described above, that the lower alpha-band correlates with attentional processes and the upper alpha-band with semantic memory processes, this could mean,

“HIQ [high intelligent individuals] solved creative problems more by relying on semantic memory processes, whereas creative individuals to a greater extent relied on processes related to attention and episodic memory. One might further speculate that this could point to more primary processes being less consciously controlled in Creative individuals when confronted with ill-defined Problems” (Jausovec, 2000, p. 234).

Starting from the premise that an increase in coherence occurs task specifically (Petsche, 1996), a higher coherence between far remote cortex areas possibly correlates with further remote associations or with a lower association gradient, respectively with a wider attention span, which is appropriate for divergent problem

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<sup>54</sup> The neural efficiency hypothesis by Richard Haier postulated that below-average intelligence is connected with an inefficient or incomplete "neural pruning" (neural adjustment). Highly Intelligent individuals require a lower metabolic rate to implement cognitive tasks, which is reflected in a reduced blood flow in the respective brain areas and can be measured by fMRI or PET.

solving. The task specific, spatially focused activation of highly intelligent individuals, which may manifest in higher decouplings, provides in turn an advantage for the solution of common convergent brain challenges by a more optimal distribution of the attentional resources.

Carlsson et al. (2000) examined the regional cerebral perfusion by measuring the correlation between creativity and hemispherical asymmetry. The probands were subdivided into two groups (N = 24) by pre-tests, depending on whether they could reach very high or low values in a creative functioning test (= CFT)<sup>55</sup>. The regional cerebral perfusion was measured during a resting phase and three different verbal tasks (automatic speech, word fluency and a divergent brain challenge)<sup>56</sup>.

Regarding the divergent use of objects, the highly creative group demonstrated, in relation to the rest condition, an increase of bilateral activations in prefrontal regions, while the low creative group exhibited an increase of activations in the left hemisphere primarily. However, the comparison between the two groups regarding the number of different categories for the use of bricks within the divergent brain challenge did not yield any significant findings. This result may be due to the instruction, where they asked for both conventional and unconventional purposes of use, or it may be caused by the validity of the creativity test. However, the “ideational flexibility” of the CFT had been significantly correlated with the divergent brain challenge insofar as probands who presented a smaller number of picture interpretations within the CFT also offered smaller number of categories regarding the use of bricks. The unusual stress inducing experimental situation might have been a further reason for the reduced number of creative answers to the divergent brain challenge.

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<sup>55</sup> The Creative Functioning Test = CFT was developed in order to test the visual perception of creative individuals. As stimulus a still life was tachistoscopically presented that facilitated manifold interpretations because of its diffuse contours. Within the ascending sequence, the same stimulus is presented several times, starting with 0.2 s until 3,62 s, and is then presented repeatedly in a temporal descending sequence until it can no longer be recognised as such. It is assumed that highly creative probands will continue to provide subjectively formed interpretations within the descending sequence, although the stimulus could already completely be perceived within the ascending sequence. Low creative probands, in turn, would rather inhibit further subjectively coloured interpretations after recognizing the stimulus or at least not make use of it consciously anymore.

<sup>56</sup> Within the divergent brain challenge as many as possible uses for bricks were supposed to be found, namely both normal and unusual ones.

The comparison of the absolute perfusion under all conditions attested consistently higher values to the highly creative group than to the less creative one, with particular accentuation of the rest condition. Compared to the other three states, the highly creative group demonstrated the highest perfusion during the rest condition. This phenomenon may be associated with an a priori higher arousal within physiological measurements in creative individuals, as, for instance, postulated by Martindale et al. (1996) (see also Section 4.4). In contrast, the low creative group showed the lowest activity during the rest condition.

When the average perfusion during the word fluency task was subtracted from the average blood flow during the divergent brain challenge, significant results were yielded regarding three different compared prefrontal brain areas.

Within anterior prefrontal areas, the highly creative group exhibited a bilateral increase of activation, while the low creative group presented a right side decrease of activation and an unchanged activation in the left. In frontotemporal areas, in turn, the highly creative probands did not demonstrate any changes bilaterally, but the low creative group of probands showed a bilateral decrease of activation, with accentuation of the right side. In the highly creative group, superior frontal areas revealed an increase of activation in the right hemisphere, but no change in the left side, while the low creative group manifested a bilateral decrease of activation. Thereby, it was possible to observe that the highly creative group presented bilateral increases or an unchanged activation in all three prefrontal areas. The low creative group, in turn, predominantly revealed decreases in activation; a consistent activation level was only manifest in the left anterior prefrontal region.

The importance of the frontal lobes for creativity, their executive as well as directive functions, were described above in Section 4.5.1 and found support in the related study. Carlsson et al. (2000) proceeded from the assumption that verbal tasks, which became increasingly complex, would also lead to an increased activation within both groups. The groups would only differ from one another in the divergent brain challenge. It was assumed that the divergent brain challenge activated creativity-inherent visual-spatial right hemispherical functions, thereby causing a more accentuated bilateral activation in the highly creative group than in the low creative group. This was actually observed and proved to be true.



However, the pre-selection of the probands and the resulting subdivision in a highly creative and a low creative group by specification of the creativity test CFT (see Footnote 55, p.158) remains questionable.

Furthermore, it remains uncertain whether one may thereby validly differentiate between various creativity forms. However, this question arises indeed at all creativity tests. The CFT certainly does not require a form of creativity that implies a rational or analytical approach.

#### **4.5.4 Activation patterns in different cognitive strategies**

Divergent thinking is considered as a process underlying creative productivity. Mölle et al. (1996) were able to prove by the associated EEG-activity that divergent thinking differs from convergent, analytical thinking. An individual instructed to produce as many unusual, unique ideas as possible regarding a given topic, will probably try to establish new associations between representations (objects or episodes) by switching between different thoughts. Proceeding from the assumption that the activity of competing neuronal cortical cell complexes results in an increased dimensional complexity, a divergent brain challenge was supposed to increase the dimensional complexity in comparison to a convergent one. During a convergent brain challenge, it is useful to suppress irrelevant information, whereby the occurrence of simultaneous activations of cell complexes and thus also the competition between them will be reduced.

The female probands (N = 20) were tested during the mental processing of divergent and convergent brain challenges<sup>57</sup> as well as during mental relaxation. The monitoring took place with the help of 10 scalp electrodes, according to the 10-20-system of Jasper (1958). The average values of the dimensional complexity were determined for the respective conditions and electrodes, and subsequently analysed by a variance analysis in repeated measurements.

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<sup>57</sup> During the divergent brain challenge, a hypothetic situation was determined (e.g.: Because of a new invention, people no longer need to eat.) The female probands were supposed to create from this sentence as many as possible unusual consequences. The convergent, arithmetical tasks required the use of logical thinking operations. During the mental relaxation, the female probands should imagine a relaxing situation ('sun, beach, sea'). The solutions were written down. The EEG-analysis was limited to the thinking periods.

The results revealed that divergent thinking in comparison to divergent thinking and mental relaxation led to an increased EEG-complexity, which was especially pronounced in the central and parietal cortical areas [ $F(18, 342) = 4.21, p < .001$ ]. Over frontal areas, the EEG-complexity during divergent thinking and mental relaxation was comparable but reduced during convergent thinking. These findings attest to a loosened attention control during creative thinking. The observed general increased EEG-complexity during divergent thinking in comparison to convergent thinking is supposed to be consistent with the hypothesis that non-linear EEG-dynamics reflected an essential component of creative thinking characterised by a de-structuring of strong mental associative “habits”. Divergent thinking would probably require a reconfiguration of neuronal cell complexes within a given network of mental representations, thereby causing an expansion of the activation to rarely activated cell complexes. Mölle et al. (1996) concluded:

“Assuming that the associative (habit) strength in these newly activated ranges of the neural network is low but comparable for all representations, a spread of excitation is expected to result in strong competition among the cell assemblies representing these mental representations, and in turn, to result in enhanced complexity of the scalp-recorded EEG” (p. 63).

An additional analysis of the spectral performance testified reduced power-values in the delta band (1.0-3.5 Hz) during mental relaxation in comparison to divergent and convergent thinking. The power-values within the theta band (3.5—7.0 Hz) over the frontal cortex areas were higher during convergent than divergent thinking or mental relaxation. The alpha power-values (8.0-12.1 Hz) over the central and parietal regions, in turn, were less pronounced during the convergent brain challenge than during both other conditions. The power-values of the beta band (14.1-30.1 Hz) were highest during the divergent brain challenge, at an average value during the convergent task and lowest during mental relaxation. Mölle et al. (1996) failed to give possible explanations for these results. They considered the EEG-complexity as a more suitable method to differentiate between both brain challenges.

A PET-study (Bechtereva et al., 2004) demonstrated correlates of verbal creativity in the left parietal-temporal areas (Brodmann areas 39 and 40). Two different cognitive strategies of creativity were tested. The ‘successive strategy’ was produced by

instructing the probands to create a story from a matrix consisting of 16 words from different semantic groups. The presentation time was 90 seconds. A control task consisted in presenting words from a single semantic group. It was assumed that a higher rate of creativity was required for writing a short story using words from different semantic groups. In contrast to the control task, a significantly higher activation, occurred in the left middle temporal lobe (BA 39). Based on other studies, the authors concluded that the Brodmann Area 39 was probably involved in flexible, creative thinking and necessary for imagination and fantasy, which are also prerequisites for performing creative tasks.

For the second task ('insight strategy'), the probands were presented with a matrix of 12 nouns for 90 seconds. They were supposed to create word chains and to speak their logical associations out loud. A word chain could be, for example, "glass, river, magnet, time, parquet, book, snow, wax, ceiling, package, woodpecker, armchair." It could, for instance, be transformed as follows: "glass-reflection-water-river, river-sand-element- electron-magnet, magnet-attraction-movement-time", and so on. Pre-tests were carried out for securing the cognitive strategies. In contrast to the control group, significantly higher activations in the left gyrus supramarginalis within the parietal lobe occurred (BA 40). The authors assumed that the left gyrus supramarginalis is involved in flexible thinking and imagination. In both test series, activations in the left medial frontal gyrus (BA 8) were registered. The authors interpreted this as an indication that the memory is strongly involved in both tasks. By the comparison of both tests, brain areas could be identified that affected the execution of creative tasks independently from the applied cognitive strategy.

A poly-methodological study with a similar test design ('successive strategy') had already earlier been conducted by the authors (Bechtereva, Dan'ko, Starchenko, Pakhomov & Medvedev, 2001). In this study, the regional perfusion of 16 subjects had been measured, and an EEG-measurement taken from further 26 subjects in two procedures, each with different word groups. The results plead for an interaction of both hemispheres. Activations were recorded in both frontal lobes (BA 8-11 and BA 44-47). The importance of the coherence between the occipital and frontopolar brain areas, as pronounced by Petsche (1996), could not be confirmed by this study to the same extent. The interpretation of the EEG-results regarding the topography of the

activations is only insufficiently feasible due to the small number of testings, respectively probands, and the concurrent inhomogeneity of the group.

The 'insight strategy' had previously also been tested by the authors with the use of a similar test design (Starchenko et al., 2002). Sequential words of a chain had to be connected with associative nouns and to be spoken out loud. Nine probands were tested by means of PET. In association with the creative process, activations in the left gyrus supramarginalis (BA 40) and the left cingulate gyrus (BA 32) had been registered. The observed activation of the Brodmann Area 40 could be verified by the above study (Bechtereva et al., 2004).

#### **4.5.5 Creativity and the effect of emotions**

Shemyakina and Dan'ko (2004) investigated the effect of induced positive or negative emotional states<sup>58</sup> on the EEG-correlates of verbally creative processes. The authors postulated that the quality of the emotional background would change the functional state of the brain and that these changes would be reflected in the EEG within the activation pattern. Within a specified time frame, the probands (N = 15) had to create as many original definitions as possible of presented emotionally coloured or neutral terms. Two-word pairs were presented within three testings that differed regarding complexity, emotional value, and one control condition. The test persons performed the tasks merely mentally, with their eyes open.

The test task O consisted of a complex, creative, emotionally neutral task. The word pairs 'essence — sand' and 'pedestal — foil' were presented. The probands were supposed to create logically coherent definitions of the first word, as many and as creative as possible, with additional use of the second word. The definitions had to differ semantically<sup>59</sup>. The test task P (complex, creative, emotionally positively

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<sup>58</sup> The induction of the emotions was carried out by two methods: on one hand externally by the task of defining emotionally expressive terms, and, on the other hand, internally by asking the probands to maintain their individual emotional attitude to the presented term.

<sup>59</sup> An example of the complex, creative, emotionally neutral test task O regarding the word pair "essence - sand":

- a) The essence is those few grains of sand that remain in the palm (possibly, adhere to it) when one takes a handful of sand on a beach and the greater part of it pours through the fingers when the fist is unclenched.
- b) The essence is a thought. In intelligent creatures from other planets, it may exist in the form of grains of sand in the head. To activate their mental activity, these creatures must walk on their hands, and then a thought in the form of sand grains, as if passing through a sieve, pours into the real world and "materializes" (Shemyakina & Dan'ko, 2004, p. 146).

coloured) involved the word pairs 'love – goats' and 'kiss – hat'. The test task N (complex, creative, emotionally negatively coloured), in turn, included the word pairs 'death – paste' and 'exile – ore'. The task requirements of the conditions P and N were similar to those of the condition O. However, the probands were supposed to consider their individual emotional feelings regarding the first word of each word pair in P and N. This emotional state should be maintained during the entire task processing. The control condition C consisted in a simple, creative, emotionally neutral task with word pairs originating from the same or similar semantic group ('splinter – firewood'; 'chest [of drawers] – linen'). The control task was supposed to evoke a slightly creative process because the association of two words from the same or a similar semantic family mostly does not raise any particular problems. Regarding the tasks P and N, the probands were asked, among other, for the value and the duration of the subjective emotional experience, the depth of the emotions and their effect on the performance (inhibiting or stimulating).

By means of 19 scalp electrodes, the average power-values per electrode position were computed as an index of the local synchronisation. The correlations of all possible electrode pairs were calculated as an index of the spatial synchronization (coherence). A Within-Subjects-Design was carried out so that the probands were exposed to all conditions. The significance of the average values was tested by means of variance analyses. The contrasts were calculated for the combinations PN, PO, NO and OC.

Significant differences regarding the local power-values manifested mainly in the temporal electrode positions at the comparison of contrary emotions (in tasks P and N), or respectively at the comparison of positive versus neutral emotions (in tasks P and O). Significantly higher average power-values could be mainly observed in the complex, creative, emotionally positive tasks P in the electrode positions T3, T4 and T6 (contrast PN) as well as in F7, T3 and T6 (contrast PO). The comparison of the emotionally neutral, complex and creative and the emotionally likewise neutral but simple creative task (contrast OC) resulted in significant differences in the electrode positions C3, T3 and T6.

The coherence analyses (see Figure 26) evidenced the most pronounced differences in the comparison of the complex and simple creative tasks (contrast OC). During the

complex creative, but emotionally neutral task a generalised increase in both intra- and inter-hemispheric functional communication became manifest. The increases in the medial temporal and parietal electrode positions (T4 and P4) of the right hemisphere and within the posterior temporal electrode position (T5) of the left hemisphere were particularly distinct.

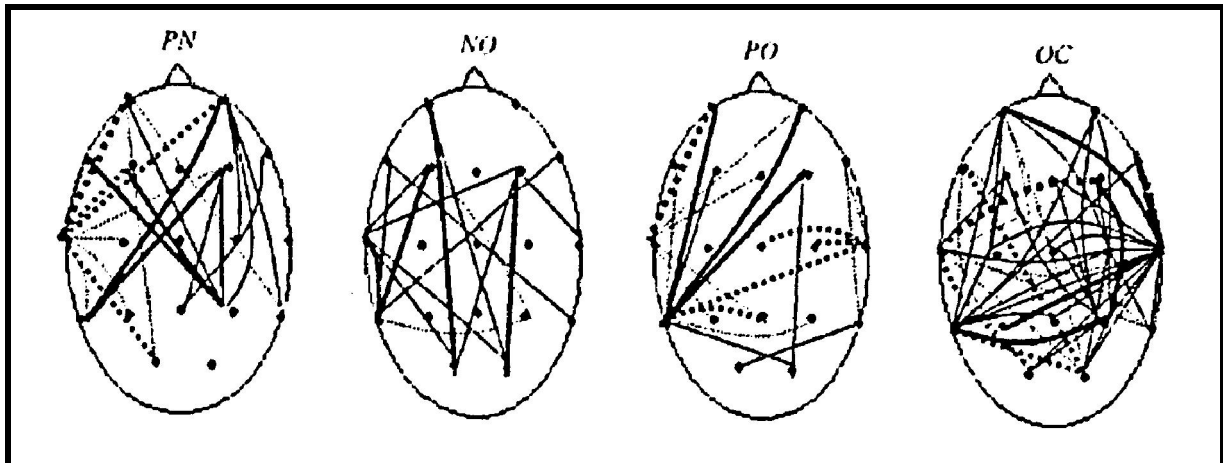


Figure 26: Significant coherence differences during the performance of creative tasks with or without emotional induction regarding the contrasts PN, NO, PO and OC. A solid line shows a coherence increase; a pointed line shows a coherence decrease during the first task in comparison to the second one within the contrast. The strongest line is  $p < .0001$ ; the thinnest line is  $.01 < p < .05$ . O: complex, creative, emotionally neutral; P: complex, creative, emotional positive; N: complex, creative, emotionally negative; C: simple, creative, and emotionally neutral (from: Shemyakina & Dan'ko, p. 148).

The emotionally positive creative task in comparison to the emotionally neutral one (contrast PO), showed a more pronounced coherence between the frontal areas of both hemispheres and the left posterior temporal areas (at Fp1-T5; Fp2-T5; F3-T5 and F4-T5) as well as between the posterior temporal and occipital cortex areas of the left and right hemisphere T5-O2 and T6-O1). In addition, coherence decreases manifested within this contrast, mainly in the medial temporal positions T3 and T4.

An emotionally negative background in turn (contrast NO) caused in the intra- and interhemispheric frontooccipital (Fp1-O1, Fp1-O2, F4-O1 and F4-O2) and frontotemporal areas (F7-T6 and F8-T5) increased functional coherences between far remote electrode positions. Furthermore, interhemispheric interactions became visible which involved the medial temporal area of the left hemisphere (T3- F4, T3-O1 and T3-O2). Besides, the coherence within the left hemisphere between frontal and

temporal areas (F3-T3, F7-T5, F3-T5 and T3-T5) increased. In contrast to task P (contrast PO), task N (contrast NO) could be associated with a significant coherence increase in all temporal electrode positions of both hemispheres. Coherence decreases were less represented and less pronounced.

Independent of the quality of the emotions, an increase in coherences appeared during the induction of emotions at creative tasks. The increases involved mainly the temporal and frontal cortex areas of both hemispheres. The performances during both positive and negative emotional tasks (contrast PO and NO) led additionally to a significant increase of intrahemispheric functional connections between F3 – T5 and F4 – O2. Such a manifestation could not be observed during the creative task (contrast OC) nor at the comparison of both emotional tasks (contrast PN).

Consequently, the induced emotions were apparently able to modify and affect the EEG correlates of the creative activity. For instance, the coherence increases between Fp1-T5 and Fp2- T5, which could be observed during the complex creative task (contrast OC), were additionally strengthened by the induction of positive emotions (PO). The coherence increases between T3 – F3 and T5 – F8 within the contrast OC were in turn heightened by the induction of negative emotions (contrast NO).

Finally, the contrast PN was characterized by the generation of new functional connections, which had not been significant in the other contrasts. For example, intra-hemispherically enhanced interactions were observed between the positions Fp2-T6, Fp2-P4, F4-Pz, F4-P4, and F8-Pz as well as between Fp1-P4 and F7-P4. At the same time, coherent decreases occurred between T3-C3 and Fp1-T6. The EEG of the creative, emotionally positive task P showed in comparison to the creative, emotionally negative task N a rather higher number of intra- and interhemispheric coherence increases of far remote positions. Characteristical for both tasks, however, was an increase within the frontal, temporal and posterior cortical areas of the two hemispheres (Fp2-T6; Fp2-T5 and Fp2-P4 in task P and Fp1-T3, Fp1-O1 and Fp2-T3 in task N).

In an interview, most probands rated the complex creative, but emotionally neutral test task O as the most difficult. The pronounced coherence increase during this task,

in comparison to the simple, creative control condition C, may be associated with their rating, if one proceeds from the assumption that a correlation exists between the degree of coherence and difficulty of a task (see Section 4.5).

The reason given for the perceived difficulty was that emotional terms (in contrast to neutral ones) facilitated the generation of creative definitions by evoking lively, associative visual imaginations. The latter might have been a reason for the increased couplings between various cortical areas and the occipital and posterior temporal areas of both hemispheres in the contrasts PO and NO. According to Shemyakina and Dan'ko (2004), this observation correlated with the modulation of imagination and memory by emotions and with the activation of visual cortical cortex areas during the mental reproduction of visual objects. According to the statements of the probands, the construction of original definitions in connection with emotionally neutral terms required substantial mental effort. The strategy, they applied in this case, was creating a mental associative logical chain by defining one term by another. Thereby, a visual picture appeared only later, as the result of a search activity and not spontaneously and sudden as in the case of the emotional induction. According to the authors, this finding suggested

“[...] that the significant differences in EEG SS [spatial synchronization] involving the posterior cortical areas of both hemispheres reflect a specific influence of the induced emotions on the task performance by subjects“ (p. 148).

Furthermore, the probands found it difficult to determine precisely, which kind of emotion (positive or negative) appeared faster and was maintained longer.

The topography of the increasing functional connections during the complex, creative, emotional neutral task O in comparison with the simple, creative task C would, in turn, indicate the involvement of both hemispheres during a complex creative process. This finding would be “inconsistent with the common idea of the high dominance of the right hemisphere in creative processes” (Shemyakina & Dan'ko, 2004, p. 148). In a comparison of both tasks O and C, which differ regarding complexity, the most outstanding differences during the complex task were observed in the prefrontal, left posterior temporal, right temporal and right medial temporal lobes. Since cortical functional connections converged during imaginative thinking in



the parieto-temporal and during abstract thinking in frontal points, the authors concluded that the observed involvement of both the parietio-temporal and frontal areas during the complex, creative task, "probably confirms again the significance of the intensification of different types of thinking during solving a Creative task" (p. 149).

In summary, Shemyakina and Dan'ko (2004) could prove that the additional induction of emotions during creative activity generated significant increases or decreases in the functional couplings or, respectively, measurable new couplings. The induced emotions changed the significant interactions observed within the contrast OC by approximately a third. The negative emotions increased the couplings between particular brain areas, while the positive emotions generated new couplings, which caused both an increase and a decrease of spatial interactions.

Only the connections F3 – T5 and F4 – O2 were equally influenced by positive and negative emotions. Left temporal areas, mainly the position T3, seemed to play a significant role during creative performances under the condition of emotional induction. This area functioned as a convergence centre of heightened spatial interactions within the contrasts NO and PN, which represent the effect of a negative emotional background. An increase of local synchronisation appeared particularly pronounced in this area, namely within the contrasts PN and PO, which means in connection with induced positive emotions. Altogether both hemispheres seemed to be involved, since a large number of interhemispheric functional connections could be observed as well.

The reports of the probands demonstrated, as already mentioned, that emotions as reactions to emotional terms appeared quickly and initially increased the occurrence of associations regarding the terms during the tasks P and N. At the same time, the emotions seemed to inhibit the transfer of one emotionally justified idea to another. Therefore, the optimizing effect of an emotional background (positive or negative) consisted in an increased speed of the association occurrence and the total sum of definitions (fluency). However, the inhibitory effect led to a reduced originality of definitions. (In general, various variants were produced on the basis of one idea.) "Generation of vivid emotional images and spontaneous emotional associations

impeded the transition to a search for a new idea“, concluded Shemyakina and Dan'ko (2004, p. 150).

A problem in the study by Shemyakina and Dan'ko (2004) is the small number of probands (N = 15, 8 female) of both genders and additionally, the small number of testings (see Section 1.9.1). For the method of the coherence analysis applies as already discussed above, that due to a missing conduct of source localization the source of the cortical activation is only inaccurately determined. Although the research approach to observing the effect of induced emotions on the cortical activity during the performance of creative tasks seems interesting, it would be desirable to apply different methods, possibly imaging procedures. Furthermore, it would be worth thinking about expanding this research approach to other forms of creativity. About the actual creative output of the probands is only known so far that the induction of emotions, independent of their quality, positively affects the fluency of the productions, but rather inhibits the originality of the output. A creative verbal brain challenge was presented, but this does not necessarily secure an efficient, creative output. Possibly, the testing of two proband groups could be revealing. They would have to be divided into highly creative and low creative individuals by means of pre-testing through implementing tasks similar to the actual test tasks. It can be assumed that the level of difficulty will determine a part of the results in this case. An extremely creative group familiar with such tasks would presumably yield different results under the induction of emotions.

## Chapter 5

### CONCLUSION

In the context of the research objectives described in Chapter 1, the question of a validation of the two models presented in Chapter 2, namely the model of aesthetic experience by Leder et al. (2004) and the model of visual aesthetics by Chatterjee (2003), shall be further analysed here.

In this analysis, the core studies presented in Section 3.4 and, if needed, further related studies will be taken into account.

Vartanian and Nadal (2007) pose the fundamental question of the usefulness of the model of experience by Leder et al. (2004) for biological approaches. So far, the model had been considered to be formulated on a psychological level (Nadal et al., 2007). According to Nadal et al., (2007) the model seemed inappropriate to form specific hypotheses about brain activities that can be brought into connection with the stages of the model.

Vartanian and Nadal (2007) provided however three reasons why the model of aesthetic experience by Leder et al. (2004) could also be considered as valuable in the context of neuroimaging studies:

- The model integrates cognition and emotion in terms of an aesthetic response; at the same time current neuroscience has just made remarkable progress in the dissociating of the "neural pathways belonging to those nodes of information processing" (Vartanian & Nadal, 2007, p. 435)
- The authors also assume that despite intensive neuroscientific research, only little is known about the neural networks correlating with the different stages of this model. This provides an opportunity to test various involvements by means of specific hypotheses for each of these levels with regard to the 'aesthetic response' .
- Finally, according to Vartanian and Nadal (2007), this model contains time limits for its individual stages, which means that one level has to be completed before a new processing can take place.

According to Vartanian and Nadal (2007), especially this latter aspect has particular importance in the context of neuroimaging studies. About the 'temporal constraints' the authors point out the following:

"This can be a valuable tool in neuroimaging because one can conduct time-course and functional analysis to see whether the time course of activation corresponding to various structures occur in structures with the predictions of the model" (p. 435).

The neuroimaging studies presented in Section 3.4, and other similar ones are primarily designed for designating the cortical correlates of aesthetic experience. Vartanian and Nadal (2007) have nevertheless tried to evidence the correctness of the model of aesthetic experience by the aforementioned study results and similar ones. In addition to the studies listed in Section 3.4, they also resorted to neuroimaging studies by Jacobsen et al., (2006), and Skov, Christensen, Rowe and Paulsen (2005).

The studies by Cela-Conde et al. (2004), Kawabata and Zeki (2004), and Vartanian and Goel (2004) illuminated differences in brain activation during the evaluation of stimuli as 'beautiful' and 'not beautiful'. Jacobsen et al. (2006) compared the whole aesthetic decision-making process with a different decision, namely the symmetry.

Accordingly, the research results of Cela-Conde et al. (2004), Kawabata and Zeki (2004), and Vartanian and Goel (2004) relate to the neural correlates that were evoked by stimuli assessed as 'beautiful' compared with the neural correlates that were elicited by stimuli determined as 'ugly' (Vartanian & Nadal, 2007). In addition, it should be noted at this point that the results by Jacobson (2006) therefore relate to the neural correlates of the assessment process as such.

Jacobsen et al. (2006) instructed the subjects in their study to judge geometric fabrics in the first task according to their symmetry and in the second task the same fabric for its aesthetic effect. If one refers this approach to the model of aesthetic experience by Leder et al. (2004), one may ascertain that an assessment according to symmetry is made in the first stage, in the course of perceptual analysis. The

aesthetic judgement, however, takes place on the fifth level of the procedural assessment.

Jacobsen et al. (2006, as cited in Vartanian & Nadal, 2007) argue 'that the contrast between aesthetic and symmetry tests would reveal the brain areas that are involved in aesthetic judgment, in relation to symmetry judgment' (p. 436).

Vartanian and Nadal (2007) refer to the model of aesthetic experience by Leder et al. (2004) according to which "the activation pattern that reflects aesthetic judgment must differ from the pattern that reflects symmetry judgment" (p.436). By the research results of Jacobsen et al. (2006), the authors consider the aforementioned hypothesis as proven. However, Vartanian and Nadal (2007) emphasize that further research would be required for eventually comparing the individual stages of "successive information processing" to possibly correlating cortical structures in order to allocate these to the model by Leder et al. (2004).

Moreover, Vartanian and Nadal (2007) explore the question of what the study results by Vartanian and Goel (2004) reveal about the model of aesthetic experience by Leder et al. (2004).

In this context, they remind us that the "information processing stream" runs parallel to an "affective evaluation stream" and that the former continuously receives information from the latter.

In relation to the model of aesthetic experience by Leder et al. (2004), this means for a recipient that he can evaluate the artwork at any time according to the information-processing sequence, that means without having reached a certain level of the information processing. Vartanian and Nadal (2007) remarked to the above question, that according to a first possibility the research results by Vartanian and Goel (2004) would confirm the cortical and subcortical structures that cause a continuous affective assessment.

Furthermore, those areas would thereby be designated, which were also expected to react at any time when issuing a positive favour judgement. According to the authors, another possibility is that the judgements of the recipients in the study by Vartanian and Goel (2004) would express the aesthetic emotion, which, according to the model

of aesthetic experience, could only occur after an evaluative stage. An additional study, which required the assessment at a particular time, could shed light on this dissent.

The next point, which needs a further discussion is, to what extent the research results by Skov et al. (2005) and Kawabata and Zeki (2004) may contribute to a validation of the model of aesthetic experience by Leder et al. (2004). Because the study by Skov et al. (2005) was not presented in Section 3.4, but could make a significant contribution to the clarification of the abovementioned question, it should be outlined here shortly.

Skov et al. (2005) presented to their subjects stimuli from the international affective picture system. In this system, stimuli are categorized in emotionally positive, negative, and neutral stimuli. As in the study by Kawabata and Zeki (2004), the subjects should judge the stimuli as 'beautiful', 'ugly' or 'neutral'. The fMRI generated results showed that by stimuli assessed as beautiful, in contrast by those assessed as 'ugly', far-scattered circuits such as occipital, parietal and frontal lobes were activated (Vartanian & Nadal, 2007; Nadal, 2013). At stimuli, which were categorized by the international affective picture system as emotionally negative, but were assessed as 'beautiful', a slightly different network became apparent consisting of occipital, temporal and the frontal lobes, and especially of the bilateral frontal cortex (Vartanian & Nadal, 2007; Vartanian, 2013).

Despite methodical differences, Kawabata and Zeki (2004), and Skov et al. (2005) tried to detect such brain regions that become more activated than others by stimuli assessed as 'beautiful'. Vartanian and Nadal (2007) postulate:

"According to the model of aesthetic experience, evaluation of beauty tap aesthetic judgment. Thus its computation can only occur following processing all five stages of the model, culminated by evaluation"(p. 438).

This statement can be interpreted in such a way that the "Continuous Affective Evaluation" observed in the model of aesthetic experience by Leder et al. (2004) cannot be seen in connection with the activation of the frontal orbital cortex. One may rather assume that certain affective units of beauty are generated in the same. In line with research results by Kringelbach (2005) and Kringelbach and Rolls (2004),

Vartanian and Nadal (2007) mentioned in connection with the previously described also the involvement of the orbital frontal cortex in "complex reward interactions hedonic and emotion interactions" (p. 438).

Finally, also the study by Cela-Conde et al. (2004) should be investigated as to what extent it may contribute to validating the model of aesthetic experience by Leder et al. (2004). According to this study, especially the dorsolateral prefrontal cortex is activated in the assessment of stimuli considered as 'beautiful' (see Section 3.4). Likewise, its involvement in the decision-making process has already been highlighted (see Section 3.4). In their attempt to validate the model of aesthetic experience by Leder et al. (2004) by the research results of Cela-Conde et al. (2004), Vartanian and Nadal (2007) refer to the fact that no correlation was recorded during the activation of early latencies and stimuli judged as 'beautiful'. This assumption as well as the results of previous similar studies cause Vartanian & Nadal (2007) to postulate that

" 'Cela-Conde and colleagues' (2004) reflect the neural correlates of the cognitive stages posited in the model of aesthetic experience. It is during these stages that the success of the cognitive mastering in producing satisfactory understanding is monitored" (p. 439).

Furthermore, Vartanian and Nadal (2007) emphasize the role of the dorsolateral prefrontal cortex at the monitoring and initiation of top-down processes.

In the context of the study by Cela-Conde et al. (2004), the authors also point to the occurrence of response latencies in less than two seconds in most subjects.

In accordance with this, they regard one of the fundamental assumptions of the research by Leder et al. (2004; described earlier in Section 2.3) as confirmed, namely that the anticipation "judgments may have relied heavily on affect-based heuristics" is reasonable (Leder et al., 2004, as cited in Vartanian & Nadal, 2007, p.439).

Eventually, Vartanian and Nadal (2007) conclude that the left dorsolateral prefrontal cortex in the model of aesthetic experience by Leder et al. (2004) plays a role both in the "evaluation phase, the initiation of feedback loops" and the "interaction of between cognitive and affective states" (p. 439).

The next point further to be clarified refers to the validation of the model of visual aesthetic by Cahatterjee (2003). As already stated in Section 3.4, an attempt will be made to explain to what extent the designated model can be verified despite or exactly on behalf of the differing research results presented in Section 3.4. First, one has to investigate the reasons for these differences despite similar research questions.

The most noticeable difference of the studies listed in Section 3.4 lies in the diversity of the applied neuroimaging techniques. While Kawabata and Zeki (2004) and Vartanian and Goel (2004) conducted their studies using event-related functional magnetic resonance (fMRI), Cela-Conde et al. (2004) used magnetoencephalography (MEG) as neuroimaging technique. While the workings of functional magnetic resonance imaging (fMRI) have already been introduced in Section 1.9.2, it should be added here concerning magnetoencephalography (MEG), that by this neuroimaging technique magnetic fields are measured, which are generated by excitatory and inhibitory postsynaptic potentials in the dendrites of pyramidal neurons (Lounasmaa, Hämäläinen, Hari & Salmelin, 1991; Maestú et al., 2005).

Most striking and probably more significant in the context of the differing research results are the varying temporal and spatial resolutions, which in turn "require different exposure times to the stimuli and interstimuli intervals" (Nadal, 2007).

The experimental designs are also different. While Kawabata and Zeki used a 3-points scale (beautiful, ugly, neutral) in connection with the assessment of preference judgment, Cela-Conde et al. (2004) used a dichotomous scale (beautiful, not beautiful) and Vartanian and Goel (2004) even a 5-point scale.

With regard to the gender composition of the experimental group, one has to mention that 5 women and 5 men participated in the study by Kawabati and Zeki (2004), whereas 8 women and 2 men participated in the study by Cela-Conde et al. (2004) and 10 women and 2 men in the study by Vartanian and Goel (2004). Many studies have pointed out the importance of gender differences in the context of studies on aesthetic preferences (Eysenck & Castle, 1971; Furnham & Walker, 2001; Polzella, 2001). Moreover, gender differences exist in relation to neural correlates of various



cognitive (Bell, Willson, Wilman, Dave & Silverstone, 2006; Boghi et al., 2006) and affective tasks (Azim, Mobbs, Jo, Menon & Rice, 2005; Mackiewicz, Sarinopoulos, Campbell & Nitschke, 2006; Piefke, Weiss, Markowitsch & Fink, 2005).

A difference not to be neglected is the composition of the stimulus material. For example, portraits as stimuli were only used in the study by Kawabata and Zeki (2004). The use of non-artistic stimuli in the study by Cela-Conde et al. (2004) was also unique. Vartanian and Goel (2004) used two modified versions of each image in addition to the original version of the image. Referring to the research by Bernard (1972), Cela-Conde Marty, Munar, Nadal & Burges (2002), Furnham and Walker (2001), Hekkert and Wieringen, (1996a, 1996b), Johnson and Knapp (1963), Lindauer (1990), Neperud (1986), and Winston and Cupchik (1992), Nadal et al. (2007) annotate: "There is an extensive literature showing differences in the aesthetic preference for visual stimuli according to their degree of abstraction, artistic qualities and modification" (p. 387).

Finally, it should be noted that there were also fundamental differences between the three studies regarding the curriculum. In contrast to the two other studies, only Kawabata and Zeki (2004) were concerned to select stimuli in a pre-selection procedure. Cela-Conde et al. (2002), and Nadal, Marty & Munar (2006) refer, in this context, to unintended recognition processes which were measured during the brain activity of the participants in the context of the confrontation with study related tasks, which in turn revealed a relation to mnemonic processes and aesthetic judgement.

A further fact that may have led to different outcomes of research in the context of aesthetic preference for visual stimuli, is the influence of various psychophysical variables such as luminance, contrast or predominant wavelength or complexity, novelty or prototypicality (Berlyne, 1970; Martindale & Moore, 1988). The effect of some of these variables on aesthetic preference for visual stimuli has also been shown in the context of studies dealing with neural correlates of visual processes (Müller, Lutzenberger, Preißl, Pulvermüller & Birbaumer, 2003; Sasaki, Vanduffel, Knutsen, Tyler & Tootel, 2005). As already described in Section 3.4, Cela-Conde et al. (2004) have homogenized the stimuli in their study regarding complexity, novelty, colour spectrum and luminance, and resolution and size. Neither Vartanian and Goel

(2004) nor Kawabata and Zeki (2004) has reported on such a procedure. Therefore, one may ask the question whether these variables were controlled.

Based on the follow-up study by Nadal et al. (2007), one can investigate the issue of whether the model of visual aesthetic is verifiable by the three aforementioned studies. For a better understanding, the model of visual aesthetics by Chatterjee (2003) will be briefly outlined. Chatterjee (2003) developed the concept of visual aesthetics based on the cognitive neuroscience of vision. After confronting an observer with a visual stimulus, the model proposes an early visual processing stage (i.e. processing colour, brightness, shape, movement and location), followed by a middle stage of visual processing (i.e. the grouping of these characteristics). These stages are combined with attention and figurative representations (e.g. locations and faces), followed by an emotional response, and finally by the decision.

In their follow-up study, Nadal et al. (2007) present empirical results about Chatterjee's (2004) model by comparing it with three different fMRI studies (i.e., Cela-Conde et al, 2004; Kawabata & Zeki, 2004; Vartanian & Goel, 2004). Three components of Chatterjee's (2003) model of visual aesthetics are identified in the three fMRI studies: first, the process of the early visual processing stage; secondly, the emotional reaction and, thirdly, the decision.

The early visual processing stage can be allocated to the occipital cortex, the most significant brain area for seeing (Vartanian & Goel, 2004). Emotional reactions become apparent in the representation of the reward value and awareness of the emotional state (Kawabata & Zeki, 2004; Vartanian & Goel, 2004). Nadal et al. (2007) argued that the cortical part of the reward value of aesthetically rated stimuli corresponds to the activity in the medial orbitofrontal cortex. Particularly noteworthy is that visual stimuli are evaluated as beautiful, if these were associated with a higher reward value in the brain of the participant than the stimuli assessed as ugly (Kawabata & Zeki, 2004). In addition, the subcortical part of the reward value was identified in the nucleus caudate by Vartanian and Goel (2004). Moreover, Nadal et al. (2007) argued that an increased activation of the motor cortex might reflect a meaning for the reward at ugly stimuli or the motoric readiness highlighted by them (Kawabata & Zeki, 2004).

Vartanian & Goel (2004) identified the subjective emotional experience associated with the aesthetically preferred stimuli in the anterior cingulate cortex; the decision component of Chatterjee's (2003) model of visual aesthetics was verified in the work of Cela-Conde (2004). Nadal et al. (2007), however, conceded that it was not possible to determine whether the identified brain activity in the left dorsolateral cortex reflected decisions based on perceptual information or information of reward value.

In summary, one may conclude that the empirical underpinning of the model of visual aesthetics of Chatterjee (2003) by Nadal et al. (2007) conveys a comprehensive overview of the potential mechanisms that play a role in the confrontation with aesthetic stimuli.

Although these insights into the visual processes and processes relevant to decision making in the brain are interesting, the results about the emotional reactions seem to be the most significant for the current research. These findings suggest that a reward (i.e. the desire for an aesthetic product) is essential in triggering aesthetic preferences, ratings, and subsequent decisions (Leder et al., 2004; Zeki, 1999).

## Chapter 6

### DISCUSSION AND CRITIQUE

Neuropsychological and neuroimaging studies have made significant contributions in recent in recent years to clarify the neurobiological basis of the art experience. The experience of art can be considered as a complex of perceptual, cognitive and emotional experiences. From the scientific evidence, one can clearly deny the question whether there exists a brain centre responsible for processing the aesthetic experience (Cela-Conde et al., 2004).

Instead, art and aesthetic experience rather arises in the context of the interaction of widely ramified cortical and subcortical networks. Already Zeki and Bartels (1999, as cited in Cela-Conde et al., 2004) have pointed out about the visual system:

"Anatomical evidence shows that there is no single area to which all of the specialized visual areas connect, which would enable it to act as an integrator capable of bindings signals coming from all of the different visual systems" (p. 6324).

One may add that none of the cortical and subcortical brain areas is designed to respond exclusively to aesthetic experience.

Besides the neural basis for common creative processes, artistic actions involve many specific neural processes. The different visual processing routes and association areas of the occipital, parietal, and temporal cortex are necessary for the visual imagination. Planning and action control involves the prefrontal areas. Motoric performance requires the motoric areas, basal ganglia and cerebellum (Changeux, 1994). Also, the models of aesthetic experience by Leder et al. (2004) and of visual aesthetics by Chatterjee (2003; see chapter 2 and 5) both support the theory of a network of different brain areas for visual aesthetic experience with coexisting emotional reward systems.

Thus, Gardener (1982) is right in assuming there does not exist any single specialised brain area for artistic skills. However, his assumption that artistic creation always requires a fully functioning brain could not be confirmed in recent years. To the contrary, as the lesion studies have shown (see Section 3.7.2.4) artistic abilities are preserved despite severe neurodegenerative diseases.

In the introductory section, the question arose whether and how these lesion studies (see Section 3.7) may contribute to clarifying the aesthetic experience.

Their findings prove that neurological processes underlying aesthetic experience are a widely ramified and nonspecific network of various brain areas. This system seems also to be responsible for the first occurrence, development or preservation of artistic abilities (see Section 3.7.2.4).

Due to the aforementioned broadness of this network and the correlating possibilities to compensate or shift, could artistic skills resist against at least complete failure. Likewise, a change in the artistic style or an artistic primary manifestation in the context of a neurodegenerative disease may, in fact, be explained by that shift of neuronal activity to non-degenerated brain areas.

As mentioned in Section 3.7, neural injury and neurodegenerative diseases result in certain constraints and changes in artistic style. Therefore, works by artists with right-sided brain damage partly display distinct distortions in their spatial organization (Zaidel, 2005; Bätzner & Hennerici, 2007). However, pronounced artistic abilities can be retained even up to late stages of severe neurodegenerative diseases, such as Alzheimer (Fornazzi, 2005) or Parkinson (Chatterjee et al., 2006).

Ranking et al. (2007) reported in the context of investigations on patients with Alzheimer disease and frontotemporal dementia that in Alzheimer patients a simplified composition and a subdued colour palette could be determined, whereas patients with frontotemporal dementia preserved the ability to copy by drawing. They explained this phenomenon by the fact that posterior structures had been spared in latter patients. Viskontas and Miller (2007, as cited in Miller & Miller, 2013, p. 100) assume that "patients with frontotemporal dementia develop focal cognitive and behavioural deficits, with sparing of function of unaffected brain regions".

The neuropathological constraints sometimes lead indeed to a greater expression of the non-affected aspects of artistic creativity (Chatterjee, 2004, 2006). In individual cases of neurodegenerative diseases (Miller et al., 1998; Miller & Hou, 2004) or of brain damages caused by intracerebral haemorrhage (Lythgoe, Kalmus, De Haan & Khean Chong, 2005), profound artistic skills may even appear for the first time, although the patients had previously dealt little or not at all with art. Stylistically, the works created thus are more realistic or surrealistic than symbolic or abstract-oriented (Miller et al., 1998).

Particularly damages in the orbitofrontal and left hemispheric brain area seem to favour a sudden occurrence of artistic activity. This phenomenon is interpreted as disinhibition, particularly of the right half of the brain. If dominant rational and detail related processes are damaged, then the remaining structures can unfold even better (Méndez, 2004; Pollak, Mulvenna & Lithgoe, 2007).

In the context of a study in which creative achievements of people with frontotemporal dementia were investigated, De Souza et al. (2010) reported a decrease in creative accomplishments. At the same time, the authors also reported a periodically observed increase of creativity in such patients. More critically to look at are, however, studies such as those by Halpern and O'Connor (2013) or Halpern, Elkin, Frankston & O'Connor (2008), which report on an unchanged art experience in patients with Alzheimer disease and frontotemporal dementia. A comparison with a control group is missing here. Chatterjee remarks to the question of to what extent lesion studies contribute to the understanding of the neurobiological processes of the art experience: "Studies of people with brain damage can also advance our understanding of the perception and experience of art" (p. 394).

According to the author, this is because:

"Investigations of patients with brain damage have contributed greatly to our understanding of cognitive and affective systems. This approach also has substantial promise in advancing neuroaesthetics. By contrast, while damage to brain certainly impair the ability to produce art, paradoxically, in some cases art abilities seems to improve [...] The paradoxical improvements offer unique insight into the creative underpinnings of artistic output" (Chatterjee, 2011, p.393-394).

Zaidel (2005, as cited in Miller & Miller, 2013) remarks on a possible investigative isolation of a brain centre for aesthetic experience in the context of lesion studies:

"Overall, the study of the impact of neurological disorders on the art experience argues against the existence of specialized brain mechanism underlying the experience of art" (p.140).

In summary, one may state that neuroimaging studies prove that art processing involves three functional groupings of brain activity. These are also an integral part of models by Chatterjee (2003) and Leder et al. (2004). Nadal (2013) explains in this context:

"Appreciating art engages processes related to perception (attentional enhancement of the analysis of certain features), cognition (evaluative judgment, attention, and retrieval of information from memory), and affect (generation of pleasant feelings, emotions, representations and anticipation of reward, and awareness of one's affective state. These processes are performed in parallel, they are highly interrelated, and they rely heavily on information feedback, making it impossible to describe any meaningful sequence of events" (p. 152).

In Chapter 5, the different results of the studies presented in Section 3.4 in the context of the verification of the model of aesthetic experience by Leder (2004) and the model of visual aesthetics by Chatterjee (2003) have already been mentioned. Subsequently, a further critical appraisal will follow here.

As already mentioned, the investigations by Kawabata and Zeki (2004), Cela-Conde et al. (2004), and Vartanian and Goel (2004) were, despite similar research questions, carried out methodically different, which may be the reason for their differing results. Cela-Conde used a different methodological approach and measured the activity using magnetoencephalography (MEG) while the two other research groups evaluated metabolism activities by means of functional magnetic resonance imaging (fMRI). Kawabata and Zeki made use of a pre-test, in which the subjects classified the images beforehand. The effect may have been that an additional recognition process took place before the second classification, whose activity was additionally measurable. Further studies also demonstrate that psychophysical variables, such as brightness, complexity and contrasts of the

presented images, may have an impact on the aesthetic perception. In two of the three studies, no information was found whether these confounding variables had been controlled. Because of such differences, no adequate control can be guaranteed, and one cannot infer from the activity, which cognitive partial processes are involved and whether all related aesthetic decision processes were measured.

Overall, the results must not be seen as contradictory but as completing one another. The judgement about aesthetics is overall a very complex, multimodal cognitive process. Different cognitive operations take place in various areas of the brain at different times and must eventually be integrated with one another. Due to the differing experimental designs, the individual working groups may have filtered out only parts of the processes and therefore prognosed distinct participating areas. In a decision and categorization of images different processes connected with each other take place, starting from the pure visual processing in the visual cortex or the influence of memories and emotions that a picture produces.

Some more aspects should therefore extend the previously presented experimental designs. For example, in order to determine whether the dorsolateral prefrontal cortex is involved in the decision-making and classification, subjects should just contemplate, but not classify pictures. In this case, no decision-making process takes place, and therefore, it can be assumed that the dorsolateral prefrontal cortex is only active in decision processes. In addition, confounding variables such as brightness and contrast of the artworks have to be standardised for the study. Factors such as gender, emotional content, accurate description of the task are to be recorded and incorporated into the evaluation.

The results of imaging processes are however always only usable if the components of the cognitive performance are known and can be examined in isolation, or if the function of an individual brain area is known, in order to determine whether this area is involved in a particular task. Within the still young research field of neuroaesthetics, the components of the aesthetic experience are not precisely known, and the involved areas not yet detected. Therefore, it is not yet possible to derive adequate hypotheses and information from the data, and the so-called reverse inference problem remains a major problem within the imaging procedures. Within an experiment, a certain task causes activity in certain brain areas. From the activity,



one can however not infer to a particular cognitive performance. The quality of this inverse derivation depends on the selectivity of the brain area. If a certain brain region is active at many different performances, only a weak evidence arises. If, however, the region is only active for a particular task, it is more likely to assume that this performance also takes place in this area.

Philosophers, art theoreticians and art historians exercise fundamental criticism on neuroaesthetics. For them, art is a fundamental cultural construction, the subject of a contextual variation, historical changes and criticism.

Liberal arts acknowledge the way in which art displays adaptive flexibility in the context of its various culture-specific roles at different time epochs (Davis, 2012). According to liberal artists, the methodology of interpreting artworks neuroaesthetically and deducting from this interpretation the neural textures of their creator, is just one of the numerous ways to functionalize art, and is, in this respect, an aberration. Leonardo da Vinci's terse statement that "every painter paints himself" may serve as an example. It is just as much in need of an interpretation as is the missing distinction between image - and perception-specific aspects of the image effect and the lack of differentiation between a production- and an effect-aesthetics (Davis, 2012). Some humanists go as far as to say that art would be in principle not accessible to scientific or neurobiological questions (Massey, 2009).

Fenner (1992) responds to this fundamental criticism by emphasising that some of the issues posed by philosophers are not applicable to psychology or neuroscience. As an example, he mentions the question, "what is art?" or "how is art to be defined?" You cannot address neuroscientists and psychologists with such issues that you would rather address to philosophers or theorists of art. In this sense, it is not right to judge neuroscientific approaches to art according to the extent they would fit philosophical issues of the same context.

However, the psychological and neuroscientific research must allow to be asked, whether it does not neglect the influence of the context of art and its significance for the art. Thus, neuroimaging studies need such highly controlled settings that can only with great difficulty be experimentally manipulated. In order to take this problem into consideration, Kirk, Skov, Christensen & Nygaard (2009) introduced semantic

contexts with verbal and visual clues in their investigation of the aesthetic experience. These instructions are designed in such a way that 'gallery' labels or 'computer' labels are used to implicate a mental association between stimuli and the environment of an art gallery or computer software for test subjects. In this context, it should be once again referred to the model of experience by Leder et al. (2004), which emphasizes the role of such information and knowledge, and includes their role as integrative components of the model of the experience of art.

Finally, it should be added that neuroaesthetics is a young emerging branch of research and a field where there is tension between art and science. This research domain is sure to shed light on our understanding of the neurobiology of human hedonic experience. It does so by applying aesthetic stimuli and the resulting neural mechanisms. As demonstrated in this dissertation, lesion studies may contribute as well to the understanding of the nature of art experience.

It remains the task of a future, and more comprehensive, analysis to explore the role of art style and expertise in depth by referring again to the two presented models of perception. In this future research, special attention shall be paid to the interaction between cognitive and affective processes.

A controversy which remains a significant, but unresolved question is whether neuroscience should remain limited to the research of the biological basis of aesthetic experience or if this approach could make a significant contribution to the understanding of artistic activities.

A further fundamental question arises in the context of the interdisciplinary embedding of neuroaesthetics in the triads consisting of the evolutionary aesthetics, enactivism and cognitive psychology, neurophenomenology and aesthetics.

Moreover, a detailed list would be required of neurodegenerative diseases reflected in the art. Such a list would allow investigating whether certain regularly recurring form elements in works of art reflect neurodegenerative diseases. Could it thus also become at least partially possible to diagnose neurodegenerative disorders by means of such patterns?

Chapter 4 dealt with several factors associated with the neuroaesthetic focus of this paper, the main approaches in creativity research, where again the neurobiological foundations dominated. The fundamental question, whether neuroscience is able to explain creativity cannot clearly be answered. In a certain sense, the answer is "yes". Since human mental states are fundamentally based on neurobiological processes, creative processes are also based on neural processes - and therefore creativity within a narrower, psychological meaning can be explained by the neurosciences in principle. In a different sense, however, the answer is "no", because the concept of creativity is not a purely individual-psychological one. In general, it is not only defined by the way an  $X$  (an idea, a theory, a piece of art or a product) is produced, but also and essentially by the fact whether the  $X$  receives social recognition - a process that does not primarily fall within the competence of the neurosciences.

In the narrower psychological sense, creativity is often understood as a staged process, which proceeds, however, not strictly chronologically, but is overlapping, that means it runs recursively and comprises, as a rule, the following steps: preparation, incubation, (sudden) insight and implementation. From a neurobiological perspective, the first and the last level are of less interest than are especially the second and third: What neurobiological explanations exist for the fact that the process of incubation develops apparently unconsciously and that a focused, conscious engagement with a problem often impedes creativity? Can neuroscience explain to us, how insight or problem solution are achieved in the creative process?

Although a general neurobiological theory of creativity does not yet exist, the first framework for such a theoretical framework was presented (2004) by Dietrich (see Section 4.4.1). Similar to the research results summarized in Section 3.4 "type preference and neural mechanisms", the prefrontal cortex is in Dietrich's framework theory of central importance. Similar also to the research results on the neural correlates of the art experience, the prefrontal cortex plays a significant role but one cannot designate it as the seat of creativity. It is embedded in a widespread network of different brain areas.

Chapter 4 included primarily a clarification about fundamental issues of (neurobiological) creativity research such as, for example, the generation of original ideas.

A further specification with respect to the biological and neural underpinnings of creativity in the arts should be addressed in a more detailed work.

Section 3.7 included the topic of how and whether any neurodegenerative processes may lead to a change of artistic creation or even occasionally induce first artistic manifestations, such as in the literature described. By the identification of the respective degenerated area, for example, conclusions could be drawn on its involvement in artistic creation.

About the neurobiological research on creativity, the question arises after the clarification of the relationship between the degeneration of various brain areas and the emergence of new creative impulses. This issue could also be analysed in an additional research work.

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