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Assessment of Drawing and Art-Making Differences between Parkinson’s Disease Patients and Healthy Psychology Students

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1. What art-related changes can tell us about Parkinson's Disease – Rising relevance in our aging world

"What a paradox, what a cruelty, what an irony, there is here – that inner life and imagination may lie dull and dormant unless released, awakened by an intoxication or disease!" (Sacks, 1985, p. 55; comment on drawings of patients with Parkinson's Disease)

Parkinson's Disease (PD) is the fastest-growing neurodegenerative disease in the world (Dorsey et al., 2018) and is currently affecting approximately 0.3 % of the population while rising to 3 % in people over the age of 65 (Gillies et al., 2014). This condition progressively impacts the ability to produce, release, or re-uptake the neurotransmitter *dopamine* (DA), leading to several symptoms, including loss of motor control, impaired cognition, language processing, emotion regulation, sensory and visual function (Sveinbjordsdottir, 2016). The manifestation of these symptoms extends to myriad movement-related dysfunctions such as bradykinesia, tremor, shaking, or rigidity, as well as non-motor issues impacting sleep, pain, perception, emotion, and cognitive processes, which can manifest as subtle changes at least 20 years before PD is diagnosed (Chaudhuri et al., 2006). Furthermore, it is suggested that the neuropathology of PD is already severely advanced and possibly irreversible once motor symptoms appear (Hawkes et al., 2010). In addition, PD frequently coexists with psychological symptoms such as depression or anxiety (Bayulkemand & Lopez, 2011; Connolly & Lang, 2014; Grover et al., 2015). PD has a significant impact on individuals and society and is expected to have a twofold increase in cases by 2040 as a consequence of an aging population (Dorsey et al., 2018). As a cure for this disease has not been developed yet (Fox et al., 2018), it becomes essential to understand the underlying neurobiological mechanisms (Tysnes et al., 2017), as well as new strategies for early or non-motor-based detection that support early diagnosis of PD (Darweesh et al., 2018; Chaudhuri et al., 2006) or alternative non-pharmacological treatments (Bloem et al., 2015). Currently, the most common pharmacological therapeutic approach is levodopa, which helps to replenish their cerebral dopaminergic levels, often combined with other treatments such as DA agonists (Dorsey et al., 2018).

While the early neurobiological detection and understanding of PD remain critical, it is equally intriguing to explore the more subjective, creative responses observed in some patients. Visual art is a promising area for exploring the connection between behavior and brain changes, with studies documenting art-related changes connected to different neurological damages or diseases (see Section 2.2.1 for further explanation). Understanding how artistic creativity might change individuals provides valuable insights into the cognitive and emotional processes involved in artistic expression. This framework becomes particularly relevant when examining how neurological conditions, such as PD, can influence these processes.

As motor symptoms and cognitive decline progress, certain individuals paradoxically experience heightened creativity, suggesting an unexpected shift in the way PD affects the brain. Currently, emerging evidence suggests that people diagnosed with PD and undergoing treatment experience a sudden awakening of artistic motivation, felt creativity, or desire to make art (Chatterjee et al., 2006; Kulisevsky et al., 2009; Lakke, 1999; Lhomée et al., 2014; Pinker, 2002; Schwingenschuh et al., 2010; Walker et al., 2006; Lauring et al., 2019a; Lauring et al., 2019b; Pelowski et al., 2022). Various studies propose changes in self-reported creativity in PD patients while the direction and actual prevalence remains unclear (Joutsa et al., 2012, Spee et al., 2023; see Section 2.2.2). Intriguingly, alterations in artistic technique or style, including emotional expressiveness, altered color perception, increased abstraction, improved artistic quality, and heightened novelty, have been mentioned as well in people with no previous artistic interest or motivation (Pelowski et al., 2022; Chatterjee et al., 2006; Kulisevsky et al., 2009; Lhomée et al., 2014; Pinker, 2002). For creativity-related changes, especially DA agonists have been suggested to play a role (Lauring et al., 2019a), which will further be discussed in Section 2.2.2.1. These findings provide a captivating set of data for approaching and understanding the neurophysiological and contextual bases of artistic creation (Chatterjee, 2004; Lauring et al., 2019a; Inzelberg, 2013). Further, previous studies have reported art-related changes that may significantly affect artists. Thus, the upcoming study will focus on examining similar art-related differences to find possible evidence for the direction of this change. In addition, this study will focus on artworks produced by non-artistic PD patients.

Although there is some intriguing evidence for art-related changes within PD patients, there are existing limitations of the previous studies that should be considered. Specifically, most studies lack systematic methodology when evaluating artwork and use inconsistent art-making paradigms throughout different studies or even within (Lauring et al., 2019a). Further, case studies often consist of small sample sizes of PD patients (occasionally only one patient). Moreover, a clear cohort description is frequently missing (e.g., treatment/medication, symptoms, stage, or age) (Lauring et al., 2019a). There remains a gap in connecting self-reported changes with more controlled assessments of other perceptual changes (e.g., color, contrast, cross-hatching, etc.) and cognitive or affective shifts (Pelowski et al., 2022). Furthermore, when it comes to produced artworks, there needs to be more consistent assessments that could unveil systematic patterns or serve as a basis for empirically derived insights into brain and perceptual differences (Pelowski et al., 2022).

Thus, this master thesis aims to gain a first systematic approach for future studies and comparisons by developing an art assessment program to assess differences in art making that might be connected to PD. This research was conducted as a part of the project “Unlocking the Muse: Transdisciplinary Approaches to Understanding and Intersection of Artistic Creativity and Parkinson’s Disease“ in collaboration between the University of Vienna and Radboud Medical Center (Radboudumc), funded by the Austrian Science Fund (FWF-der Wissenschaftsfond, #ConnectingMinds) which will afford access to a substantial and systematically collected dataset on individuals with PD, facilitating the development of a methodology that could be applied to PD, but also to different creativity-linked diseases, such as Alzheimer’s disease.

Having access to this large cohort of PD patients will allow for a first systematic study of produced artwork compared with similar artworks produced by healthy psychology students (healthy control group; HC). These artworks will be produced via one specific sub-test of the art assessment approach, “Cued, Drawing Task” (Pelowski et al., 2018), which was already utilized in healthy participants but never in people with PD. Subsequently, they will be rated using a modified version of the Assessment of Art Attributes battery (AAA, Chatterjee et al., 2010; modified by Lauring et al., 2019a; Pelowski et al., 2022) resulting in subjective ratings for different scales, similar to the categories mentioned above (creativity, quality, style and content, emotional expressivity; see Section 3.2 for a detailed description of the study procedure). Further, to provide a more comprehensive comparison, a computer-based art image assessment, Fractal Dimension (FD), will be applied to give a more objective analysis of the artworks regarding complexity. Fractal Dimension (FD) offers a method to measure how patterns display self-similarity in their geometrical-spatial structure across various levels of magnification (Estrada-Gonzales et al., 2020). Thus, FD is associated with relative structural complexity and has also been proposed as a general 'handprint' of a mature artist. Individuals tend to show consistent FD scores across various artworks, with significant changes in FD/complexity possibly indicating shifts in perception, cognition, or neural function (Forsythe et al., 2017).

This project thereby aims to answer the exploratory research question of whether there are any systematic differences in artistic drawings produced by PD patients and HC using a standardized black-and-white drawing paradigm.

By understanding and identifying these art-related changes, promising possibilities are opened for a deeper comprehension of the neurobiological basis of PD itself (Lauring et al., 2019a). Additionally, this and further studies could potentially aid in a tool for diagnosis or early detection of PD (e.g., Chatterjee et al., Chaudhuri et al., 2015), treatment improvement, enhancing patients' quality of life (Bloem et al., 2018; Chatterjee et al., 2010; Cools et al., 2020; Cucca et al.; 2021; Fancourt, 2017; Fancourt & Finn, 2019), and support evidence-based medical practices (Sacket & Rosenberg, 1995).

Furthermore, changes in art-making behavior due to brain alterations may offer insights into brain plasticity and deepen our understanding of reward, motivation, perception, and disorder-related symptoms (Joutsa et al., 2012; Schwingenschuh et al., 2011), providing empirical proof (Sims et al., 2014; Snyder et al., 2003; Young et al., 2004). It could also add a unique perspective on the neurophysiological and contextual foundations of human art-making and visual creativity (Boot et al., 2017; Mendez, 2004; Pelowski et al., 2017), an emerging focus in neuroscientific research (Chamberlain et al., 2014; Chatterjee, 2004; Mendez, 2004; Pelowski et al., 2017).

2. Theoretical Background

2.1. Parkinson's Disease

Current research suggests that PD results from a complex interaction between genetics and the environment rather than primarily caused by environmental factors (Kalia & Lang, 2015). PD is now recognized as a slowly progressing neurodegenerative disorder, where cognitive symptoms appear up to 20 years earlier before diagnosis. The affected neuroanatomical areas result in diverse symptoms, which will further be discussed in the next section (Kalia & Lang, 2015).

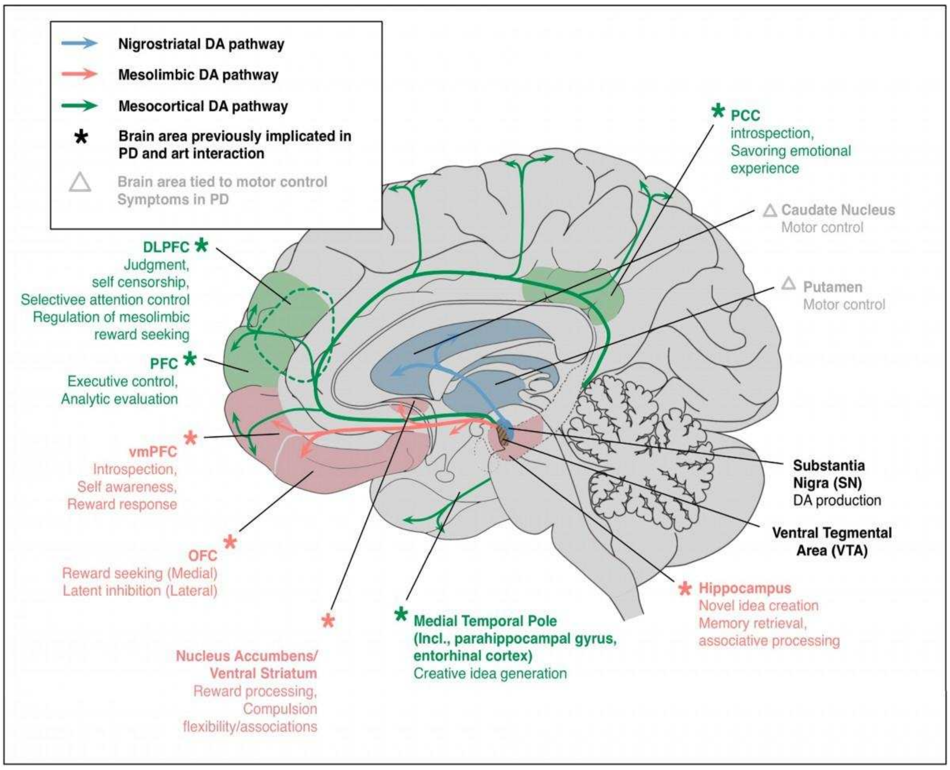
2.1.1. Neurobiological Mechanisms in Parkinson's Disease

For the systematic approach to assess art-related differences between people with PD and HC, it is also essential to look at the interaction between changes in produced artworks and changes in cognitive processes that could be related to some of the proposed changes. By implementing objective tests in art assessment approaches that assess various cognitive aspects, such as memory or objective perception, possible links between art-related changes and cognitive processes or brain regions might be created since cognitive symptoms, which arise because of degeneration in different brain regions, play a role in PD (see Section 2.1.2). For the implementation of art assessment approaches, which also include tests that measure objective perception, memory, or IQ, it is essential to understand the neurobiological background of the disease and how the different brain regions could be connected to these changes in PD patients.

PD is characterized by the loss of the brain's ability to produce DA. This neurotransmitter is a vital component of brain functions, mainly causing action potentials in postsynaptic neurons, resulting in interconnectivity among neurons. Figure 1 shows the main PD-related brain areas and their potential overlap with evidence relating to art (Lauring et al., 2019b).

Figure 1

Main DA-pathways and brain regions as implicated in both art interaction and PD studies



Note. Lauring et al. (2019b)

The primary brain region of PD-related DA production is the substantia nigra pars compacta (vSNc), an area in the midbrain (Cameron et al. 2010). As a result of the intricate interplay of these neural pathways, the brain can generate fluid movements. These are disturbed by the lack of produced DA when suffering from PD, resulting in a loss of smooth movements (Jankovic, 2008). The nigrostriatal DA pathway connects the vSNc to the basal ganglia, a group of subcortical nuclei located at the base of the forebrain that is primarily involved in action selection, habit formation, and regulation of motor/premotor areas (Lauring et al., 2019b; Grahn et al., 2008). These nuclei include the substantia nigra, pallidum, subthalamic nucleus, and caudate/striatum (Grahn et al., 2008).

Further, the ventral tegmental area (VTA) and related regions along the mesolimbic and mesocortical DA pathways have also been shown to have neuronal depletion (Lauring et al., 2019b). However, compared to the degeneration of dopaminergic neurons in the vSNc, there seems to be less pronounced damage in the VTA (Alberico et al., 2015). The non-motor symptoms experienced by PD patients, such as anxiety, depression, emotional responses, memory loss, learning difficulties (including motivation and reward response), judgment problems, and loss of cognitive and executive function, have been suggested to be caused by the depletion and dysfunction of dopaminergic neurons in the VTA (Alberico et al., 2015; Lauring et al., 2019b).

2.1.2. Symptoms, Classification, and Treatment

Symptoms

The above-described neurobiological mechanisms cause various symptoms in PD patients, some of which could influence art-related changes (e.g., loss of motor control and cognitive symptoms). Assessing the exact symptoms and getting a detailed description of their severity and duration through questionnaires (see 3.1.2) could help to find possible reasonings for the expected art-related changes in PD patients when applying all proposed art assessment approaches. It could be hypothesized in future studies that one specific symptom (e.g., decline in memory) or a particular category of symptoms (e.g., cognitive symptoms) might be responsible for changes in produced artworks. This could be analyzed by comparing descriptive data of PD patients with the results from the proposed art-drawing tasks, as well as the tests for objective perception, memory, or personality. Unfortunately, due to ethical guidelines, Radboudumc did not provide us with descriptive data on PD patients, which is why this study cannot include hypotheses for art-related changes linked to symptoms. Nevertheless, the general application of proposed approaches for art assessment should consist of descriptive data, including symptoms of PD patients, to control for these. Thus, a short description of the numerous amounts of PD symptoms will follow in the next part.

In James Parkinson's initial description of this disease (refined by Jean-Martin Charcot), motor symptoms were recognized as one of the most prominent components (Parkinson, 1817; Charcot, 1872; Goetz, 1986). These movement-related symptoms include bradykinesia[1], muscular rigidity[2], rest tremors[3], postural instability[4], and gait impairment (Kalia & Lang, 2015; Armstrong & Okun, 2020; Okun, 2012). Besides the characteristic motor symptoms, PD is also associated with a wide range of non-motor symptoms. Table 1 shows an overview of all further described symptoms. The non-motor symptoms are prevalent in early PD, potentially preceding motor symptoms by up to twenty years (Hawkes et al., 2019), while being linked to a reduced health-related quality of life (Martinez-Martinez et al., 2011; Duncan et al., 2014), and also frequently progress more severe with the disease (Hawkes et al., 2019). These include prodromal symptoms, olfactory loss[5], sleep dysfunction[6], autonomic dysfunction[7], as well as cognitive impairment[8], fatigue, hypophonia[9], sialorrhea[10], or trouble of swallowing, as well as psychiatric disturbances like depression, anxiety, apathy, or psychosis (Armstrong & Okun, 2020). More precisely, cognitive and emotional symptoms may involve difficulties with attention language, reduced motivation memory, and increased anhedonia and apathy (Lauring et al., 2019b; Connolly & Lang, 2014; Grover et al., 2015; Le Bouc et al., 2016), as well as a reduced ability to distinguish emotional information (Enrici et al., 2015; Lauring et

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[1] Bradykinesia = “Slowness and progressively smaller movements (hypokinesia)as an individual repeats a task (e.g., tapping index finger and thumb, opening and closing fist) multiple times in a row” (Armstrong & Okun, 2020)

[2] Rigiditiy = „Involuntary, velocity-independent resistance to passive movement of a joint (eg, elbow, wrist) by an examiner, with or without a cogwheel phenomenon“ (Armstrong & Okun, 2020)

[3] Rest tremor = “A 4- to 6-Hz tremor in a fully resting limb, which temporarily disappears when the limb is held outstretched and then returns (reemergent tremor) and is not present during movement” (Armstrong & Okun, 2020)

[4] Postural instability = “Balance impairment affecting a person’s ability to change or maintain postures such as walking or standing; typically a late Parkinson disease feature“ (Armstrong & Okun, 2020)

[5] Olfactory loss = sense of smell is decreased or absent (hyposmia) (Armstrong & Okun, 2020)

[6] Sleep dysfunction = “symptoms of rapid eye movement sleep behavior disorder, daytime sleepiness, sleep-maintenance insomnia” (Armstrong & Okun, 2020)

[7] Autonomic dysfunction = “Constipation, delayed gastric emptying, urinary urgency and frequency, erectile dysfunction, orthostatic hypotension, blood pressure variability“ (Armstrong & Okun, 2020)

[8] Cognitive impairment = “Mild cognitive impairment or dementia, often initially affecting attention, executive, and visuospatial functions“ (Armstrong & Okun, 2020)

[9] Hypophonia = Softening of the voice (Gates et al., 2024)

[10] Sialorrhea = Hypersalivation or excessive drooling (Isaacson et al., 2020)

al., 2019b). Furthermore, sensory symptoms involve impaired olfaction and vision (Lauring et al., 2019b; Bayulkem & Lopez, 2011; Chaudhuri et al., 2006; Sveinsbjornsdottir, 2016). The electrophysiological and morphological evidence of a disrupted retinal structure and function (Lauring et al., 2019b; Bodis-Wollner et al., 2014), damaged visual cortices, or ventral and dorsal pathways, or visual associated-related areas in the brain (Archibald et al., 2013; Bodis-Wollner, 2009; Diederich et al., 2014) may tie to a range of symptoms in the sensory field, such as suggested "blurred or double vision, reduced contrast sensitivity, color discrimination (Alenicova et al., 2017; Müller et al., 2002; Oh et al., 2011), motion detection and perception of space (Davidsdottir et al., 2005); and selective attention or visual recognition (Bodis et al., 2009)" (Lauring et al., 2019a, p. 2). In addition to psychiatric symptoms like depression and anxiety (Armstrong & Okun, 2020; Bayulkemand & Lopez, 2011; Connolly & Lang, 2014; Grover et al., 2015), symptoms also include hallucinations (Lauring et al., 2019a; Conolly & Lang, 2014; Diederich et al., 2014; Fénelon et al., 2010), and compulsive or repetitive behaviors (Lauring et al., 2019a).

Table 1

Overview of symptoms of Parkinson's Disease

Motor-symptoms	**Non-motor symptoms**			
Motor symptoms	**General non-motor-symptoms**	**Cognitive & emotional symptoms**	**Sensory symptoms**	**Psychiatric symptoms**
• Bradykinesia • Muscular rigidity • Rest tremors • Postural instability • Gait impairment	• Prodormal symptoms • Olfactory loss • Sleep dysfunction • Autonomic dysfunction • Fatigue • Hypophonia • Sialorrhea • Trouble of swallowing	• Difficulties with attention language • Reduced motivation memory • Increased anhedonia • Increased apathy • Reduced ability to distinguish emotional information	• Olfaction and vision • Blurred or double vision • Reduced contrast sensitivity • Reduced Color discrimination • Reduced motion detection	• Depression • Anxiety • Hallucinations • Compulsive or repetitive behaviors • Psychosis

Classification

Integrating aspects of PD-related impairment of cognition and motor ability into approaches for art assessment (see 3.1.2) could help identify how these specific symptoms and the different stages of disease progression at which they occur could impact artistic production or creativity in general. Similarly, to collect descriptive data about PD patients' symptoms, questionnaires should include items asking about the exact classification of PD. Numerous different scales are utilized to classify PD.

The *Unified Parkinson's Disease Rating Scale* (UPDRS; Fahn & Elton, 1987), updated to the MDS-UPDRS (Stebbins et al., 2007), is the most common scale by medical doctors and researchers to assess and document symptoms. Therefore, this classification scale is included to gather an accurate description of the sample of PD patients (see Section 3.1.2). Moreover, MDS-UPDRS, with the four-part structure, is often used to classify disease severity (Goetz et al., 2007). Part I assesses "Nonmotor Experiences of Daily Living," including items to evaluate for complex behaviors requiring medical expertise (i.e., cognitive impairment, anxious mood). Part II focuses on "Motor Experiences of Daily Living" (i.e., speech, eating tasks). Part III measures for "Motor Examination" (i.e., speech, facial expression, rigidity). In Part IV, two "Motor Complications," dyskinesias and motor fluctuations, are assessed by a neurologist based on clinical observation and judgments of patient-derived information. All items offer five response options on a 0 – 4 scale (0 = normal, 1 = slight, 2 = mild, 3 = moderate, and 4 = severe) (Goetz et al., 2007).

Additionally, the *Hoehn and Yahr (HY) Scale* (Hoehn & Yahr, 1967) is typically used to describe PD stages based on the assessment of symptoms (Goetz et al., 2004). The HY scale ranges from Stage I to Stage V, reflecting the severity of motor disability in PD. In stage I, motor impairment is unilateral (one side), with no or minimal functional impairment. Stage II is characterized by bilateral (both sides) or midline motor impairment and balance issues. In Stage III, patients exhibit impaired postural reflexes but can still live independently, albeit with some activity restrictions, depending on the type of activity. In this stage, disabilities are seen as mild to moderate. Stage IV represents a fully developed disease with severe disability, where patients can still walk and stand without assistance but are significantly incapacitated. The most severe stage is Stage V, where patients are bedridden or reliant on a wheelchair unless receiving external aid. For some clinical trials, 0.5

increments between Stage I and II and Stage II and III were introduced in the modified HY scale (Goetz et al., 2004). For this study, PD patients were excluded when they were classified in the HY stage 5 of PD. Further, it was hypothesized that PD patients have a looser style as the HY stage increases. In addition, a quadratic trend for complexity and beauty was detected, which seemed to peak in very early HY stages (between HY I and HY II; for a review, see Lauring et al., 2019b). As already mentioned, no descriptive data was provided for the PD cohort in this study, except for the exclusion criteria. Thus, this study cannot assess the proposed impact of more severe HY stages.

Ultimately, for completeness, the *Braak stages of lesions* (Braak et al., 2003) are applied to organize specific damage to the brain to PD. Damages or brain lesions are classified from Stage 1 to Stage 6 (lesions getting more severe), which will not be further described as they are not utilized for this study or in the proposed art assessment approach.

In general, it is feasible to describe the progression of PD by combining the factors, MDS-UPDRS, HY scale, and Braak stages of lesions (Lauring et al., 2019b; Hawkes et al., 2010; Skorvanek et al., 2017; Zhao et al., 2010). The combination indicates a broad timespan of approximately forty years. The initial twenty years involve subtle changes in particularly non-motor regions and eventual cognitive and emotional symptoms, usually emerging three years before diagnosis. This phase is followed by the onset of motor symptoms, diagnosis, and treatment (HY Stage 1, Braak Stage III). The subsequent period, extending up to twenty years post-diagnosis, is marked by increasing cognitive, emotional, and visual symptoms (corresponding to HY Stage 3-5) in individuals diagnosed with PD (Lauring et al., 2019b).

Treatment

The initial pharmacological treatment for motor symptoms of PD commonly involves DA replacement, typically administered via oral levodopa preparations (Armstrong & Okun, 2020). As PD progresses, patients tend to lose their ability to respond to dopaminergic medication over more extended periods, leading to a need for more frequent doses of levodopa (Chou et al., 2018). In addition, the brain can no longer store extra DA (regardless of whether it is internally produced or provided via medication) for later use (Chou et al., 2018). This treatment is often enhanced with DA agonists, which boost the brain's responsiveness to DA, and monoamine oxidase-B (MAO-B)-inhibitors. Since every treatment has its benefits and risks, it is often considered to find the individual optimal strategy by combining levodopa, DA agonists, or MAO-B inhibitors.

Furthermore, advanced therapies can be included in the treatment plan for patients with motor symptoms that are medication-response but suffer from difficulties like off periods or dyskinesias that are irresponsive to medication adjustments. Advanced therapies include deep brain stimulation (DBS)[11], magnetic resonance imaging (MRI)-guided focused ultrasound[12], and therapy with levodopa-carbidopa enteral suspension[13] (Armstrong & Okun, 2020). DBS is utilized to manage motor symptoms, tremors, and dyskinesia associated with the wearing-off effects (Fox et al., 2018). Furthermore, meta-analyses suggest an improvement in the MDS-UPDRS scores on medication (Shulman et al., 2010; Bratsos et al., 2018). Some studies regarding art-related changes in PD focus on patients being on or off DBS/MRI-focused ultrasound and describe possible effects of these (see Section 2.2.2 for a review), while unfortunately, no detailed description of the exact medication and therapies of PD patients in the study is available. Particularly in older age individuals (≥ 75 years), outcomes from DBS are often worse since patients are showing more cognitive impairment (predominantly dementia) and the presence of levodopa-unresponsive symptoms like gait or balance disturbance (Moro et al., 2006).

These therapies are often combined with other effective interventions treating motor symptoms of PD (e.g., music- and dance-based approaches, gait training), as

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[11] DBS entails the surgical insertion of unilateral or bilateral leads (wires) into the subthalamic nucleus or globus pallidus interna. These leads are connected to a battery implanted in the chest, like a pacemaker. Patients undergo programming sessions after surgery to fine-tune the stimulation settings and adjust their medications (Armstrong & Okun, 2020). Further, in some cases, the ventralis intermedius nucleus (thalamus) is used as a target area, which can reduce medication-refractory tremor, especially in combination with MRI-guided focused ultrasound (Bond et al., 2017).

[12] In focused ultrasound, the target area (thalamus) is burned by highly focused ultrasound beams, with MRI guidance to accurately target and monitor the extent of the lesion (Bond et al., 2017).

[13] Levodopa-carbidopa enteral suspension = Instead of oral administration, levodopa gel is delivered continuously through a pump via a percutaneous endoscopic transgastric jejunostomy, which results in more stable plasma levodopa levels (Virhammer, 2017)

well as pharmacological treatment for non-motor symptoms of PD (similar to the general population; Armstrong & Okun, 2020) that may help to maintain or improve these (Factor et al., 2016), as well as.

Overall, at this time, the progression of PD cannot be prevented or delayed by any available pharmacologic treatments (Fox et al., 2018).

2.2. The Intertwine of Creativity and Parkinson’s Disease

While current therapeutic interventions aim to manage PD's motor and non-motor symptoms, the condition also presents an unexpected link to creativity, particularly in visual art-making. In addition, people with PD may undergo art therapy, as this is a clinically efficient complementary treatment for the disease (Ettinger et al., 2023).

2.2.1. Visual Creativity & The Art-Making Process

Understanding the relationship between creativity and PD requires an examination of the art-making process itself (Pelowski et al., 2017). During the 1920s and 1930s in the U.S. and Europe, art-making became a focus due to the growing interest in assessing people's skills, aptitudes, and personalities, alongside a rising conversation about "creativity."

This led to the development of standardized assessments of human visual memory and perspective or spatial arrangements (e.g., Meyers & Meyers, 1995; McManus et al., 2010). Aesthetic reception, linked to art viewing, and artistic production, linked to creating art, are both at the ends of the art spectrum (Pelowski et al., 2017). Due to the complex and dynamic nature of art-making processes, there are fewer studies on artistic production than on artistic reception (Chatterjee, 2010; Lundy, 2012). In contrast, this is the opposite for studies focusing on artistic production and neurodegeneration. Despite the difficulty of conceptualizing what creativity in art should look like, a shifting definition of art itself, and the possible differences between cultures (Pelowski et al., 2017), some noteworthy studies on creativity in art exist. One part of the art assessment approach will include tasks where participants have to produce drawings or artwork (see Section 3.1.3). Thus, it is important to look at theories discussing the art-making process.

Building on previous theories (Campbell, 1960; Niu & Sternberg, 2011; Wallas, 1926 (cited in Torrance, 1988; see Niu & Sternberg, 2011 for a review); Tinio, 2013), a model proposed by Lauring et al. (2019a) suggests that the art-making process can be broken down into five key aspects. The first aspect is the initial ability to adopt a more accessible idea-generation mode, which includes the desire and/or ability to pursue artistic questions (1). This is followed by generating ideas ('ideation,' e.g., Runco & Chand, 1995) (2). The third aspect involves the actual acting on or pursuing of output (3), followed by the execution of the idea through produced art (4). Finally, the time and attention invested in pursuing an already-began artwork (5) completes the process.

Despite the complexity of defining visual creativity or art-making processes, the model proposes how these can be specified. Moreover, the challenging nature of measuring artistic creativity will be described in the next part.

How is Artistic Creativity measured? As the art assessment approach will include measurements to assess creativity in participants (see Section 3.1.5) and rater-based assessments to rate artwork produced (see Section 3.1.3), it is essential to examine the definition of creativity. For measuring artistic creativity, Lemons (2011) considered approaches from different studies exploring visual creativity (e.g., Dake, 1991; Sternberg & Lubart, 1999) and split them into four main areas: the creative person, product, process, and environment.

“The Creative Person” focuses on the creator and involves the search for aspects of personality or behavior that might correlate with creative achievement or future proficiency (Pelowski et al., 2017; Feist, 1999). Research shows that creative people tend to share specific characteristics that may be connected to individual skills in art, such as independence, resourcefulness, spontaneity (Cassandro & Simonton, 2010; Eyseneck, 1997; Lemons, 2011), tolerance for risks, conflict, or ambiguity (Feldman, 1999), confidence in their abilities, and low levels of cognitive or behavioral inhibition (Eyseneck, 1997). Further, “Openness to experience,” an element of the Big Five Personality Inventory (Costa & McCrae, 1992), has been linked to art making and art viewing (Myszkowski et al., 2014). To assess the creative

person, various scales[14] and biographical inventories[15] (identifying creative talent) can be applied (Pelowski et al., 2017), which will be included as tests for the proposed art assessment approach.

To investigate *“The Creative Art Product,”* most studies focused on assessing general creative ability using tasks where participants had to create figures or images conceptually similar to art making. The use of figural creation instead of other verbal measures is valued since art-making is considered ecologically valid when inducing creative action and offers an alternative to verbal tests of creativity when emphasizing visual problem-solving (Pelowski et al., 2017). Standard methods include figure completion tasks[16], free drawings from imagination[17], selection of still-life objects[18], and methods for rating creative art products[19], of which some should be applied when using the art assessment approaches.

“The Perspectives on the Creative Process” refers to the modeling stages of a creative process. Tinio (2013) proposed a model of art making that includes three stages: initialization, expansion and adaption, and finalizing. Other comparable theories (Wallas, 1962; cited in Torrance, 1988; see Niu & Sternberg, 2001 for a review; Getzels & Csikszentmihalyi, 1976; Bogousslavsky, 2005) share the principle that a baseline knowledge of materials, techniques, and approaches is essential for the beginning of art making (Acosta, 2014). Moreover, the creation process often involves ideation, which is the “process of creating an initial idea or goal for the creative act, and, more specifically, the ability to compose ideas that are novel or surprising” (Jackson & Messick, 1965; Kay, 1991). Studies showed a correlation between the assessed creativity of artworks and the time spent thinking of an idea

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[14] E.g., Kaufman Domains of Creativity Scale (K-DOCS; Kaufman, 2012); Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973; see McKelvie, 1995 for review; cited in Pelowoski et al., 2017b; see Section 3.1.4).

[15] Biographical inventories to assess life history to identify creative talent, e.g., Creative Achievement Questionnaire (CAQ; Carson et al., 2005; cited in Pelowski et al., 2017; see Section 3.1.5)

[16] Figure completion tasks involve participants drawing from visual cues pre-printed on a paper (Pelowski et al., 2018; cited in Pelowski et al., 2017; see Section 3.1.4).

[17] E.g., Clark’s Drawing Abilities Test (CDAT; Clark & Zimmerman, 2004; see Section 3.1.3)

[18] Using paradigms where participants have to complete collages or still-life drawings based on predefined arrangements of shapes or objects (cited in Pelowski et al., 2017; see Section 3.1.3)

[19] Complementary approach to rating individuals’ artwork by peers, teachers, or experts (Pelowski et al., 2017; see Section 3.1.3)

before drawing or the time required to rough out the main aspects of a composition (Getzels & Csikszentmihalyi, 1976). All tasks from the ‘Art Making and Drawings’ part in the approaches for art assessment will include not only time for the actual art-making process but also time for ideation (see Section 3.1.3)

Lastly, *“Artistic Development and the Environment”* are often approached through componential models that posit elements that control and influence creative individuals while looking at development and specific interactions of biology, culture, and/or the environment (see Rostan, 1997 for a review; Pelowski et al., 2017). The art assessment approach will correspondingly cover this part by applying different questionnaires and scales to assess personality, life history, demographics, or art interest (see Section 3.1.2 and Section 3.1.5).

2.2.2. Art-related changes in Parkinson’s Disease

"I discovered artistic abilities I never knew I had." (Parkinson’s Europe, 2023)

Numerous case studies over the past thirty years documented changes in art-making activities among individuals with neurological damage or diseases, such as PD or Alzheimer's Disease (Castellani et al., 2010: Drago et al., 2006; Emery, 2004; Mendez, 2004; Miller et al., 1998; Palmiero et al., 2012; Schott, 2012). These studies include assessments of artworks created before and after the disorder onset, revealing intriguing alterations in artistic behavior and motivation (Pelowski et al., 2022).

Studies discuss the potential changes in artistic behavior and motivation before and after the onset of PD (e.g., Inzelberg, 2013; Baloyannis, 2020; Boot et al., 2017), while case studies, e.g., also mention changes in music and poetry (Lauring et al., 2019b). The focus remains on visual art-making due to its universal accessibility and unique ability to record changes on a canvas or page. These observations can be recognized by 41 % of PD patients of PD patients (Spee et al., 2023) reporting noticeable differences in their artistic activities. Similarly, Joutsa et al. (2012) found comparable results in the past, where 20% of PD patients reported changes, with the direction remaining unclear, where 21% reported a decrease, 12% increase, and 8% fluctuations in creativity (Spee et al., 2023).

Overview of changes in artworks from people with PD: The next part will first describe two reviews regarding art-related changes in PD patients shortly. Subsequently, the proposed changes will be described in more detail in Sections 2.2.2.1 to 2.2.2.5. This concludes with an explanation of the limitations of the mentioned studies in Section 2.2.2.6.

Lauring et al. (2019a) published a paper reviewing 16 relevant publications regarding PD and creativity changes. First, the authors compared studies of artists with a PD diagnosis and explored changes in artistic creativity, motivation, and style (Lakke, 1999; Pinker, 2002; Kulisevsky et al., 2009; Schwingenschuh et al., 2010; Forsythe et al., 2017; Witt et al., 2006; Drago et al., 2009a; see Table 2 for an overview). These changes will be described in detail in the next paragraphs. All studies were based on subjective ratings, except for Witt et al. (2006) and Drago et al. (2009a), both additionally concerned DBS. In addition, Forsythe et al. (2017) also compared artworks from across the lifespans of two artists diagnosed with PD, Salvador Dali, and Norval Morriseau, assessing fractal dimensions using computer analysis.

A similar review from Pelowski et al. (2022) tried to find systematic evidence for art-related changes that are linked to neurodegenerative diseases such as Alzheimer's disease, PD, strokes, or aphasia. For the analysis, they utilized 32 published individual artworks from previous studies (10 artworks pre-disease/diagnosis; 22 artworks post-disease/diagnosis). These artworks were then rated (including artworks for the other neurodegenerative diseases) with scales measuring for formal-perceptual factors (e.g., balance, color saturation), conceptual-representational factors (e.g., abstractness, symbolism), and additional factors (e.g., page usage, artistic creativity). In addition, structural complexity was measured via fractal dimension (FD). The results from Pelowski et al. (2022) suggested general overall changes in the quality and creativity of produced art, color perception, style and content, and emotional expressivity.

Researchers propose that the mentioned patterns can serve as a 'roadmap' of 'artistic signatures,' providing an evidence-based insight into the functional, cognitive, and neurobiological changes associated with the onset and progression of disease (Baloyannis, 2020; Boot et al., 2017; Chatterjee, 2004; Gretton & Ffytche, 2014; Lauring et al., 2019b; Lindemann, 2014; Pelowski et al., 2020; Snyder & Barlow, 1988; Zaidel, 2014).

The next section will provide a detailed description of all changes that might be connected to PD (artistic motivation and creativity, quality, style and content, color, and emotional expressivity). Additionally, Table 2 includes an overview table of all changes mentioned in the upcoming part. These factors (excl., color) will also further be analyzed in the forthcoming study.

Table 2

Overview of PD-related changes in artworks

Artistic motivation & creativity	**Decline:**
	• Reduced DA correlated with decreased creativity • *Shimura et al. (2012):* (2012): Diminished artistic creativity in non-creative • *Canesi et al. (2012):* Decreased motivation in non-creative patients • *Drago et al. (2009c):* Decreased verbal creative fluency
	Neutral:
	• *Canesi et al. (2012):* No change
	Increase:
	• *Lakke (1999, p. 471):* Rising urge to make artwork • Several studies: Positive changes in motivation towards making art & creativity • *Pinker, 2000:* Felt more creative • *Kulisevsky et al. (2009):* Artwork production increased • *Schwingenschuh et al. (2010):* Increased DA helped to enhance creativity after not feeling creative • *Forsythe et al. (2017):* Artists with PD showed significantly higher FD • *Chatterjee et al. (2006), Joutsa et al. (2012a), Walker et al. (2006), Witt et al., 2006):* Getting artistically productive after diagnosis/medication/ DBS
Quality	**Decline:**
	• Decline in quallity on DBS
	Neutral:
	• *Lakke (1999), Pinker (2002), Schwingenschuh et al. (2010), Drago et al. (2009a): No* decline in quality
	Increase:
	• *Pelowski et al. (2022):* Ratings tend to be higher for quality and creativity • *Drago et al. (2009a):* Quality seems to improve presymptomatic • *Kulisevsky et al. (2009):* Commercial success and exhibitions of artworks
Style & Content	**Changes**
	• *Lakke (1999):* Compositional imbalance, lack of vertical or fluid strokes, cross-hatching, changes in format or style • *Kulisevsky et al. (2009):* Shift towards impressionism with emphasis on color and light (post-PD) • *Drago et al. (2009a), Chatterjee et al. (2006):* Change towards more abstract and less realistic artwork • *Drago et al. (2009a):* more colorful, cross-hatching • *Shimura et al. (2012):* Gradual transformation from abstract art into realism • *Pelowski et al. (2022):* Trend for symbolism & abstraction • *Witt et al. (2006), Shimura et al. (2012):* Theme change

	• *Drago et al. (2009b):* Significant reduction in the evocative impact
	No changes
	• *Chatterjee et al. (2006):* Lines seemed to stay regular in thickness and spacing
Color	**Changes**
	• *Pinker (2002), Chatterjee (2006):* Shift towards usage of more vibrant colors • *Lauring et al. (2019a), Pelowski et al. (2022):* Shift towards more saturated colors • *Kulisevsky et al. (2009):* Increased emphasis on color and light • *Walker et al. (2006):* Strong sense of color and kinesthesia • *Drago et al. (2009a):* Artworks being less colorful • *Lauring et al (2019), Pelowski et al (2022):* Colors becoming subjectively cooler
Emotional expressivity	**Decline**
	• *Assogna et al (2008), Enrici et al. (2015), Gray & Tickle Degnen (2010), Serranová et al. (2011):* Decreased emotion perception tied to reduced ability in emotion recognition • *Lima et al. (2013), Mattei et al. (2013); van Tricht et al. (2010):* Lowered proficiency in classification & perception of emotions in environment
	Increase
	• *Kulisevsky et al. (2009):* Patients felt emotional relief while evaluating art posivitely • *Canesi et al. (2012), Kulisevsky et al. (2019), Lakke (1999), Shimura et al. (2012), Lauring et al. (2019a), Pelowski et al. (2022):* Increased emotionality, reporting mood changes & emotional expressivity • *Lauring et al. (2019a):* Overcompensation or increased emotional signals may lead to shift towards emotion

Note. Summarized from Lauring et al. (2019a); Pelowski et al., (2022).

2.2.2.1. Artistic Motivation & Creativity

Table 2 shows an overview of all changes regarding artistic motivation and creativity in people with PD (Lauring et al., 2019a; Pelowski et al., 2022). Since motoric deficits are one of the most common symptoms in PD, one could suggest that creativity and style in artists with PD would be affected by the physical difficulties (i.e., rigidity, tremors) and the loss of cognitive and executive functions with the progressing disorder (Lakke, 1999). Despite the physical and cognitive complications, Lakke (1999) found that all 40 artists in his study show further remaining and growing their creativity. Lakke (1999, p. 471) stated that some patients mentioned a rising urge to make artwork or that they experience a trancelike state during hyperkinetic periods. This study was limited by subjective judgments and the missing medication record (Lauring et al., 2019a). Subsequently, interest in this field suddenly evolved, and other clinical case reports (often with a few of the authors' patients) arose.

Several studies stated positive changes in motivation towards making art as well as creativity (Pinker, 2002; Kulisevsky et al., 2009; Forsythe et al., 2017; Walker et al., 2006; Chatterjee et al., 2006; Joutsa et al., 2012a; Llhomée et al., 2014). In a case study from Pinker (2002), PD patients noticed that they felt more creative since their diagnosis, with a "need to express" themselves and let themselves go. Further, Kulisevsky et al. (2009) found that artwork production increased from one painting in several months to one per week up to two years after starting their DA therapy, followed by painting into the night after three years. Canesi (2016) and Llhomée et al. (2014) mentioned that this phenomenon seems not to be related to impulse control disorder, which often arises in patients receiving dopaminergic treatment. Correspondingly, one hobby painter-PD patient of the study from Schwingenschuh et al. (2010) described that increased DA helped to enhance creativity after not feeling creative. In addition, Forsythe et al. (2017) assessed fractal dimensions by using computer analysis to compare artwork from artists before and after the PD diagnosis[20] with three typical aging control artists. The authors reported that in contrast to the control group, the output of artists with PD showed significantly higher FD and had periods of output above their annual average. Other studies described the effects of getting artistically productive after the PD diagnosis (Chatterjee et al., 2006; Joutsa et al., 2012a), the increase in DA medication (Walker et al., 2006), or being treated with DBS (Witt et al., 2006). Moreover, spontaneously creative PD patients experienced greater artificial euphoria[21] during DA agonist treatment. In contrast, reduced DA significantly correlated with decreased creativity (Lhommée et al., 2014). In a pre-and post-DBS study by Drago et al. (2009a), the authors mentioned that the creativity index was above average pre-DBS (but did not report a creativity index post-DBS). Additionally, some studies have not found any changes in motivation or creativity (Canesi et al., 2012) or even have stated opposite effects, such as diminished artistic creativity (Shimura et al., 2012), decreased motivation in non-creative PD patients (Canesi et al., 2012), or decreased verbal creative fluency

[20] Forsythe et al. (2017) compared artworks across lifetimes from artists (Salvador Dali, Norval Morisseau) who were not only diagnosed with PD but also with Alzheimer's Disease. These were matched with normal-aging control artists (Marc Chagall, Claude Monet, Pablo Picasso).

[21] Artificial euphoria = Refers to a state of intense happiness or excitement that is induced by external factors (.e.g, substance use, manipulative environments) rather than arising naturally from within an individual (Gierzynski et al., 2024)

(Drago et al., 2009c). Particularly, Kulisevsky et al. (2009) and Lhommée et al. (2014) hypothesized that the increased motivation or creativity results from DA agonist medication, as the motivation to produce art diminished after stopping or lowering the dosage. Similar results were found for DBS, possibly because of lower needed dosages, even if DBS itself also led to changes in art rating (Lauring et al., 2019a). In addition, Canesi et al. (2016) did not find significant effects of DA pharmacotherapy and the emergence of artistic creativity but still reported an increased motivation to create. This offers a contrast to the other studies, where creativity-related changes were often connected to Parkinsonian treatment.

Increased motivation and reward in art-making are especially associated with dopaminergic treatment (see Lauring et al., 2019a for review). DA is a crucial modulator of reward processing (Berridge et al., 2009; Salimpoort et al., 2011), related to the mesolimbic dopaminergic circuit and is tied to the regulation of personal pleasure, received from an activity via “hedonic hotspots,” located in subcompartments within the nucleus accumbens (NAcc) shell, ventral palladium, insula, and orbitofrontal cortex (OFC) (Berridge & Kringelbach, 2013, 2015). As described in Section 2.1.1, many of these brain areas from the mesolimbic dopaminergic circuit are similar to those activated in artistic behavior (Lauring et al., 2019a; see also Figure 1). Further, PD patients often described a felt impulse to make art (Chatterjee et al., 2006; Kulisevsky et al., 2009). Weintraub & Nirenberg (2013) reasoned that this could be tied to impulse control issues, a complication of high-dosage DA agonist therapy, while Canesi et al. (2011) showed that the impulse to create art in patients with PD is not associated with impulsivity or ICDs.

Importantly, this connection between dopaminergic medication, brain regions, and reward or motivation does not fully explain why changes may be detected in ability itself, style, or quality (Lauring et al., 2019a).

2.2.2.2. Quality

In general, previous studies did not find any decline in quality (Lakke, 1999; Pinker, 2002; Schwingenschuh et al., 2010; Drago et al., 2009a; see Table 2). On the other hand, ratings tend to be even higher for quality and creativity (Pelowski et al., 2022), and quality seems to improve presymptomatic (Drago et al., 2009a), even showing commercial success and exhibitions of artworks (Kulisevsky et al., 2009).

However, a decline in quality was detected in PD patients on DBS (Chatterjee et al., 2006), further supporting the argument that changes in art-making might be tied to dopaminergic therapy (Lauring et al., 2019a).

2.2.2.3. Style and Content

Numerous studies explored changes in style and content in PD patients (see Table 2), finding some evidence for changes (Lakke, 1999; Kulisevsky et al., 2009; Shimura et al., 2012); Witt et al., 2006; Drago et al., 2009a; Chatterjee et al.; 2006; Drago et al., 2009b; Pelowski et al., 2022), while at the same time, some other studies did not report any changes (Pinker, 2002; Forsythe et al., 2017; Llhommée et al., 2014; Canesi et al., 2012). Lakke (1999) reported compositional imbalance, lack of vertical or fluid strokes, unusual manner of hatching (cross-hatching), and changes in format or style. Furthermore, a shift towards impressionism with an emphasis on color and light (Post-PD) instead of detailed and figurative painting, accurate reflection of reality, and an emphasis on shape and detail (Pre-PD) was noticed by Kulisevsky et al. (2009). These changes were justified by a need for greater emotional expressivity by PD patients. Correspondingly, a change towards more abstract and less realistic artwork was observed (Drago et al., 2009a; Chatterjee et al., 2006), as well as being more colorful (Drago et al., 2009a) and showing cross-hatching, while lines seemed to stay regular in thickness and spacing (Chatterjee et al., 2006). Conversely, Shimura et al. (2012) found a gradual transformation from abstract art into realism shortly after PD diagnosis. Even if not significant, Pelowski et al. (2022) stated a trend for symbolism and abstraction with a concomitant increase in realistic content and themes. At the same time, only some studies reported a theme change (Witt et al., 2006; Shimura et al., 2012). Both studies represented atypical (non-medicine- or DBS-related) patients (Lauring et al., 2019a). Furthermore, a significant reduction in the evocative impact (How strongly the painting induces feelings or thoughts was found (Drago et al., 2009b).

Especially in artistic style, not merely dopaminergic treatment is considered to be an explanation for changes, but also brain damage caused by PD. Diminished functionality in the nigrostriatal DA areas, connected to tremors or issues with motor control, could be tied to changes in mark-making, such as less fluid vertical lines or cross-hatching (Lauring et al., 2019a). Moreover, this could also be associated with blurred vision or impaired processing of spatial relations, which are often connected to decreased DA in the retina, other issues within visual cortices and pathways, sensory association areas, as well as effects of dopaminergic medication (Archibald et al., 2013; Diederich et al., 2014; Müller et al., 2002). The ability to identify line orientation may be reduced by damage in parietal regions (Drago et al., 2009b).

2.2.2.4. Color

In addition to changes in style and content, a shift towards the usage of more vibrant (Pinker, 2002; Chatterjee et al., 2006) or saturated colors (Lauring et al., 2019a; Pelowski et al., 2022), as well as increased emphasis on color and light (Kulisevsky et al., 2009), could be detected (see Table 2 for an overview). Other studies recognized a strong sense of color and kinesthesia[22] (Walker et al., 2006), a restricted color palette, and a move towards denser and darker tonality (Chatterjee et al., 2006), and artworks being less colorful (Drago et al., 2009a), or becoming subjectively cooler (more blue/green) (Lauring et al.; 2019a; Pelowski et al., 2022). However, Lauring et al. (2019a) reported a relation between age and increasing brightness and decreasing saturation regardless of the PD diagnosis. Changes in color utilization and perception may be caused by overusing or ignoring specific colors or increasing their intensity, as in color “blue” (Lauring et al., 2019a), because of the difficulty of perceiving this color (Alenicova et al., 2017).

2.2.2.5. Emotional Expressivity

Another aspect that seems to change is emotional expressivity (see Table 2). PD patients justified the changes in style with a need for emotional expressivity. They claimed they could move more easily and felt emotional relief while evaluating art positively (Kulisevsky et al., 2009). Conversely, evidence from previous studies would have proposed decreased emotion perception as PD has been tied to reduced ability in emotion recognition (Assogna et al., 2008; Enrici et al., 2015; Gray & Tickle-Degnen, 2010; Serranová et al., 2011) or lowered proficiency in the classification and

[22] Kinesthesia = Kinesthesia is the sense that allows individuals to perceive the position, movement, and spatial orientation of their body parts through feedback from muscles and joints, enabling coordination and balance during physical activities (Stillman, 2002).

perception of emotions in the environment (Lima et al., 2013; Mattei et al., 2013; van Tricht et al., 2010). However, current studies do support evidence for increased emotionality by reporting mood changes and emotional expressivity in combination with greater emphasis on colors and abstraction (Canesi et al., 2012; Kulisevsky et al.; 2019; Lakke, 1999; Shimura et al., 2012; Lauring et al., 2019a; Pelowski et al., 2022). It is proposed that overcompensation or increased emotional signals in detection may lead to a shift towards emotion (Lauring et al., 2019a).

Furthermore, patients reported an increased focus on mood or emotion (e.g., Lakke, 1999; Kulisevsky et al., 2009). It is suggested that patients might explore their emotions due to their felt ambiguity (Lauring et al., 2019a) as PD has been connected to lowered proficiency in emotion recognition (Assogna et al., 2008; Gray & Tickle-Degnen, 2010; Serranová et al., 2011) and reduced intensity of negative emotions (Vicente et al., 2009).

Overall, the changes in style and attitude could improve quality, make people freer in their produced artworks, make them do less inhibited marks, and get more colorful, abstract, and impressionistic (Lauring et al., 2019a).

Other possible factors explaining these changes that should be mentioned could be tied to contextual factors in the everyday lives of PD patients (e.g., suggestions to make art as a means of rehabilitation) (Lauring et al., 2019a). Additional possible explanations include personal or biological prerequisites, such as individual characteristics linked to a higher interest in art-making, and genetic aspects, such as the dopamine active transporter gene, responsible for DA reuptake and associated with cognitive flexibility.

Since art-related changes seem to consist predominantly of areas linked to premotor symptoms of the disease, such as perception, cognition, and emotion regulation, an advanced comprehension of these changes could also offer promising tools for understanding PD itself (Lauring et al., 2019a). As the current understanding suggests that PD is apparently already "neuropathologically severely advanced and possibly irreversible" by the time motor issues appear (Hawkes et al., 2010, p. 82), it is crucial to find ways to diagnose PD before the most apparent symptoms occur. Forsythe et al. (2017) state that results suggest a possibility to identify atypical changes in artwork and that these changes may not only tie to DA treatment but also to low-level cognitive and affective symptoms of PD. Art-making or aesthetic response could contribute their part by the potential to identify particular art-making or rating changes and tie these to brain damage or modulation processes (Lauring et al., 2019a).

In general, this might provide opportunities for future therapy, differential diagnosis, or early PD detection (Bech et al., 2017; Chancellor et al., 2014). The most promising factors that could be included for identifying art-related changes include visual complexity and cross-hatching (as in Forsythe et al., 2017), or changes towards abstraction, higher emotional expressiveness, and a shift towards bluer shades in color (Lauring et al., 2019a).

2.2.2.6. Limitations of Previous Research

Even if past research shows promising evidence for artistic changes in PD patients, these studies have significant limitations in their approaches. First, many case studies consisted of only a small sample of PD patients, often assessing only one person (e.g., Kulisevsky et al., 2009; Shimura et al., 2012; Witt et al., 2006, etc.).

Moreover, future studies should contain a more detailed description of their cohort, including a clinical assessment of PD symptoms, identification of specific stages or laterality, a clear history of medication and treatment, and corresponding reports of behavior (Lauring et al., 2019a). Additionally, the reasons why PD patients begin to make art and if they are registered in art therapy programs should be reported (e.g., Canesi et al., 2016). Another aspect that should be mentioned is the utilization of inconsistent artworks. As previous studies frequently had to work with existing artwork or different types of artworks from various studies were put together in computational analysis, artworks and thus detected changes in artworks are not entirely comparable.

One of the most critical limitations is the missing systematic methodology in the assessment of artwork since only a few studies include a more systematic method in their evaluations (e.g., Drago et al., 2009a; Forsythe et al., 2017; Lauring et al., 2019a; Pelowski et al., 2022). Evaluations of almost all previous studies merely consisted of subjective opinions of the artist or the author without including any other more objective method. For a better investigation and to shed light on existing art-related changes, techniques from aesthetic psychology for assessing artworks and art viewing (e.g., Pelowski et al., 2018) should be applied (Lauring et al., 2019a). To detect art-related changes that might reveal underlying changes in the brain, systematic approaches for art assessment should be developed to detect changes in art (Chatterjee et al., 2010; Lauring et al., 2019a). In addition, computer-based methods could be implemented to measure color or complexity (e.g., FD in Forsythe et al., 2017; Lauring et al., 2019a; Pelowski et al., 2022).

3. Methods: Application and Development of Art Assessment Approaches for PD

This section is divided into two parts. Part 1 will describe the Art Assessment Approaches, including one specific task, that will be utilized in Part 2, where produced artworks (N = 210) from the ‘Cued, Drawing Task’ (Pelowski et al., 2018) from PD patients and HC will be rated by subjective lay raters (N=35) to explore systematic differences in art-related factors such as quality, emotional expressivity, style and content, and creativity. In addition, a computer-based analysis (FD) will be applied to analyze differences in artwork complexity.

3.1. Part 1: Development Art Assessment Approaches

One aim of this master thesis is to develop a comprehensive art assessment approach to facilitate future comparisons between patients and healthy cohorts, with the potential to identify changes before motor symptoms manifest. Analyzing specific changes in the artistic approach may provide insights into other PD-related symptoms, such as compulsion and punding (Schwingenschuh et al., 2010).

This will be conducted as part of the project "Unlocking the Muse: Transdisciplinary Approaches to Understanding the Intersection of Artistic Creativity and Parkinson's Disease," led by the University of Vienna. The project is coordinated by Asst.-Prof. Dr. Matthew Pelowski from the University of Vienna, Faculty of Psychology, Department of Cognition, Emotion, and Methody in Psychology, along with collaborating researchers Dr. Julia Crone from the University of Vienna, Vienna Cognitive Science Hub (Vienna CogSciHub), and Mag. Blanca T.M. Spee, PhD from the University of Vienna, Faculty of Psychology, Department of Cognition, Emotion, and Methods in Psychology, as well as Vienna CogSciHub, and Radboud University Medical Center (Radboudumc), Donders Institute for Brain, Cognition and Behaviour. Another collaborating international research institute is Prof. Dr. Bastiaan R. Bloem, MD, FRCPE from Radboudumc, Department of Neurology as the Head of the Centre of Expertise for Parkinson & Movement Disorders (ParC), Donders Institute for Brain, Cognition and Behaviour.

3.1.1. Description of the Development Process

The art assessment program will include drawing paradigms, standardized perception, and cognitive tests to explore potential correlations with visual creativity that are yet to be systematically linked to art or PD. Several tests previously associated with art-making ability in a healthy cohort by Pelowski et al. (2018) will be included. In addition, these tests were chosen in retrospect of the described theory for measuring creativity in Section 2.2.1. Moreover, it will encompass subjective assessments, as only certain individuals may exhibit artistic changes, suggesting potential insights that could be gained from systematically evaluating life history, art training or interest, and interpersonal or contextual differences in PD patients (Pelowski et al., 2017; Pelwoski et al., 2018; Rostan et al., 2002). The art assessment approach is divided into four parts: (1) Description of the study population, (2) Art Making and Drawings, (3) Objective perception, memory, and IQ measures, (4) Subjective personality, art ability, interest, and creativity assessments. An overview of all 24 implemented sub-tests is shown in Table 3, while the next section will provide a detailed description of each part and sub-test.

Table 3

Overview of Art Assessment Approaches including test/task/paradigm, operationalization and relevant factor for PD

Art Assessment Battery Test / Task / Paradigm	Operationalization	Factor
1. Description of study population		
1.1. Disease-Related Aspects and General Demographics	Including age, gender identity, ethnicity, education, living situation, working status, diagnosis, age of diagnosis, duration of disease in years, laterality, body side predominantly affected by PD, medication, and severity of ON/OFF experience.	Demographics and disease-related aspects
1.2. Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS; Stebbins et al., 2007)	Objective Classification of the severity of PD	Part 1: Non-motor and motor aspects of daily living experiences, including hallucinations Part 2: Motor examination
1.3. Standardized Evaluation of Colour Vision (Ishihara test)	Assessment of colour vision deficiency using Ishihara test; qualitative assessment of colour perception	Colour vision deficiency

2. Art Making and Drawings		
2.1. Cued, Free Drawing (Pelowski et al., 2018)	Assesses an individual's ability to spontaneously produce quality, aesthetically pleasing, creative, and/or technically proficient visual artworks in a free style that can be either abstract/representational, using any part of page, including symbolism, etc.	Artistic production 1) Finished artwork 2) Movement in the drawing task (from video recordings)
2.2. Hand Drawing Task (McManus et al., 2010; Chamberlain et al., 2013)	Assesses an individual's ability to accurately recreate a given image, reflecting visuospatial ability, skill in copying, and perceptual-motor encoding and control in a visual art domain.	Realistic drawing, approach, execution, correlation between other artworks and copying
2.3. Clark's Drawing abilities test (CDAT; Clark & Zimmermann, 2004) + Verbal Cue (Pelowski et al., 2018)	Assesses realism, drawing from imagination, originality, and free expression in drawings made from the imagination after hearing the verbal cue.	Realism, Drawing from imagination, originality and free expression ('fantasy' drawing and 'verbal cue'), Accuracy, Ability to complete task in a given timeframe
2.4. Drawing Emotions (Pelowski, 2024)	Assesses two main factors: (1) Emotional expressivity of the drawings and (2) Emotional recognition while viewing the drawings through two phases (1) Phase 1: Drawing and (2) Phase 2: Art Viewing.	Emotional expressivity, Emotional recognition, Creativity
2.5. Colour choice in Drawing emotions (Based on Damiano et al., 2023 and Pelowski, 2024)	Assessing the creative expression and the spontaneous choice of colour for the emotion term "wonder", "pride", and "relief".	Colour usage (warm/cool), colour-emotion-association, correlation between preference and usage, emotional expressivity, creativity
3. Objective perception, memory, and IQ measures		
3.1. Rey-Osterrieth Complex Figure test (ROCFT; Rey & Osterrieth, 1993	This test assesses visuospatial abilities and memory by asking participants to copy a complex figure and then reproduce it from memory.	Visuospatial ability, immediate and delayed visual memory
3.2. Cain's house task (Cain, 1943; McManus et al., 2010)	Participants are asked to make an exact copy a series of five irregular hexagons resembling houses.	Spatial processing (via attention to angles) and attention to proportions (relative side lengths)
3.3. Shepard illusion (Mitchell et al.; 2005; Shepard, 1990)	This test requires the copying of two parellelograms with the same dimensions (2:1) between long and short sides (one horizontally and one vertically, two modalities: with/without legs)	Misperception of proportion, Degree of perceptual distortion
3.4. Group Embedded Figures Test (GEFT; Oltman et al., 1971; Witkin et al., 1971)	Asks participants to find a target shape that is hidden in a more complex figure	Field dependence/independence, local and global visual processing ability
3.5. Out-of-focus picture task (OFPT; Kozbelt, 2001; images from Schooler & Melcher, 1994)	The task requires the identification of an object from a set of ten 3 x 3.75 monochromatic out-of-focus photographs.	Object identification
3.6. Mental rotation (Kozbelt, 2001; images from Vandenberg & Kuse, 1978)	Participants are asked to find two matching, rotated shapes among four possible from a series of target shapes composed of a number of cubes	Cognitive style ('Object','Spatial', 'Verbal')
3.7. 2D and 3D Angle drawings (Ostrofsky et al., 2015)	In this test, participants have to view a series of 2D parallelograms or 3D cuboid shapes and are asked to draw one target angle designated by an arrow	Angle mistakes
3.8. Ravens Advanced Progressive Matrices (APM Short Form; Arthur & Day, 1994; see Arthur et al., 1999 for validation and normalization)	Participants have to find the correct solution for 12 items by matching a pattern depicted in a target image to one of eight possible anwers.	Non-verbal IQ
3.9. Multiple choice vocabulary intelligence test (MWT-B; Lehrl, 2005)	The 'Mehrfachwahl-Wortschatz-Intelligenztest' requires participants to identify a real word from five-word-options-lists with progressing difficulty	Verbal IQ

4. Subjective personality, art ability/interest, and creativity assessments		
4.1. Art-Making ability (Chamberlain et al., 2013; McManus et al., 2010)	Assesses self-assessed ability at several drawing or mark making techniques using a 5-point-Likert scale (1 = “far beyond average”, 5 = “far over average)	Self-assessed art-making ability
4.2. Self-assessed art expertise/training and interest (based on Chatterjee et al., 2010)	Asks for the amount of courses in different domains and number of hours spent in average per week making visual art; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”)	Self-assessed art expertise/training and interest
4.3. Ten Item Personality Measure (TIPI; Gosling et al., 2003)	Brief measure of the big five personality domains; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”)	Extraversion, Agreeableness, Conscientiousness, Emotional stability, Openness to experience
4.4. Cognitive Style, Object-Spatial Imagery and Verbal Questionnaire (OSIVQ; Blazhenkova & Kozhevnikov, 2009)	Self-report instrument which asks participants to agree with 45 statements; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).	Verbal vs. spatial cognitive style, object-spatial imagery, tolerance for complexity, ambiguity and strategies for scanning or focusing
4.5. Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973)	Self-report measure that asks participants to read a scene’s description (e.g., walking on the beach) and then to rate the vividness of specific aspects of their mental representation via 16 items; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).	Mental imagery or imagination
4.6. Need for Cognitive Closure (16-NCCS; Schlink & Walther, 2007; Webster & Kruglanski, 1994)	16-item German translation of the brief version of the NCC; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).	Disliking/liking of ambiguity, desire for clear classifications
4.7. Creative Scales		
A: Creative Personality Scale (CPS; Kaufman & Baer, 2004)	20-item self-assessment scale with statements referring to creativity; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).	Creativity
B: Creative Achievement Questionnaire (CAQ; Carson et al., 2005)	Self-report scale where participants are asked to rate their real-world creative achievements in ten domains including visual art; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).	Creative achievements
C: Creativity Scale for Different Domains (CSDD; Kaufman & Baer, 2004; see also Silvia et al., 2009)	Ten-item questionnaire measuring individual’s own view of themselves as creatives in nine areas including visual art; Computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).	Individual’s own view of themselves as creatives

3.1.2. Description of Study Population

To characterize the study population, participants should complete the following three questionnaires:

- **Disease-Related Aspects and General Demographics**
- **Unified Parkinson’s Disease Rating Scale (MDS-UPDRS; Stebbins et al., 2007)**
- **Standardized Evaluation of Colour Vision (Ishihara, 1917)**

The demographics and disease-related aspects should include questions regarding age, gender, identity, ethnicity, education, living situation, working status, diagnosis, age of diagnosis, duration of disease in years, laterality, body side predominantly affected by PD, medication or therapies, and severity of on-medication or off-medication experience.

Furthermore, the MDS-UPDRS is included to objectively classify the severity of PD (see Section 2.1.2 for a detailed description).

Following this, participants undergo a standardized assessment of color vision using the Ishihara test, which is relevant given the color-specific drawing tasks included in this study. The Ishihara test evaluates color vision deficiency by qualitatively assessing color perception and may also capture experiences related to synesthesia[23] (Ishihara, 1917).

3.1.3. Art Making and Drawings

The range of subjective and objective observable symptoms in creativity and artistic output may provide valuable insights into the functional, cognitive, and neurobiological changes associated with the progression of PD (Boot et al., 2017; Pelowski et al., 2020). For this approach of art assessment, the following five tasks will be included where PD patients have to create drawings or artwork:

- **Cued, Free Drawing (Pelowski et al., 2018)**
- **Hand Drawing Task (McManus et al., 2010; Chamberlain et al., 2013)**
- **Clark's Drawing Abilities Test (CDAT; Clark & Zimmermann, 2004)**
- **Drawing Emotions (Pelowski, 2024)**
- **Color Choice in Drawing Emotions (following Pelowski, 2024 and Damiano et al., 2023)**

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[23] Synaesthesia is a neurological condition where stimulation of one sense involuntarily triggers the perception of another, such as seeing colors when hearing sounds (Simner & Hubard, 2013).

The subsequent part will describe the *'Cued, Free Drawing'* task in more detail, as this task is included in the upcoming study in Section 3.2. For a detailed description of the other tasks of the 'Art Making and Drawings' part, see Appendix A and Table 3 for an overview. In the beginning, the factor that is assessed, as well as the operationalization, will be described. Additionally, factors that may overlap with PD will be mentioned. This is followed by a detailed description of the procedure, including the needed time for the task, the number of trials, materials, and the specific procedure.

'Cued, Free Drawing' (Pelowski et al., 2018) enables evaluating an individual's ability to spontaneously create artwork, focusing on aspects such as quality, aesthetic pleasantness, creativity, and technical skill. Participants are free to adopt any style, whether abstract or representational, and can utilize any portion of the page, with the option to incorporate symbolism.

The finished artworks can then be further analyzed utilizing subjective rater assessments where lay or expert raters can rate for factors that seem to change when being diagnosed with PD, such as quality, creativity, emotional expressivity, technical skill, aesthetic pleasantness, page usage, symbolism, abstractedness, positive or negative valence (e.g., using the Art Attributes Scale; Chatterjee 2010). As style and content, creativity, quality, and emotional expressivity seem to change in PD patients (for a detailed overview, see Section 2.2.2), these factors could be relevant for early detection of PD.

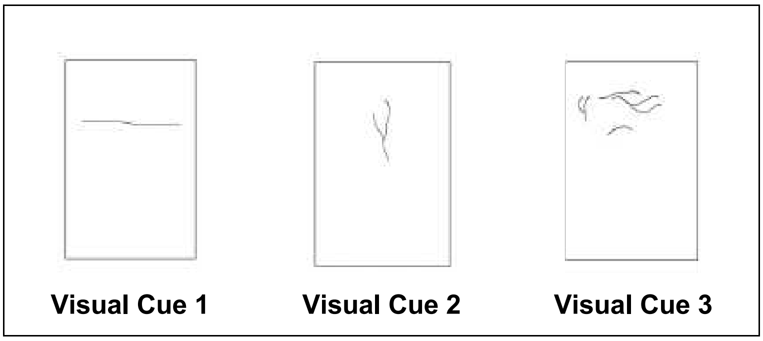
Further, the produced artwork could be coded by the researchers themselves by defining whether it is abstract, whether and how much symbolic content is included, whether crosshatching is present and whether the paper orientation is vertical or horizontal.

Additionally, visual properties could be analyzed, such as stroke length, page usage, vertical or horizontal mark-making, and complexity (using fractal dimension analysis). If a camera setup was fixed before the drawing task, individual hand movements in the task could be analyzed in addition to the finished artwork.

The materials needed for this task are a black pen (1mm, Edding 400 permanent marker) for the participants to draw, three white DIN A4 paper with pre-printed cues (see Figure 2), and one blank sheet of DIN A4 paper. Additionally, a camera with a tripod can be set up on the table to record the hand movement in the drawing task.

Figure 2

Visual Cues utilized in the Cued, Drawing Task



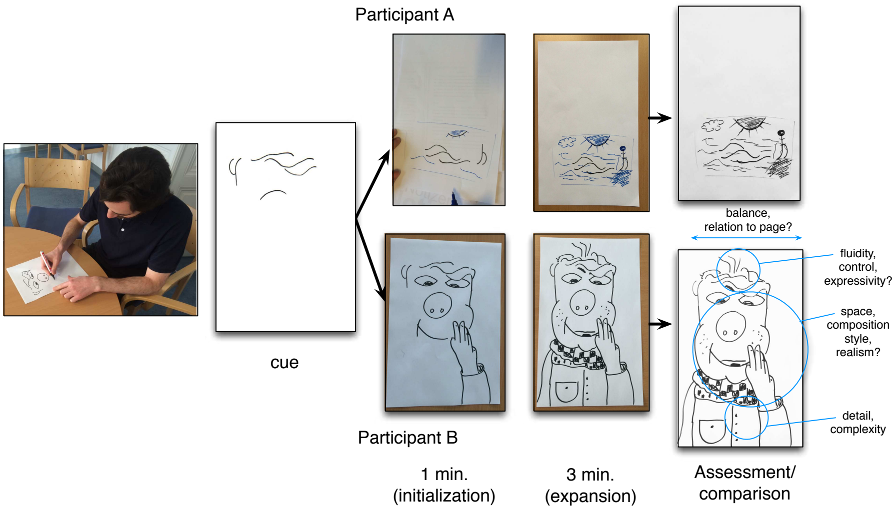
Note. Pelowski et al. (2018)

The participants will be told that they will be presented with a piece of A4 paper. Participants are then asked to "make an artwork" by incorporating the cue and using the black pen. Participants will be instructed that they may freely draw whatever comes to mind. However, they should approach the task as if it were an exercise of "making art" and will be asked to make a successful, visually compelling work as if they would find it in a museum. The paper will be presented in front of the participant face down on a desk at a 45 angle to see if they choose to use it vertically or horizontally. Afterward, the participants will be cued to draw by turning over the page. They will be given three minutes per visual cue and supplied with a new paper after the finished time. For three visual cues, this results in a repetition of the task three times, with a total duration of nine minutes (see Figure 3 for an example of the procedure). The participants are only allowed to use a black pen in order to limit the focus to formal depiction without added variables of color and without allowing for erasing, thus encouraging the participant to view the task as an evolving process and to focus on the overall gestalt blocking in of an artwork.

The three-minute time duration per cue is based on pilot testing (Pelowski et al., 2018), which also includes a verbal warning after two minutes. The paradigm allows for an initial blocking of the drawing and expansion corresponding to the first two stages, "initialization" and "expansion," based on Tinio (2013) (see Section 2.2.1). All cue stimuli will be selected for the same level of initial complexity to elicit responses that might be generalized across cues and subjects. Cues will avoid shapes eliciting apparent stereotypical responses (e.g., a box that can be turned into a house).

Figure 3

Sketching procedure 'Cued, Drawing Task'



Note. Results from a pilot study by Pelowski et al. (2018)

3.1.4. Objective Perception, Memory, and IQ Measures

After the Drawing Tasks, standardized perception, memory, and IQ measures referring to Pelowski et al. (2018) will follow. These should be done in the same order for all participants. Several hypotheses suggest that shifts in artistic output may be linked to impairments in visuospatial abilities and task-switching, affecting 3D thinking, depth perception, and the capacity to transition between different conceptual frameworks (Chatterjee, 2004; Zaidel et al., 2013; Zeki, 1999). Additionally, mood and color perception changes could explain variations in artistic expressivity and style (Meyer & Turner, 2006). Further, cognitive impairment (mild cognitive impairment such as PD or dementia) often initially affects attention, executive, and visuospatial functions (Armstrong & Okun, 2020). The following tests will be included in the approaches for art assessment:

- **Rey-Osterrieth/Taylor Complex Figure Task (ROCFT; Rey & Osterrieth, 1993; for review see Hubley & Tremblay, 2002)**
- **Cain's House Task (based on Cain, 1943; McManus et al., 2010)**
- **Shepard Illusion (Shepard, 1990; Mitchell et al., 2005)**

- **Group Embeddd Figures Test (GEFT; Oltman et al., 1971; Witkin et al., 1971)**
- **Out-of-focus-picture-task (OFPT; Kozbelt, 2001)**
- **Mental Rotation (Kozbelt, 2001; images from Vandenberg & Kuse, 1978; Shepard & Metzler, 1971)**
- **2D and 3D Angle Drawings (Ostrofsky et al., 2015)**
- **Ravens Advanced Progressive Matrices (APM Short Form; Raven, 1941; Arthur & Day, 1994; see Arthur et al., 1999 for validation and normalization)**
- **Multiple Choice Vocabulary Intelligence Test (MWT-B, 'Mehrfachwahl-Wortschatz-Intelligenztest'; Lehrl, 2005)**

Appendix B provides a detailed description of all tests, as these will be excluded from the upcoming study. In addition, see Table 3 for an overview.

3.1.5. Subjective Personality, Art Ability and Interest, and Creativity Assessment

Even if there is existing evidence supporting art-related changes in PD patients, not all individuals show such artistic changes (see Section 2.2.2). This suggests various questions and potential insights that might be gained from systematically assessing subjective personality traits, life history, art training, or interpersonal and contextual differences in general (Pelowski et al., 2017; Pelowski et al., 2018; Rostan et al., 2002). This could include the following tests:

- **Art-Making ability (Chamberlain et al., 2013; McManus et al., 2010)**
- **Art training (Art experience questionnaire; based on Chatterjee et al., 2010)**
- **Tem-Item-Personality-Measure (TIPI; Gosling et al., 2003)**
- **Cognitive Style, Object-Spatial Imagery and Verbal Questionnaire (QSIVQ; Blazhenkova & Kozhevnikov, 2009)**
- **Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973)**
- **Need for Cognitive Closure (16-NICCS; based on Webster & Kruglanski, 1993; Schlink & Walther, 2007)**

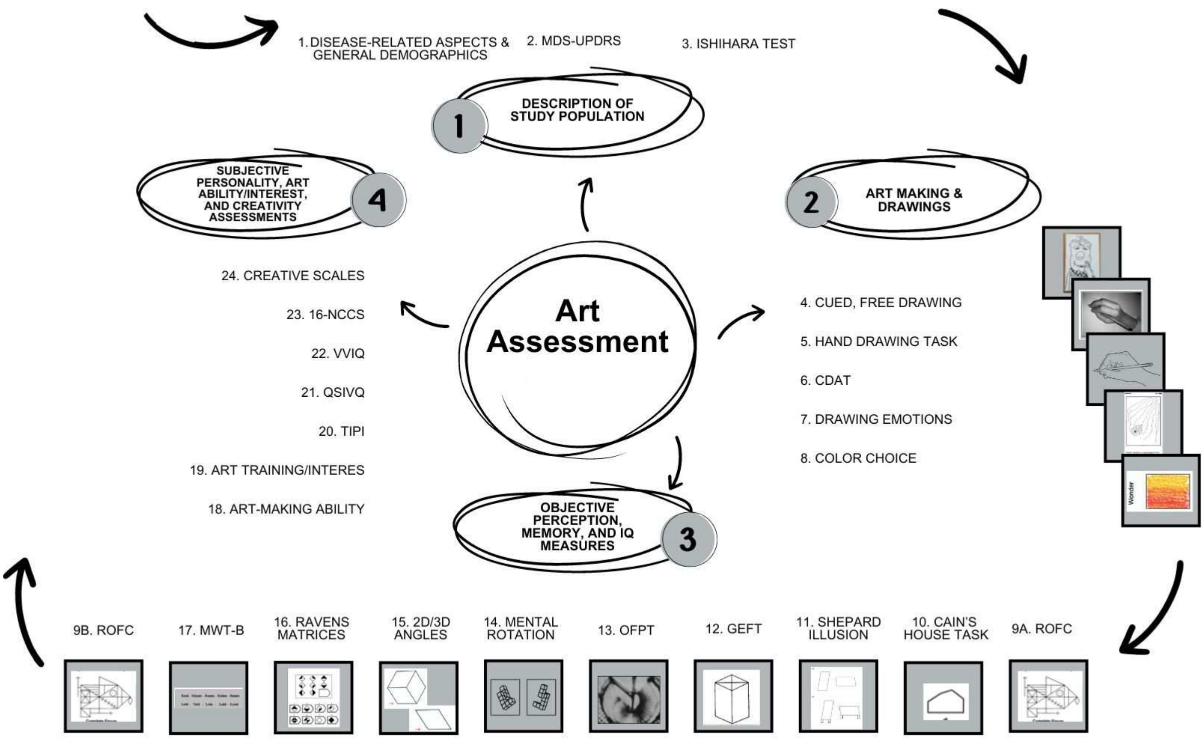
- **Creative Personality Scale (CPS; Kaufman & Baer, 2004)**
- **Creative Achievement Questionnaire (CAQ; Carson et al., 2005)**
- **Creativity Scale for Different Domains (CDSS; Kaufman & Baer, 2004; see also Silvia et al., 2009)**

Similar to above, none of these questionnaires is included in this study. Thus, a detailed description of each questionnaire is available in Appendix C and Table 3.

Furthermore, Figure 4 illustrates the optimal sequence for administering all tests from the art assessment approaches. This order should be maintained to ensure comparability across future studies.

Figure 4

Proposed Sequence of Art Assessment Approach



Note. (1): Description of Study Population (1. Disease-related aspects & general demographics; 2. MDS-UPDRS; 3. Ishihara-Test); (2): Art Making & Drawings (4. Cued, Free Drawing; 5. Hand Drawing Task; 6. CDAT; 7. Drawing Emotions; 8. Color Choice in Drawing Emotions); (3) Objective Perception, Memory, and IQ Measures (9A. ROFC; 10. Cain's House Task; 11. Shepard Illusion; 12. GEFT; 13. OFPT; 14. Mental Rotation; 15. 2D/3D Angles; 16. Ravens Matrices; 17. MWT-B; 9B. ROFC); (4) Subjective Personality, Art Ability/Interest, and Creativity Assessments (18. Art-Making Ability; 19. Art Training/Interest; 20. TIPI; 21. QSIVQ; 22. VVIQ; 23. 16-NCSS; 24. Creative Scales)

3.2. Part 2: Application of the ‘Cued Drawing Task’ for PD and HC

The proposed standardized art assessment approach (see Section 3.1) could serve as a guideline for future or follow-up studies. Consequently, using the tasks and questionnaires in various settings and studies allows for more reliable comparisons between different cohorts.

Unfortunately, it was impossible in the given frame for this Master thesis to conduct an analysis utilizing the entire described art assessment approach from Section 3.1 to validate for a PD patient cohort. Consequently, only one part of the battery, the ‘Cued, Drawing Task,’ will be applied to PD patients as well as a healthy cohort. For a detailed description of this task, refer to Section 3.1.3. Subsequently, produced artworks from the ‘Cued, Drawing Task’ from both groups (PD patients vs. Psychology students) will be analyzed to find potential art-related changes that might be tied to the disease and to answer the following exploratory research question if there are any systematic differences between artworks of PD patients and healthy psychology students using a standardized black-and-white-paradigm.

In the following part, the procedure from Pelowski et al. (2022) was adapted for this study.

3.2.1. Study population

Artworks: The sample for the selected artworks consists of two groups: PD patients and healthy psychology students (HC).

First, artworks from idiopathic PD patients under the care of Radboudumc and the Expertise Centre for Parkinson and Movement Disorders in Nijmegen. These patients are routinely advised to participate in research studies, providing a well-established recruitment pathway for this study. Specifically, the PD patients participated in the ARTS-CAP (Artistic Creativity & Anxiety in Parkinson’s Disease)-study referring to the project “Unlocking the Muse: Transdisciplinary Approaches to Understanding and Intersection of Artistic Creativity and Parkinson’s Disease” as already described in Section 3.1. The inclusion criteria for the PD patients required a confirmed diagnosis of idiopathic PD, being at least 18 years old or older, and being willing to participate in the intervention program and attend all scheduled test sessions. Potential subjects were excluded from the study when they were legally incompetent adults who could not provide informed consent, manage their own affairs, or require full-time nursing care. In addition, they were excluded when being classified as HY V, showed severe cognitive impairment as indicated by a Montreal Cognitive Assessment (MOCA) score of less than 24, or did not give written informed consent. The artworks resulted from the sub-test ‘Visual art cuing test’, including ‘Cued, free drawing’ based on the Art Making Paradigm Pelowski et al. (2018).

In total, artworks from N = 35 patients were sent to the University of Vienna with an allowance for use in this study. This results in three artworks per person (three cued drawings), leading to 105 artworks from PD patients. Due to data protection regulations at Radboudumc, demographic and clinical information is missing.

As a first comparison, these were matched to previously collected drawings from psychology students in Pelowski et al. (2018), where the Art-Making Paradigm was applied at the University of Vienna. To balance out both groups, the decision was made only to use artworks from N = 35 psychology students randomly chosen by a random name picker instead of including all participants (N = 57 original participants).

Artwork Judges: The ratings were made by a final sample of 95 students from the University of Vienna participating for class credit (72 female, 20 male, 3 diverse, M_{age} = 22,81, SD = 4.60; no visual impairments, all fluent in German).

3.2.2. **Image Processing**

All selected images (105 drawings from PD patients and 105 drawings from psychology students) were digitally copied from the original PDF files to be processed. The copied versions were preprocessed in Canvas to remove borders, correct uneven lighting, or adjust the contrast (using masked curve adjustments). Additionally, a grey frame was added to all images to enhance the focus on the artwork and provide a more professional appearance. All artworks were published in black and white (as in the original), without applied contrast corrections, to maintain the original appearance of the artworks (see Figure 5 as an example).

Figure 5

Example of processed images for each visual cue

Visual Cue 1 Visual Cue 2 Visual Cue 3

3.2.3. Rater-based Assessment

Following the procedure from Pelowski et al., 2022, the art images were evaluated by 95 independent raters using several scales. Even though rater-based assessments include subjective opinions, they still have various essential advantages over other approaches, particularly with visual arts. Further, a controlled analysis design allows us to provide more robust results that could be compared with previous ones. Another possible advantage of using human judges is their ability to consistently "standardize" their evaluations by disregarding variations in image presentation (as proposed by the facsimile accommodation hypothesis, Locher et al., 1999; Locher et al., 2001). In contrast, Specker (2022) found no supporting evidence for the facsimile accommodation hypothesis after testing. Therefore, the previous statement has to be viewed critically. This method can be combined with other techniques, such as computerized image statics (Fractal Dimension Analysis; FD), to allow for a more complete analysis.

3.2.3.1. Artwork Judges

The rating method employed a Latin Square Design to minimize fatigue and loss of motivation for a large number of artworks and scales (Pelowski et al., 2022). This allowed us to split the complete image set into three sets (A/B/C), where each participant rated only one (70 images per rater). The images for each rater were selected quasi-randomized, resulting in 31-32 unique ratings for each artwork. All raters had never been exposed to any of the artwork and were naïve to the purpose of this study. The study followed the ethical guidelines of the University of Vienna Ethics Committee.

Before the beginning of the study, all participants signed an informed consent. Based on previous research in visual art and creativity, lay judges were chosen. Non-expert judges are shown to reliably evaluate artworks for specific factors with high levels of internal consistency and sensitivity to subtle differences (Pelowski et al., 2018). Moreover, concerning time-/cost-efficiency and routine, it is more convenient and pragmatic to have greater access to a significant amount of judges (Pelowski et al., 2022). Overall, no significant differences between lay and expert judges have been found in factors such as aesthetic value, originality, technical skill (Amabile, 1982a; Amabile 1982b; Chan & Chan, 2007; Getzels & Csíkszentmihályi, 1976; Hekkert & Van Wieringen, 1996; Hennessey, 1994; Kozbelt, 2004), and realism (Pelowski et al., 2018). In addition, it is reasonable to utilize lay judges in this scenario since a possible future clinical assessment battery would commonly be applied by non-experts.

The argued best practice in artwork/creativity rating studies showed that the number of judges should be at least ten judges to provide stable scoring with good reliability (Baer & McKool, 2009; Carson, 2005; Pelowski et al., 2018). As lay raters are more accessible, more participants were included in this study. Since there was a greater interest in creating stable mean rating scores for each artwork (rating quality) instead of detecting effects between raters and images, no power analysis was conducted to identify a minimum ideal number of judges (Pelowski et al., 2022).[24] This was followed by assessing rating quality Intra-Class Correlation Coefficients

[24] Alternative method to determine judge numbers: Random permutation models with a defined desired effect size when comparing final images and corresponding SD of judge ratings. This was not applied for pragmatic and sufficient reasons (Pelowski et al., 2022).

(ICCs) to check for rating consistency, which provides a pragmatic and sufficiently controlled working method.

3.2.3.2. Rating Procedure

The design of the artwork presentation and collection of ratings was created by using the online questionnaire tool (Qualtrics.com). The ratings were conducted in a laboratory room at the University of Vienna (Liebiggasse 5, 1010 Vienna) with five separate workstations (allowing five participants to work simultaneously). Following the procedure of Pelowski et al. (2022), participants were informed that they would be shown various pieces of visual art and asked to evaluate each image using several rating scales. They were asked to focus on the underlying artwork and do their best to make consistent ratings across the complete artwork set without informing them about the relation to PD or provenance. In addition, they were asked to ignore differences in presentation quality and size when making their ratings (following procedures from Locher et al., 1999 & Locher et al., 2001).

All artworks were displayed on a monitor (Intel core i5 vPro, 8^{th} Gen, Intel UHD Graphics 630, 1280x1024, 100 Hz), with the longest artwork dimension (vertical or horizontal) fixed at a maximum of 707 x 1000 pixels. No image was enlarged to avoid pixelation or other distortions. All raters were positioned approximately .5 m from the screen.

The rating procedure began by individually showing images centered on the screen, 1 inch from the top edge, with a white background. The participants were presented with a list of scales below the artwork, which could be seen by scrolling down with the mouse. They could always scroll up to look at the artwork again. All participants were instructed to take as many short breaks as needed and take their time to complete the ratings. The completion of the ratings took 96 minutes on average.

Furthermore, the chosen artworks were shown in a randomized order for each participant, with a predefined scale. This allowed for stable judgments against quality or other aesthetic factors regarding works of art (Pelowski et al., 2018, for review), resulting in a final score that allows for cross-study comparisons (Pelowski et al., 2022).[25]

3.2.3.3. Art Attributes Scales

Appendix D provides a complete list of scales with exact wording. Two scales were implemented to evaluate the artworks and assess the main aspects related to art production, possibly providing a basis for early detection of PD (see Table 2 in Section 2.2.2 for an overview of art related changes).

Formal-perceptual and conceptual-representational factors: Initially, the modified version of the Assessment of Art Attributes battery (AAA, Chatterjee et al., 2006) was adapted for this study (see Table 4 for an overview). The AAA was initially applied in a study focusing on the art perception of brain-damaged individuals and may be used to investigate potential functional connections between visual artwork appearance or ratings and brain damage. Since the original factors of the scales match many identified features in art production, Pelowski et al. (2022) modified the battery for usage in art production instead of art perception by maintaining the original attributes but standardizing the scales by using a 7-point Likert scale with '1' meaning 'not at all/cold' and '7' meaning 'extremely/warm' instead of non-systematic anchor-points switching between wording and bi-polar and unipolar scales (Lauring et al., 2019b). The battery consists of six scales relating to 'formal-perceptual' factors (balance, color saturation, color temperature, depth, complexity, brushstroke) and six 'conceptual-representational' factors (abstractness, animacy, emotional expressiveness, realism, representational accuracy, symbolism). Further, the terminology for the factor 'brush stroke' was changed to a more general word, 'mark-making,' to accommodate a broader range of 2D-visual art. In addition, the terminology from the scale 'animacy' was replaced by 'active' (Osgood, 1969; Pelowski, 2015) since participants in previous studies had trouble understanding the meaning. Besides, Pelowski et al. (2022) implemented scales for 'usage of the page' to potentially identify neglect of page areas as this could be related to damages in the right or left hemisphere and for 'emotional valence' (1 = 'positive,' 7 = 'negative)

[25] Other artwork set bounded techniques, i.e., consensual assessment (Baer & McKool, 2009), where ratings might be made in comparison of pre- vs. post-examples, or rankings made of all examples of art do not allow future cross-study comparisons.

based on suggestions that brain damages may modulate emotional expressivity in positive or negative directions (Lauring et al., 2019a; Kozbelt, 2004).

In the present study, the scales 'color saturation' and 'color temperature' were excluded as both scales were irrelevant since only black-and-white drawings were included. Beyond this, the modified version of the AAA (Chatterjee et al., 2006; Pelowski et al., 2022) was incorporated.

Overall artwork quality and creativity: Following Pelowski et al. (2022), three 7-point-Likert-type scales were included to assess aspects of general artwork quality. The first scale referred to a general quality measure, asking (1) 'How good is the artwork quality?'. The second and third scales referred to major sub-aspects of quality (Newman & Bloom, 2012; Lauring et al., 2019b), frequently showing high correlations, particularly in adult artists (Chan & Zhao, 2010): (2) 'How good is the technical artistry or craftmanship?' and (3) 'How creative is the artwork?'. Additionally, a scale for general comparison and manipulation check was included, asking (4) 'Do you personally like the image?'. Previous research has shown that this is often separable from artwork quality or technical ratings by lay raters (Pelowski et al., 2018). Individual scales within each type were randomized for each stimulus to avoid sequence effects and sustain participant attention. In contrast, the general question types (1 and 2) remained in the above-fixed order.

Table 4

Overview of the modified Art Attributes Scale

Scales
Aesthetic/Quality Judgement
Creativity
Good work of art
Technical ability
Personal liking
Art attribute scales
Balance / Visual harmony
Depth
Mark-making (fluent/skilled)

Abstractness
Symbolism
Realistic content/themes
Active
Emotional expressive
Complexity
Paper usage (employed all page)
Photorealistic (like a picture)
Emotional valence
Computer-based image processing
FD / Complexity

Note. Based on Chatterjee et al. (2010) and Pelowksi et al. (2022)

3.2.4. Fractal Dimension – Computer-based Art Image Assessment

The technique for assessing FD in this study followed the procedure of previous papers (Forsythe et al., 2017; Lauring et al., 2019a; Pelowski et al., 2022). Based on the FD analysis that Forsythe et al. (2017) applied to the artworks of seven famous artists diagnosed with PD, AD, or normal aging, the authors found a general increase in FD with age. In contrast, PD patients showed a curvilinear increase following diagnosis, with a sharp decrease in later years. Lauring et al. (2019a) then assessed artworks from PD patients from several case studies and stated that FD values were higher after the onset of PD medication than before.

The open-source software package FIJI (Schindelin et al., 2012) was used to apply FD. One prerequisite for calculating FD is that the images must be black and white. Since all images were produced within a standardized black-and-white paradigm, these artworks did not have to be converted. The resulting binary images were then analyzed utilizing the box count method with box sizes 2, 4, 8, 16, 32, 64, 128, 256, 512, and 720, with resulting FD-values recorded for each image individually (ranging between 1 = low and 2 = high).

4. Analysis and Results: Exploration of Systematic Differences between Artworks of people with Parkinson's Disease and Healthy Psychology Students

Following Pelowski et al. (2022), a combination of statistical methods was applied to provide a solid foundation for ensuring reliability and identifying potential connections between disease onset and changes in the produced artworks. Table 5 shows an overview of methods and analysis steps for systematic rating of artworks by PD patients vs. HC following the procedure of Pelowksi et al. (2022).

Table 5

Overview of statistical methods and analysis steps for systematic rating of artworks

Aspect	Details and Procedure
Artwork sample	***Final Sample:*** N = 210 (scanned from original artworks produced in 'Cued, Drawing Task'; PD patients = 105; HC = 105). Pre-processing: in canva, removing borders, correction of uneven lightning and contrast (using masked curves adjustments), no color correction
Subjective (Rater-based) assessment	***Judges:*** 95 psychology students, art novices (72 female, 20 male, 3 diverse, M_{age} = 22,81, SD = 4.60). ***Rating procedure:*** Each judge rated 70 images (1/3rd total sample), 31 to 32 unique ratings per image (Latin Square Design). Images shown individually, centred on screen (Intel core i5 vPro, 8th Gen, Intel UHD Graphics 630, 1280x1024, 100 Hz); artwork dimension (vertical or horizontal) fixed at max = 707 x 1000 pix, white background, grey frame; list of scale s presented below artwork; no time-limit. Participants told they would be "shown some works of visual art" and asked to make assessments, no mention of relation to brain damage or diseases: averaged time for completion = 96 minutes. ***Scales:*** **Formal-perceptual factors** (based on Chatterjee et al., 2010; Pelowski et al., 2018; Pelowski et al., 2022): balance, depth, mark-making (fluent/skilled), complexity; **Conceptual-representational factors:** abstractness, symbolism, realism, content/themes, activeness, emotional expressiveness, representational accuracy (like a picture), all 7-point Likert-type scale (1 = "not at all", 7 = "extremely"). **Additional factors:** page usage (1 = "not at all", 7 = "extremely"), emotional valence (1 = "negative", 7 =

	"positive"), artwork creativity, artwork quality, technical ability, personal liking (all 1 = "not at all", 7 = "extremely").
Computer-based Image Assessment	***Fractal Dimension (FD):*** The measure of structural complexity is proposed to represent a consistent "signature" of mature artists, remaining stable across individual artworks and styles. Any deviations in this complexity are thought to be linked to changes in underlying cognitive or neurobiological processes, as suggested by Forsythe et al. (2017). It is assessed using the open-source software package FIJI (Schindelin et al., 2012); binary images analyzed using box count method with box sizes, 2, 4, 8, 16, 32, 64, 128, 256, 512, 720, FD-values recorded for each image (1 (low) to 2 (high)).
Analysis	**Judge Inter-rater Reliability:** Intra-class Correlation Coefficients (ICCs), one-way, random average measures, calculated using psych package in R. **Between-scale correlations:** Pearson Correlations between scales using JASP 0.19.1(Intel). **Art Differences between HC and PD:** Using JASP 0.19.1(Intel), Welch's approximate t-Test, with scales as dependent variables and group (HC vs. PD) as grouping variable was applied to find possible differences between ratings for artworks from PD patients or HC (see Table 7 for results.)

Note. Following Pelowski et al. (2022)

4.1. Judge Inter-Rater-Reliability

Initially, Intra-class Correlation Coefficients (ICCs; one-way, random average measures; see Hallgren, 2012; McGraw & Wong, 1996) were calculated to assess the level of agreement between raters for HC and PD artworks within all scales. The ICCs were computed using the psych package in R [32] using the "lmer" function, which accounts for missing data and provides estimates in cases of low variance. A one-way random effect model was applied, where each image was assigned a mean rating from a randomly chosen set of k-raters, k > 1/ M = 31.67 raters/item. This approach provides results that best generalize to the populations from which raters were sampled, as recommended by Hallgren (2012), which emphasizes averaging ratings across multiple coders. This was possible because the ratings lacked overly extreme values and thus did not distort ICC values (Hallgren, 2012; Pelowski et al., 2022). The results for each scale can be found in Table 6. The averaged ratings strongly impact the ICC (Shrout & Fleiss, 1979), resulting in a M_{ICC} = .95 [.85; .98]. With an ICC > .90, all cases showed an excellent agreement between raters (Koo &

Li, 2016). This suggests that the raters generally agreed in their assessments of the artwork, indicating that the artworks possessed distinctive qualities that were noticeable to the raters. As a result, it is appropriate to average the ratings to produce stable scores for each evaluative factor. These averaged scores can then be analyzed to examine any systematic patterns or differences within the artwork, potentially shedding light on trends across both groups, HC and PD.

Table 6

Inter-rater reliability based on a one-way random, random, average-measures ICC

Scale	Point Estimate	Lower, 95% CI	Upper, 95% CI
Aesthetic/Quality judgement (subjective ratings)			
Creativity	.97	.97	.97
Good work of art	.95	.94	.96
Technical ability	.97	.96	.97
Personal liking	.95	.94	.96
Art attribute scales subjective ratings			
Balance/visual harmony	.94	.93	.95
Depth	.97	.97	.98
Mark-making (fluent/skilled)	.95	.94	.96
Abstractness	.98	.97	.98
Symbolism	.91	.90	.93
Realistic content/themes	.97	.96	.97
Active	.96	.95	.97
Emotional expressive	.96	.95	.97
Complexity	.95	.94	.96
Paper usage (employed all page)	.99	.98	.99
Photorealistic (like a picture)	.95	.94	.96
Emotional valence	.95	.94	.96
M_{ICC}	**.95**	**.85.**	**.98**

Note. Values provided are ICC values with the 95% confidence interval (CI). 32 ratings per image on average; ICC1,k as referenced by Shrout & Fleiss (1979)

4.2. Between-Scale Correlations

In addition, Pearson correlations between the different scales were also examined to identify potential issues in the art scoring process. Overall, as expected, art quality ("good work of art") significantly strongly correlated with creativity (r=.76), technical ability (r=.91), and personal liking (r=.90). In addition, creativity showed a significantly high correlation with technical ability (r=.63) and personal liking (r=.63). As increased abstraction may be related to quality, and might have driven these judgments (Pelowski et al., 2022), abstraction to artistic quality and judgments were considered as well. Low relations were found ($r_{Abstraction\text{-}Creativity)}$=.49; $r_{Abstraction\text{-}quality}$=.09; $r_{Abstraction\text{-}TechnicalAbility}$=−.01; $r_{Abstraction\text{-}PersonalLiking}$=−.03), which is similar to the results of Pelowski et al. (2022), where they also reported relatively low relations between these scales. Furthermore, only a weak, non-significant positive correlation between computer-based FD scores and raters' subjective complexity ratings was found (r=.03). Compared to the other scales; this remains the highest correlation with FD scores. In addition, almost all items in the art attributes scale showed moderate to strong correlations. Full results are available in Appendix E.

4.3. Rater-Based Assessments Independent t-Test for Artwork Rating Differences between PD and HC

The main goal remains to examine the differences in artwork ratings for all scales and artworks divided by the group (PD or HC). An independent sample T-test was applied to compare the means between the two unrelated groups, HC and PD (Kim, 2019)[26]. While the study is exploratory in nature, statistically significant differences between PD and HC groups on each rating scale were examined. The null hypothesis for each comparison assumes no difference between group means, while the alternative hypothesis proposes that group means differ significantly. (Details of mean scores for all scales by group are provided in Appendix F.

[26] Another possibility is to apply a linear mixed model (LLM), as proposed by Pelowski et al. (2022) since the LLMs represent an emerging trend in empirical art. Despite this, when referring to Yu et al. (2022), the data shows natural clusters or groups with a PD and HC group. Thus, the application of ANOVA or other parametric methods is also recommended. In addition, the dataset did not include any dropouts and inter-rater reliability was excellent.

When reporting the results of a t-test, it is essential to first address the assumptions underlying the analysis. This includes assessing the normality of data distribution and the homogeneity of variances (Kim, 2019). First, the Q-Q plot residuals were analyzed to test for the normativity assumption, as tests like the Shapiro-Wilk test and Kolmogorov-Smirnov tests are oversensitive to unimportant deviations from normal distributions in large samples (Lantz, 2012). For this data set, all test variables for each group are normally distributed. Furthermore, the assumption of homogeneity of variances is not met for the dependent variable 'Complexity' and 'Fractal Dimension/Complexity' ($p < .05$) when applying Levene's test (Glass, 1966). Thus, Welch's approximate t-test was used in this case (Delacre et al., 2017). All results for the applied t-test are displayed in Table 7.

Table 7

Independent Samples t-Test/Welch's approximate t-Test

	t/Welch's	df	P	Mean Difference	SE Difference	Cohen's d	SE Cohen's d
Creativity	-.91	208	.37	-.10	.11	-.13	.14
Good work of art	**-2.12***	**208**	**.04**	**-.20**	**.09**	**-.30**	**.14**
Technical ability	-1.28	208	.20	-.13	.10	-.18	.14
Persona liking	-3.85**	208	<.001	-.38	.10	-.53	.14
Balance/ visual harmony	**-4.10****	**208**	**<.001**	**-.39**	**.09**	**-.57**	**.14**
Depth	-.24	208	.81	-.03	.11	-.03	.14
Mark-making (fluent/skilled)	**-3.72****	**208**	**<.001**	**-.35**	**.09**	**-.51**	**.14**
Abstractness	1.45	208	.15	.21	.14	-.20	.14
Symbolism	-1.15	208	.25	-.10	.09	-.16	.14
Realistic content/ themes	-.89	208	.37	-.10	.11	-.12	.14
Active	-1.57	208	.12	-.18	.11	-.22	.14
Emotional expressive	-.61	208	.54	-.07	.11	-.08	.14
Complexity[a]	**-.07**	**194.68**	**.95**	**-.01**	**.09**	**-.01**	**.14**
Paper usage (employed all page)	-.26	208	.80	-.04	.17	-.04	.14
Photorealistic (like a picture)	-.83	208	.41	-.07	.09	-.11	.14
Emotional valence	-4.49**	208	<.001	-.38	.09	-.62	.14
Fractal Dimension/ Complexity[a]	-5.87**	191.90	<.001	-.08	.01	-.81	.15

Note. Student's t-test.

[a] Levene's test is significant ($p < .05$), suggesting a violation of the equal variance assumption, Welch's t-Test applied

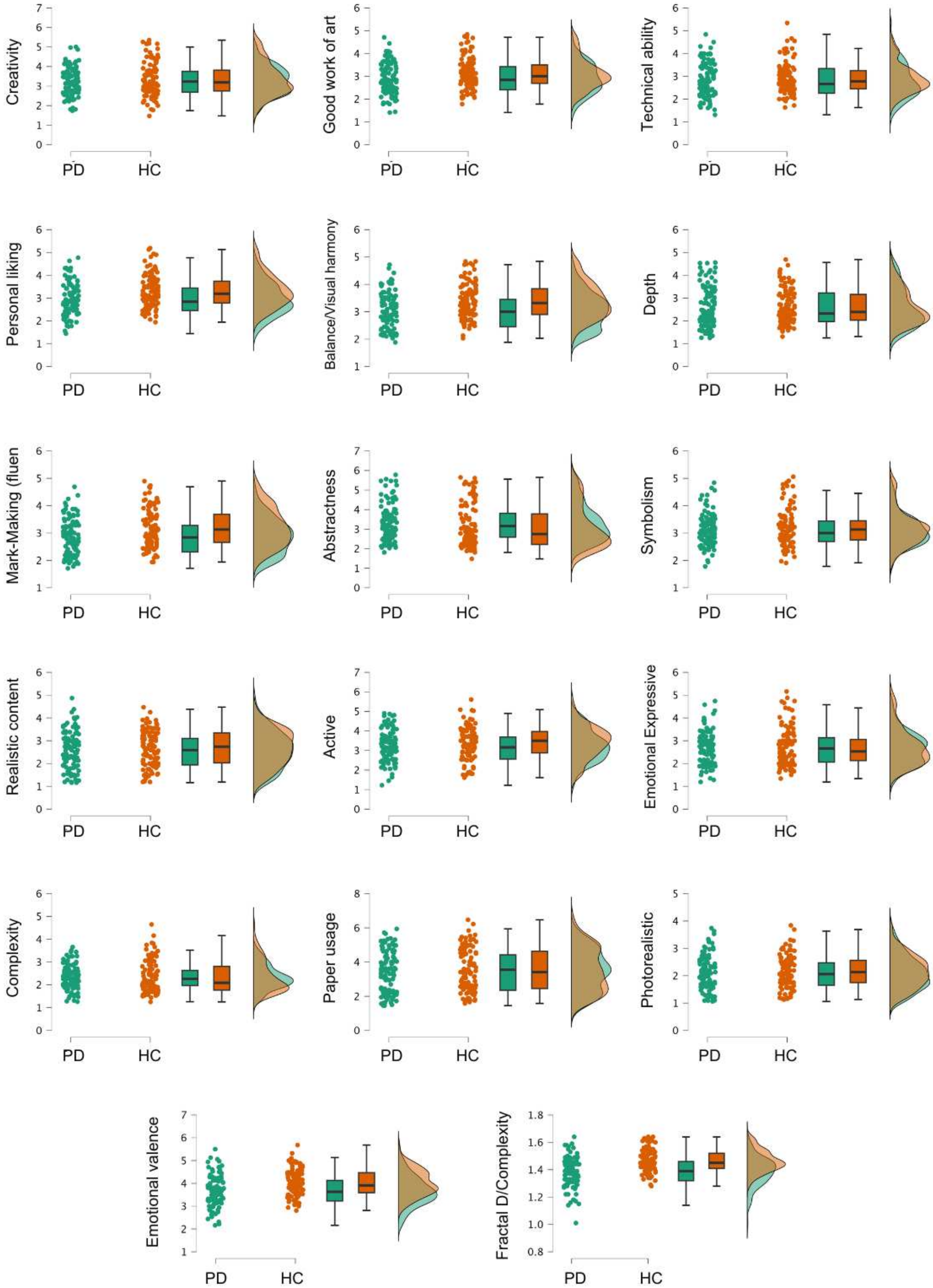
* $p < .05$; ** $p < .001$

The results presented in Table 7 indicate significant differences between HC and PD patients across several dimensions: quality ($p < .05$), personal liking ($p < .01$), balance/visual harmony ($p < .01$), mark-making ($p < .01$), emotional valence ($p < .01$), and fractal dimension values for complexity ($p < .01$). Specifically, there is a significant reduction in quality ratings for artworks produced by the PD group, with a small to medium effect size (Cohen's d; see Sullivan & Feinn, 2012 for a review for effect sizes). Additionally, personal liking ratings for artworks created by PD patients are significantly lower, demonstrating a medium effect. Similarly, significant reductions in balance and visual harmony, mark-making, and emotional valence are observed for PD artworks, all exhibiting medium effect sizes. Finally, fractal dimension values, which measure complexity, are significantly lower for the PD group, with a large effect size.

In addition, results for all factors (see Section 3.2 for an overview) are visualized via raincloud plots in Figure 6 on the next page. All results will be discussed in the final Section 5.

Figure 6

Raincloud plots for all results from the t-Test for all scales between PD and HC



Note. Green for PD, orange for HC; 1. Dots scattered for all mean scores for each image in the specific scale; 2. Error bars including information about distribution; 3. Shape of the distribution.

5. Interpretation and Discussion

This master thesis aimed to develop a standardized art assessment approach to create a standardized tool for future comparisons, especially for neurodegenerative diseases such as PD. Furthermore, artwork produced by PD patients and healthy psychology students in a standardized black-and-white drawing paradigm (Cued Drawing Task, Pelowski et al., 2018) should be compared to find possible systematic patterns that allow to differentiate between people with PD and HC. This final section will briefly discuss the application of the art assessment approach, overall findings, limitations, and implications for future research.

5.1. Application of the Art Assessment Approach

Before getting to the results of the leading research question, it is essential to discuss the development of the art assessment approaches (see Section 3.1). As already described, there was a lack of standardized methods to assess art differences, especially in different cohorts, such as those with various neurodegenerative diseases (e.g., PD, Alzheimer's disease, etc.). With the application of the described art assessment approaches, future research in this field may improve, especially if other researchers apply the same or similar approach in their studies. This will provide a reasonable basis for general comparability and lead to more reliable results regarding systematic changes in art-related patterns. However, it is crucial to point out that the validation and adaptation of this battery in future research is essential to its success.

By incorporating a variety of tests and paradigms from the areas of (1) study population description, (2) art making and drawing tasks, (3) objective measures of perception, memory, and IQ, and (4) subjective assessments of personality, art ability, interest, and creativity. By combining these measures, this approach will allow for comparisons between changes in creativity or art production with other domains, such as cognitive processes or personality differences. Combining the results with imaging techniques and detailed demographic data could help identify reasons for potential changes and shed light on the neurobiological mechanisms underlying diseases like PD. Ideally, this battery could contribute to the early identification of symptoms that emerge up to twenty years before the onset of motor symptoms (see

Section 2.1.2 for discussion). While initially applied to PD, this art assessment approach holds potential for broader application across various neurodegenerative conditions as well as normal-aging people with appropriate adjustments. Future studies should aim to validate, refine, and expand these approaches, developing it into a reliable and valid tool.

5.2. Exploring Systematic Changes between Healthy People and People with Parkinson's Disease

With the opportunity to analyze over 100 drawings produced by PD patients, this study's primary aim was to find systematic patterns by utilizing one part of the art assessment approaches (Cued, drawing task, Pelowski et al., 2018) and comparing them with HC drawings, resulting from the same paradigm. The often-mentioned limitations in methodology were addressed by creating a study within the framework of the presented art assessment approaches. Through the collaboration with Radboudumc, many artworks from PD patients could be collected (>100), resulting in the first systematic study with a significant cohort of PD patients. Further, the selected artworks were consistent, meaning they were produced within the same drawing task, which is especially important for computer-based ratings. In addition, each image was rated by 31-32 raters. These subjective ratings from lay raters prevent possible blindness when researchers would rate images themselves. Also, the number of raters was higher than the recommended sufficient number of judges.

The results displayed in Section 4 will help answer the overall exploratory research question of whether any systematic differences between the artworks of PD patients and HC can be found when using a standardized black-and-white paradigm.

As expected, art-related changes were found for *quality, balance/visual harmony, mark-making, and fractal dimension for complexity*. In addition, significantly lower ratings for *emotional valence* were detected, meaning that artworks from PD patients induced a more negative mood than artworks from the HC group.

Artworks from PD patients had significantly lower quality ratings than those from HC. This contrasts previous findings (discussed in Section 2.2.2.2), where several studies reported improved quality or no decline. Therefore, possible explanations for changes in quality and direction have to be further examined.

Additionally, several studies (see Section 2.2.2.3) discussed changes in style and content, some of which overlap with the results from this study. For example, balance and visual harmony ratings were significantly lower in PD patients' artwork, which means that these artworks seemed to show more compositional imbalance compared to artworks from HC, similar to Lakke's (1999) findings. Further, ratings for skilled or fluent mark-making in artwork produced by PD patients were also significantly lower than HC's artworks. This could indicate changes toward cross-hatching or less fluid lines, as reported in previous studies (e.g., Lakke, 1999; Drago et al., 2009a). Despite these findings, no significant trends towards symbolism, abstraction, realistic content, or themes were found, which were often reported in various other studies (see Section 2.2.2.3 for an overview).

Moreover, significantly reduced values for the computer-based analysis fractal dimension, which measures complexity, were found in PD patients' artwork compared to HC, but not in the subjective complexity ratings. As shown in Section 4.2, FD-values and subjective complexity ratings showed no significant correlation, which could result in the different significant results described here.

Unexpectedly, there are no significant differences in creativity and emotional expressiveness, one of the most reported art-related changes in PD patients. This unexpected finding adds an intriguing dimension to this study, prompting further exploration and discussion.

As noted earlier, changes in quality, style, and content could be tied to dopaminergic therapy (Lauring et al., 2019a). In addition, another explanation might be that these changes result from motor symptoms, such as tremors or problems with motor control, originating from dysfunction in the nigrostriatal DA areas. Moreover, these changes could be connected to the previously mentioned impaired processing of spatial relations, blurred vision, or damages in parietal regions (for a more detailed overview, see 2.2.2). By combining various tests from the art assessment approach in further studies, more valid explanations may be found in future studies.

One other aspect that has to be discussed is that artworks from PD patients seemed to be perceived more negatively compared to HC artworks, as emotional valence was significantly lower in these. This might result from PD patients being more emotionally expressive (Lauring et al., 2019a). On the other hand, Vicente et al. (2009) suggested a reduced intensity of negative emotions and in addition, no significant results were detected in the scale ‘emotional expressivity’ in this study. Hence, this finding has to be further explored in upcoming studies.

Given the varying results regarding art-related changes in general, the lack of consensus on the direction of these changes, and the numerous studies that utilize non-standardized methods for creating, selecting, and evaluating artworks, it is not surprising that the findings of this study do not entirely align with previous research. Despite these differences, it is essential to highlight that some systematic differences could still be detected in the evaluation of artworks produced by Parkinson's patients compared to healthy psychology students, particularly in the domains of quality, and style and content. These findings underscore the importance of this research in contributing to the understanding of art-related changes in PD patients.

The following section will discuss possible limitations and why differences in other scales, such as creativity, symbolism, emotional expressiveness, or abstractedness, could not be detected.

5.3. Limitations and Future Implications

Despite identifying specific systematic changes between the artwork of PD patients and HC, the absence of differences across often discussed key dimensions, creativity, symbolism, emotional expressiveness, and abstractedness, remains unclear. This underscores the importance of further empirical investigation to uncover the underlying mechanisms and provide robust evidence for potential factors driving these differences between PD patients and HC.

Referring to Pelowksi et al. (2022)'s implications, some limitations in this study are worth highlighting. First, it should be noted that neither group was gender-matched nor age-matched, which may have introduced selection bias into the results. Unfortunately, due to ethical guidelines, no information was available regarding the PD's age, gender, or medication status. Thus, these factors could not be controlled for. In addition, artworks in the HC group were produced by psychology students. Hence, results may be influenced by these demographic differences rather than the difference between being diagnosed with PD and not. This can limit the comparability between PD patients and HC and affect the validity of findings, potentially confounding the impact of the disease being examined, e.g., age.

Future research should aim to conduct a similar study with a more comparable, particularly age-matching sample, incorporating more contextual information about the PD group, such as medical history, symptoms, and medication, to eventually tie art-related changes to dopaminergic medication.

Nonetheless, it is necessary to emphasize that detected differences between disparate groups can provide evidence of genuine systematic differences.

Further, these artworks were primarily evaluated by psychology students. Future studies should consider including ratings from different PD patients or incorporating a more diverse group of raters.

Subsequently, it should also be acknowledged that the artworks were almost exclusively evaluated using subjective rating scales, with objective computer-based measures (fractal dimension, FD) only available for the complexity scale. This could be enhanced by incorporating additional computer-based or AI-driven methods. Upcoming research could focus on developing analysis tools that implement artificial intelligence (AI) for further computer-based analysis to differentiate between specific features similar to fractal dimensions such as complexity, balance, or stroke length. By creating a data set with various artworks of different people, this AI tool could better differentiate between different diseases by looking at these specific features.

Moreover, when it comes to statistical assessments, Pelowski et al. (2022) recommended implementing LMMs or other approaches that allow for the modeling of random variance between artists, raters, and artworks, which was not utilized in this study. In future studies, the data gained from this study could be additionally analyzed using the mentioned statistical methods to compare those results with the ones displayed in this study.

Overall, researchers are recommended to implement these guidelines in Pelowski et al. (2022) to establish a foundation for comparable results. Accordingly, more comprehensive studies should apply at least some parts of the art assessment approach to various cohorts to gain more reliable insights into art-related differences within various neurodegenerative diseases. This battery may also be utilized for aging people without neurological disorders to compare changes in art production (Bogousslavsky, 2005). Furthermore, prospective studies should examine changes in the discussed factor ‘color’ to ensure a more thorough understanding of art-related changes connected to PD.

5.4. Conclusion

In conclusion, finding systematic patterns in art-related changes between PD patients and a healthy cohort could unravel unique aspects of creativity (Perlovsky & Levine, 2012). Besides, as formerly noted in Section 2.2.2, changes in art-related patterns could be tied to neurobiological processes or differences between artistic production and art viewing (Lauring et al., 2019b). This may reveal new insights into general perception, cognition, emotion, and other neurodegenerative disorders (Pelowski et al., 2022). The described art assessment approach (Section 3.1) could be applied to the clinical identification of brain disorders (e.g., PD), as Pelwoski et al. (2022) already proposed. As pointed out before, this may directly address the need for early detection of subtle cognitive, perceptual, or behavioral changes long before many disorders are diagnosed, potentially allowing for more effective treatment (Smedinga et al., 2020; Bloem et al., 2021; Kulisevsky & Pagonabarraga, 2009). Moreover, the detected patterns suggest a promising target for causative studies that could complement brain imaging by enabling temporary modulation of healthy brains (e.g., through transcranial magnetic stimulation) to mimic changes observed in neurodegenerative disorders. This highlights the need for a systematic theoretical framework to effectively test brain-behavior linkages in affected artists (Pelowski et al., 2022). Ultimately, results from this and similar research may be implemented into strategies for rehabilitation or art therapies for people with neurodegenerative diseases as well as healthy populations, e.g., in elderly care (Pelowski et al., 2022), underscoring the potential real-world impact of this work.

The present investigation contributes to a deeper understanding of the interplay between art, creativity, neurobiological processes in neurodegenerative diseases, and cognition in general. Nevertheless, significant ambiguities persist across various dimensions. Future research should systematically address the limitations of this and prior studies, enhancing our knowledge and ultimately revealing the unresolved mechanisms and questions addressed in this work.

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List of Abbreviations

Abbreviation	Definition
ARTS-CAP	Artistic Creativity & Anxiety in Parkinson's Disease
AAA	Assessment of Art Attributes battery
CDAT	Clark's Drawing Abilities Test
CAQ	Creative Achievement Questionnaire
CPS	Creative Personality Scale
CDSS	Creativity Scale for Different Domains
DBS	Deep brain stimulation
DA	Dopamine
FD	Fractal Dimension
GEFT	Group Embeddd Figures Test
HC	Healthy control group
HY	Hoen and Yahr
ICC	Intra-class Correlation Coefficient
K-DOCS	Kaufman Domains of Creativity Scale
MRI	Magnetic resonance imaging
MAO-B	Monoamine oxidase-B
MOCA	Montreal Cognitive Assessment
NAcc	Nucleus accumbens
OFC	Orbitofrontal ccortex
OFPT	Out-of-focus-picture-task
QSIVQ	Cognitive Style, Object-Spatial Imagery and Verbal Questionnaire
PD	Parkinson's Disease
Radboudumc	Radboud Medical Center
ROCFT	Rey-Osterrieth/Taylor Complex Figure Task
vSNc	Substantia nigra pars compacta
TIPI	Tem-Item-Personality-Measure
UPDRS	Unified Parkinson's Disease Rating Scale
MDS-UPDRS	Modified Unified Parkinson's Disease Rating Scale
VTA	Ventral tegmental area
VVIQ	Vividness of Visual Imagery Questionnaire

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Appendix A: Art Making and Drawings

Hand Drawing Task

Operationalization: The Hand Drawing Task (McManus et al., 2010; Chamberlain et al., 2013) assesses an individual's ability to accurately recreate a given image. It reflects visuospatial ability, skill in copying, and perceptual-motor encoding and control in a visual art domain. It allows one to analyze for realism, approach execution, and correlation between artworks created in other tasks or paradigms (McManus et al., 2010; Chamberlain et al., 2013).

PD-related factors: As described in Section 2.2.2, some studies noticed a shift from realism to more abstract artwork. Comparable to the task above, quality, technical skill, copying ability, and realism can be rated through subjective rater questionnaires. Moreover, the researcher can evaluate the presence of crosshatching, vertical or horizontal paper orientation, and realistic copying. Similar to 'Cued, Drawing Task' (see Section 3.1.3), visual and page properties such as stroke length, complexity (using fractal dimension), page usage, vertical or horizontal mark making, accuracy, and line control can be analyzed, providing valuable insights into the changing landscape of art. In addition, hand movement can be analyzed if the task is recorded.

Procedure: For this task, participants will need a 2B pencil, a white blank sheet of DIN A4 paper, a photograph of a hand (see Figure 7), and a camera with a tripod on the table if the task should be recorded.

Figure 7

Photograph of the Hand for the Hand Drawing Task

Note. McManus et al. (2010); Chamberlain et al. (2013)

This task should be done after the art-making tasks, where participants are encouraged to draw freely and abstractly, avoiding the pressure of creating realistic artwork. The participants will receive a blank sheet of paper and will then be shown a colored photograph of a hand holding a pencil (following the procedure of McManus et al., 2010). Subsequently, they are asked to produce an accurate drawing of the shown photograph within five minutes.

Clark's Drawing Abilities Test (CDAT)

Operationalization: Clark's Drawing Abilities test (CDAT; Clark & Zimmermann, 2004) assesses realism, drawing from imagination, originality, and free expression in drawings made from the imagination after hearing the verbal cue.

PD-related factors: As described in Section 2.2.2, PD patients notice a shift towards creativity, as well as changes in accuracy or style in general and emotional expressivity. For the CDAT, drawings may be subjectively rated as in 'Cued, Drawing Task' (see Section 3.1.3), or 'Hand Drawing Task' for realism, originality, drawing from imagination, and free expression for the cue 'fantasy'.

Additionally, each completed drawing is objectively assessed and assigned a score using a Scoring Criteria Scale (5-point scale) based on the accuracy of the individual's drawings and their ability to complete the task within a given frame.

Procedure: Participants will additionally complete a drawing in which they are asked to create artwork on a white sheet of paper from a provided set of verbal cues consisting of a theme from their imagination. The drawings contain the following cues: "house", "running person", "playground", and "participant's fantasy". In addition, another verbal cue, such as "home" (see Cued verbal stimuli drawing task from Pelowski, 2018), can be included. The additional cue will provide one test for the ability to produce successful or visually compelling art in a more open task in which participants must plan and execute an artwork without visual cues. Ultimately, differences in quality or physical execution between artworks created with verbal vs. visual cues can be assessed. The time limit for each verbal cue is five minutes, whereas the cue from Pelowski et al., 2013 is limited to three minutes.

Drawing Emotions

Operationalization: The Drawing Emotions task (Pelowski , 2024) assesses two main factors: (1) Emotional expressivity of the drawings and (2) Emotional recognition while viewing the drawings through two phases (1) Phase 1: Drawing and (2) Phase 2: Art Viewing.

PD-related factors: After several studies found changes in emotional expressivity and emotion recognition, such as increased emotionality (Pelowski et al., 2022) or reduced ability in emotion recognition (Assogna et al. (2008), Enrici et al. (2015), Gray & Tickle-Degnen (2010), Serranová et al. (2011) (for a more detailed overview, see Section 2.2.2) it seems beneficial to integrate this task. This allows for subjective rater assessments, especially for emotion expressivity, and several other factors mentioned in the other drawing paradigms, including creativity, quality, technical proficiency, aesthetic pleasantness, and negative or positive valence. Besides, similar researcher-coded assessments, such as the presence of crosshatching and visual properties and page usage, as mentioned in the Art Making tasks before, can be included.

In addition, movement from the camera recordings can be analyzed.

Phase 1: Drawing Procedure: The following procedure is adapted from (Pelowski, 2024).

<u>Set-up:</u> For the drawing task, participants will need four blank white sheets of DIN A 4 paper (one for each emotion) and a black marker (1mm, Edding 400 permanent marker). Additionally, a camera with a tripod will be used.

The DIN A4 paper will be placed on a table in vertical format. The camera setup[27] can be seen in Figure 8.

[27] Camera setup: Flat desk with the camera on a tripod looking down from across the desk, so that it shows the entire drawing area (and eventually hands of participant) but no other body or face (angle as if someone is sitting in a chair across desk and watches the drawing process). After the task, all videos have to be rotated to create the feeling of effectively looking over an artist's shoulder. The white tape designates the drawing area captured by video. The tripod position is defined by black tape.

Figure 8

Example of Camera Set-Up for Drawing Emotions

Note. Pelowski (2024)

Instructions: Participants will be seated at a table with a computer screen showing the instructions, a marker, and a white sheet of paper. They will be asked to abstractly draw the following emotions: 'happiness', 'anger', 'fear', and 'pride'. All emotions will be given in a randomized order between the participants. Participants are instructed to complete the four abstract artworks and are further read the following section: *"We want you to make some drawings to communicate some specific emotion words. You can do whatever you want, but you should try to feel the emotion and express it so that another viewer would feel it when looking at their art. You can only make abstract art (no words, symbols, or readily identifiable people/objects). Please do not rotate the paper. Please depict the emotion in your drawing as best as you can. Try to feel the emotion while drawing. Continue if you make a mistake and work to adapt or incorporate it into your desired image.*

Drawing task: Next, participants will receive verbal and visual emotion cues (word on DIN A4 paper) for one specific emotion. Immediately after, the timer is started, and the participants are asked to think or plan their drawings for ten seconds. After ten seconds, they receive a sound cue and are asked to turn over the page[28] and start the drawing. Based on pilot testing, a drawing time of 90 seconds per cue was picked, as this showed a good balance between allowing most people to generally finish an initial drawing and not getting bored or feeling pressured. Overall, 100 seconds per drawing were given (10 seconds preparation or reflection time, 90

[28] Turning over the page will allow for a better synchronization of the videos.

seconds drawing), resulting in a total of three minutes and 40 seconds in total for all emotions: ‘happiness’, ‘anger’, ‘fear’, and ‘pride’.

Evaluation: After each drawing task, the participants were asked to rate nine questions to evaluate their artwork and to ask how well they thought it would express their meaning on a 7-Point-Likert-Scale, with 1 = “not at all” and 7 = “very”, except for question nine with 1 = “very negative” and 7 = “very positive”. The following questions were included in the short questionnaire:

1. How good do you think your drawing technique was for this drawing? (technique/ proficiency)
2. How aesthetically appealing as an artwork do you find the drawing? (aesthetic appeal)
3. How creative do you find the drawing? (creativity)
4. How expressive do you find the drawing? (expressivity)
5. How strongly do you agree that the drawing will evoke the intended emotion in the viewer? (successful communication)
6. How hard was this task for you? (confidence/difficulty)
7. How much did you think about the viewer while drawing? (thought of others)
8. Did you feel the emotion while drawing? (emotion felt)

Phase 2: Art Viewing Procedure: Referring to Pelowski et al. (2024), a computer screen with the video material (640 x 480 pixels, converted from full color to black and white, rotated 180 degrees) from the produced drawings in phase 1 is needed for the art viewing task. In addition, every participant should get a list of emotions, that will be shown in the videos.

Referring to Tinio’s mirror model (2013) only the first 60 seconds of the total video is shown. The trials will be presented in a randomized order without feedback about performance or time limits. After the participants are seated in front of the computer screen, the experiment will start, where they will be instructed to watch the videos and guess the emotion the artist intended afterward. Before the main block, the participants will be presented with a practice block to ensure they understand the task. Both blocks consist of the same structure. First, an instruction screen is displayed, followed by a .5 seconds fixation dot and one of the emotion drawing videos for 60 seconds. After the video is displayed, the participants must depict one of the four emotions (happiness, anger, fear, or pride) and answer the following five questions using a 7-point-Likert-scale:

1. How difficult was it for you to guess the emotion? (1=not at all, 7=very difficult) (difficulty/confidence)
2. How positive or negative was the drawing? (1=negative, 7=positive) (valence)
3. How technically good was the drawing? (1=not at all, 7=very good) (technique)
4. How expressive was the drawing? (1=not at all, 7=very expressive) (expressivity)
5. How much did you like the drawing? (1=not at all, 7=very much) (liking)

Color Choice Task in Drawing Emotions

Operationalization: The Color Choice Task assesses the creative expression and the spontaneous choice of color for the emotion term 'wonder', 'pride', and ‚relief' which has previously been shown not to have any distinct color associations to emotions (Damiano et al., 2023)

PD-related factors: As described in Section 2.2.2, changes in color usage and perception can be detected in PD patients (for a more detailed overview, see section x). This task analyzes visual properties such as color saturation or color usage (the percentage of warm vs. cool colors can be analyzed). Further, researchers could assess the number of markers used. As this task relies on procedures similar to those used in the Drawing Emotions Task from Pelowski et al. (2024), subjective raters can also rate emotional expression or other factors regarding creativity, style, and content. The emotions 'pride' and 'wonder' were picked because people used various colors when drawing these emotions in previous studies (not merely warm or cool shades) (Damiano et al., 2023). The emotion 'relief' was chosen as a control variable since relief is often drawn with cooler colors but not only (Jonauskaite et al., 2019).

Procedure: The following procedure is adapted from Pelowski et al. (2024) and Damiano et al. (2023). Participants will need three blank white sheets of DIN A4 paper and six color markers (Faber-Castell, Filzstifte Gripp, three warm colors: orange, light red/red-orange, red; three cold colors: light blue, dark blue, turquoise/blue-green). The colors of the markers had to be counterbalanced, meaning that three markers should belong to the cool color palette, and three markers should belong to the warm color palette. Yellow, light purple and green can be perceived as warm or cold colors (Jonauskaite et al., 2019). For a smoother analysis afterward, no more than six colors should be used (Jonauskaite et al., 2019). In addition, a desk with a computer screen, a table lamp to control lightning, and a camera with a tripod are needed.

Before starting the experiment, all used color markers will be tested on a blank white paper sheet (i.e., coloring squares). The sheet will be scanned to provide an accurate image of how the colors will look after the drawings are scanned. Participants will receive a blank sheet of paper and six color markers. They are instructed to draw the emotions in an abstract way, which will be displayed in a randomized order, with colored markers. The markers will be placed on the table in a randomized order (without any structure).

The following instruction will be written on a computer screen: “Please make one color drawing separately for the emotions, which will be shown to you. Please depict all emotions only through non-representational or abstract visual components. Do not use figurative art, meaningful shapes, or text in your artwork. You may use multiple colors in your artwork. You will be given a time limit of 190 sec[29] for each emotion.After completing all three drawings, participants will be asked to order their preference of the six colors, name them, and decide whether to assign them to cool or warm colors.

Afterward, the final drawings will be scanned (300 dpi) for computational image analysis. In addition, the first used color can be depicted through video analysis.

[29] 70 seconds more than in the Drawing Emotions Task (Pelowski, 2024). Participants can choose from various colors instead of only one black marker. In addition, in the Cued Drawing Task (Pelowski et al., 2018), participants get three minutes per cue.

Appendix B: Objective Perception, Memory, and IQ Measures

Rey-Osterrieth / Taylor Complex Figure Tasks (ROCFT)

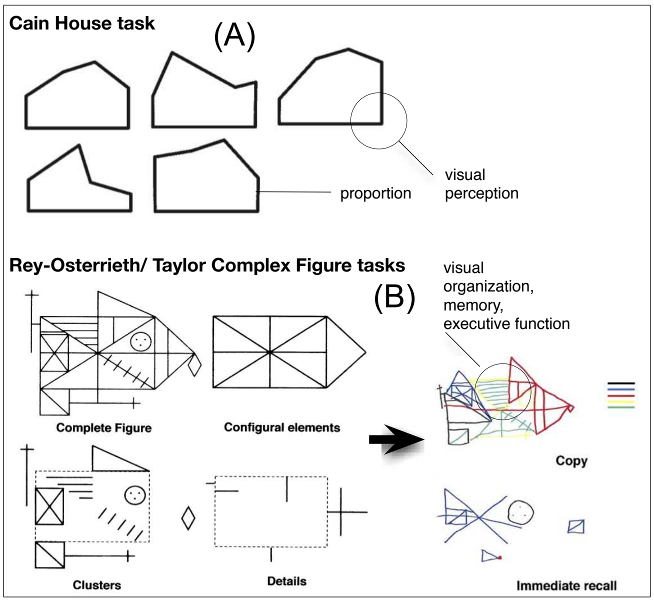
Operationalization: The Rey-Osterrieth /Taylor Complex Figure Tasks (Rey & Osterrieth, 1993; for review see Hubley & Tremblay, 2002) assesses visuospatial abilities and immediate and delayed visual memory by asking participants to copy a complex figure and then reproduce it from memory. The performance is scored based on the accuracy and placement of the figure's various elements.

PD-related factors: Studies with a healthy cohort found a positive correlation between visuospatial ability and realistic copying (Chamberlain et al., 2011) and between visuospatial ability and art quality, for novice judges only (Pelowski et al., 2018). As explained above, there are suggestions that shifts in creativity, style, emotional expressivity, quality, or color may result from impaired visio-spatial abilities since PD patients often suffer from impaired olfaction and vision (Lauring et al., 2019a; Bayulkemand & Lopez, 2011; Chaudhurri et al., 2006; Sveinsbjornsdottir, 2016). Besides it shows to have a positive correlation with realistic drawing ability (McManus et al., 2010; Chamberlain et al., 2011). Moreover, the ROCFT is suggested to be suitable to improve diagnostic accuracy (Liebermann-Jordanidis et al., 2022).

Procedure: The participants will be presented with a randomly chosen complex figure from a modified set of four versions of the ROCFT (see Figure 9*;* A). These require the participants to directly copy, and reproduce a standardized geometric figure from memory. The figures will be displayed for four minutes and the participants are asked to make an exact copy. This method can be combined with the Boston Qualitative Scoring System (Stern et al., 1999), where the figure is drawn using six different colored markers in a fixed sequence. This allows for the tracking of the drawing process and the assessment of the formal construction of artworks (Watanabe et al., 2005). If this method is used, it is crucial to perform it first and then repeat it last (after all other perception studies). In the final task, participants are asked to complete the figure from memory, which evaluates their visual memory processing (Pelowski et al., 2018).

Figure 9

Example for Cain's House Task and ROCFT



Note. (A) Series of five irregular hexagons from Cain House Task (based on Cain, 1943; McManus et al., 2010); (B) Randomly Chosen Complex Figure from a Modified Set of Four Versions of the ROCFT (Rey & Osterrieth, 1993; for review see Hubley & Tremblay, 2002)

Cain's House Task

Operationalization: In the Cain's house task (based on Cain, 1943; McManus et al., 2010) participants are asked to make an exact copy of a series of five irregular hexagons resembling houses (McManus et al., 2010; see Figure 9; B). This allows to assess for spatial processing (via attention to angles) and attention to proportions (relative side lengths).

PD-related factors: Similar to the ROFCT, a positive correlation with realistic copying (Chamberlain et al., 2013) was found for healthy participants. Pelowski et al. (2018) found similar results for novice judges only. Art-related changes could be tied to impaired visuospatial abilities and cognitive functions in PD patients as described in Section 2.2.2.

Procedure: The participants are asked to make an exact copy of the figure, which is shown on a laminated card for one minute.

Shepard Illusion

Operationalization: The Shepard Illusion Task (Shepard, 1990; Mitchell et al., 2005) assesses the misperception of proportion (Ostrofsky et al., 2015) and the degree of perceptual distortion by copying of two parallelograms.

PD-related factors: A positive correlation with realistic copying (Kozbelt & Seeley, 2007; Mitchell et al., 2005; Pelowski et al., 2018) and art expertise (Ostrofsky et al., 2015) was shown for healthy participants. In addition, visual misperceptions and hallucinations have a severe impact in PD patients (Shine et al., 2011) which could affect art-related changes in general.

Procedure: Following Mitchell et al. (2005), participants are asked to copy two parallelograms with the same dimensions (2:1) between the long and the short sides (one horizontally and one vertically, two modalities: with or without legs). The parallelograms are shown on laminated cards for two minutes. Comparing this free-drawing procedure with a equivalent computer-based method similar results have been shown (Mitchell et al., 2005; Ostrofsky et al., 2015).

Group Embedded Figures Test (GEFT)

Operationalization: The Group Embedded Figures Test (GEFT; Oltman et al., 1971; Witkin et al., 1971) assess field dependence and independence or local and global visual processing ability by detecting target shapes hidden in more complex figures.

PD-related factors: Comparable to the other tests in this section, a positive correlation with realistic drawing ability (Chamberlain et al., 2013) is shown. Pelowski et al. (2018) found similar results but only for novice judges. As already mentioned, visuo-cognitive impairment is common in PD patients and may have an impact on art-related changes. The GEFT seems to be one of the best methods to discriminate between different stages of impairment (Liebermann-Jordanidis et al., 2022).

Procedure: The procedure utilizes a standard testing package (Mindgarden.com) with two sets of nine complex figures. Participants are asked to find a target shape hidden in a more complex figure within five minutes for each set and to outline the hidden shape with a pencil.

Out-of-focus-picture task (OFPT)

Operationalization: The Out-of-focus-picture task (OFPT; Kozbelt, 2001) assesses for correct object identification by identifying objects from a set of out-of-focus photographs.

PD-related factors: The task showed positive correlation with the amount of art training (Kozbelt, 2001) and realistic drawing ability (Kozbelt, 2001; Pelowski et al., 2018), as well as art quality, but only for novice judges (Pelowski et al., 2018) in healthy participants. Since one of the symptoms is damaged vision, this test could provide additional insights into changes in art-making processes.

Procedure: Participants are asked to identify an object from a set ot ten 3 x 3.75 monochromatic, out-of-focus photographs of objects (taken from Schooler et al., 1993; Schooler & Melcher, 1994). Following the procedure and stimuli set from Kozbelt (2011), the ten individual pictures were presented for 20 seconds to the participants, which were then asked to write down the depicted object. Each response will be scored for the correct object identification with a maximum number of ten correct responses, while responses that name an exemplar or the class of the object count as correct.

Mental Rotation

Operationalization: The Mental Rotation task (Kozbelt, 2001; images from Vandenberg & Kuse, 1978; Shepard & Metzler, 1971) assess for differences in object-spatial-verbal cognitive style (Blazhenkova & Kozhevnikov, 2009).

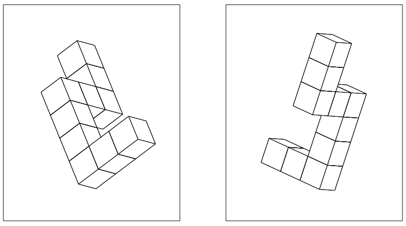
PD-related factors: Kozbelt (2001) showed a positive correlation between cognitive style and amount of art training as well as realistic drawing ability in a healthy cohort. In addition, a negative trend with art quality was shown (Pelowski et al., 2018). Since mild cognitive impairment is one of the most frequent non-motor symptoms in PD (Biundo et al., 2016) this could impact several processes in art-making from motivation and creativity to style, and color perception.

Procedure: Following the procedure of Kozbelt (2001) digital images from Vandenberg & Kuse (1978; originally Shepard & Metzler, 1971) were used. These consist of a series of target shapes composed of of 24 cube groups (see Figure 10

Figure 10). The participants are asked to find two matching, rotated shapes among four possible from each set. The score is based on the total number of correct matches found in three minutes.

Figure 10

Example for Cube Groups for Mental Rotation Task



Note. Kozbelt, 2001; images from Vandenberg & Kuse, 1978; Shepard & Metzler, 1971

2D and 3D Angle Drawings

Operationalization: The 2D and 3D Angle drawings task (Ostrofsky et al., 2015) assesses angle mistakes after drawing specific target angles from parallelograms or cuboid shapes.

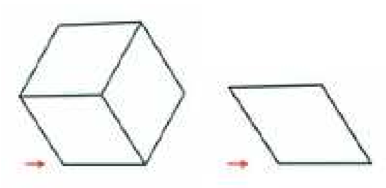
PD-related factors: Ostrofsky et al. (2015) found non-art related systematic interpersonal differences in regards to angle mistakes in healthy participants. Pelowski et al (2018) did not find significant results regarding angle mistakes and art making in healthy participants. As visuospatial function is often impaired in PD patients, this procedure may still offer some valuable insights.

Procedure: Following the procedure of Ostrofsky et al. (2015), the participants are asked to draw one target angle (designated by an arrow; see Figure 11)

from a series of 2D parallelograms or 3D cuboid shapes which are shown to them on laminated cards. Participants are shown one block of eight individual figures (either 2D or 3D) with eight different angles (29°, 44°, 57°, 83°, 97°, 123°, 136°, and 151°). For each angle they received one minute to copy. After finishing the first block, participants will be shown the missing block (either 2D or 3D).

Figure 11

Example of 3D cuboid shapes and 2D parallelogram for 2D and 3D Angle Drawings Task



Note. Ostrofsky et al. (2015)

Ravens Advanced Progressive Matrices (APM Short Form)

Operationalization: In the Ravens Advanced Progressive Matrices (APM Short Form; Raven, 1941; Arthur & Day, 1994; see Arthur et al., 1999 for validation and normalization) is a valid predictor for non-verbal IQ by matching patterns.

PD-related factors: A weak to moderate correlation was found between non-verbal IQ aesthetic sensitivity (Frois & Eysenck, 1995) as well as the General Mental Ability (Myszkowski et al., 2014). On the contrary, artistic experience and non-verbal IQ were not significant predictors of drawing ability (Chamberlain et al., 2013). Including a test to assess for non-verbal IQ is reasonable as one of the symptoms of cognitive decline is executive impairment showing in planning deficits (Sammer et al., 2006) and diminished inhibitory control which is associated with decreased motivation and increased motor slowing (Weintraub et al., 2006). This could possibly have an impact on motivation to produce art as well as creativity itself, or even style and quality.

Procedure: Following the procedure from Arthur & Day (1994) participants are required to find the correct solution for 12 items by matching a pattern depicted in a target image to one of eight possible answers.

Multiple Choice Vocabulary Intelligence test

Operationalization: In addition, the Multiple Choice Vocabulary Intelligence test (MWT-B, ‘Mehrfachwahl-Wortschatz-Intelligenztest’; Lehrl, 2005) assesses verbal IQ by asking participants to identify real words.

PD-related factors: A positive correlation between verbal IQ and realistic copying was shown (Chamberlain et al., 2014; Drake & Winner, 2009). Pelowski et al. (2018) showed similar results but only for expert judges. As PD is associated with cognitive decline (see Section 2.1.2) it is not only reasonable to incorporate a test to measure for non-verbal IQ but to also include a test to assess for verbal IQ.

Procedure: The participants are required to identify a real word from a list of five-word-options with progressing difficulty.

Appendix C: Subjective personality, art ability and interest, and creativity assessment

Art-Making Ability

Operationalization: Art-Making ability (Chamberlain et al., 2013; McManus et al., 2010) assesses self-assessed art-making ability at several drawing or mark making techniques using a 5-point-Likert-scale (1 = "far beyond average", 5 = "far over average")

PD-related factors: Chamberlain et al. (2013) and Pelowski et al. (2018) did find a positive correlation between art-making ability and realistic copying in healthy participants. Additionally, a positive correlation for art quality was shown (Pelowski et al., 2018). Similar findings may show for PD patients.

Procedure: Following the procedure of McManus et al. (2010) the measures include the self-assessed art-making ability for the following domains: (1) Drawing from observation (life drawing, still life), (2) Use of perspective and shading, (3) Confidence in making markings, (4) Use of contrast and tone, (5) Technical drawing (linear drawing, engineering drawing), and (6) Realistic copying of a photograph or another picture. In addition, the questions if participants "like to draw in their leisure time" and "if they like to doodle/sketch" may be included (Pelowski et al., 2018).

Self-assessed art expertise / training and interest

Operationalization: The Self-assessed art expertise / training and interest questionnaire (based on Art Experience Questionnaire, Chatterjee, 2010) measures for self-assessed art expertise, training, and interest.

PD-related factors: Pelowski et al. (2018) demonstrated a positive correlation between realistic copying and art quality in healthy individuals. Consequently, it would be valuable to evaluate these factors in patients with Parkinson's disease (PD

Procedure: Following Chatterjee (2010), art training is assessed through a computer-based survey with Likert-type scales (1 = "Strongly Agree", 2 = Strongly disagree") using the following items: (1) Amount of courses on studio art, (2) Art theory on a grammer school level or higher (0 to 6+), as well as (3) Number of hours spent in average week making visual art (0 to 6+).

Tem-Item-Personality-Measure (TIPI)

Operationalization: The Ten-Item-Personality-Measure (TIPI; Gosling et al., 2003) is a brief measure of the big five personality domains extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience.

PD-related factors: Several personality traits show correlations with art-related factors in healthy participants, i.e., openness is positively correlated with aesthetic sensitivity (Myszkowski et al., 2014), design judgment (Chamorro-Premuzic & Furnham, 2004), engagement with arts (Fayn et al., 2015; Kaufman, 2013) artistic creative achievement (Feist, 1998), art quality and realistic copying (Pelowski et al., 2018). Further, introversion showed a positive correlation with art expertise (Roy, 1996), while extraversion is positively correlated with creative achievements in art (Silvia et al., 2009) and realistic copying (Pelowski et al., 2018). Since art quality and realistic copying abilities seem to change, replicating these results with PD patients would be beneficial.

Procedure: Participants are asked to agree or disagree with ten statement on a 7-point-Likert scale (1 = disagree strongly; 7 = agree strongly).

Cognitive Style, Object-Spatial Imagery and Verbal Questionnaire (QSIVQ)

Operationalization: The Cognitive Style, Object-Spatial Imagery and Verbal Questionnaire (QSIVQ; Blazhenkova & Kozhevnikov, 2009) is a self-report instrument to assess verbal vs. spatial cognitive style, object-spatial imagery, tolerance for complexity, ambiguity and strategies for scanning and focusing.

PD-related factors: Verbal vs. spatial cognitive style, as well as tolerance for complexity, ambiguity and strategies for scanning or focusing, are shown to correlate with expert opinions regarding aesthetic merit of art (Blazhenkova & Kozhevnikov, 2009). Moreover, Blazhenkova & Kozhevnikov (2009) demonstrated a positive correlation between ‘object’ cognitive style and realistic copying. Further they showed a negative correlation between ‘spatial cognitive style and realistic copying and a trend for art quality for novice judges only. In addition, ‘verbal’ cognitive style was negatively correlated with art quality by trend for novice judges. As mentioned already for the task ‘Mental rotation’ (see Appendix B) cognitive impairment could influence art-related changes in PD patients. Additionally, it is possible that impaired processing of spatial relations is responsible for changes in mark-making (Lauring et al., 2019a).

Procedure: Following Blazhenkova & Kozhevnikov (2009) participants are asked to agree with 45 statements, of which 15 items are assigned to an object factor (e.g., “My images are very vivid and photographic”), 15 items to a spatial factor (“My graphic abilities would make a career in architecture relatively easy for me”), and 15 to a verbal factor (“My verbal skills are excellent”).

Vividness of Visual Imagery Questionnaire (VVIQ)

Operationalization: The Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) is a self-reported measure that assesses mental imagery or imagination via a computer-based survey.

PD-related factors: Healthy art experts score higher in mental imagery than non-experts by trend (Kottlow et al., 2011). Furthermore, a positive correlation between mental imagery and realistic copying by trend for novice healthy judges was detected (Pelowski et al., 2018).

Procedure: The VVIQ consists of 16 items in which the participants have to first, read a scene’s description (e.g., walking on a beach) and are then asked to rate the vividness of mental images they had to create. The VVIQ score is created by summing the 16 ratings (see McKelvie, 1995).

Need for Cognitive Closure (16-NICCS)

Operationalization: The Need for Cognitive Close (16-NICCS; Schlink & Walther, 2007) is the 16-item German translation of the brief version of the Need for Cognitive Closure (NCC; Webster & Kruglanski, 1994). It assesses for disliking and liking of ambiguity, and a desire for clear classification.

PD-related factors: Pelowski et al. (2018) showed negative correlations with realistic copying, as well as an inverse correlation with ‘openness’ and liking art (Pelowski et al., 2017).

Procedure: Participants are asked to answer the 16 items of the 16-NICCS on a 6-point-Likert scale (1 = strongly disagree; 6 = strongly agree).

Creative Tests

A: Creative Personality Scale (CPS)

Operationalization: The Creative Personality Scale (CPS; Kaufman & Baer, 2004) is a 20-item self-assessment scale with statements referring to creativity (e.g., “love to daydream”) via a computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).

B: Creative Achievement Questionnaire (CAQ)

Operationalization: The Creative Achievement Questionnaire (CAQ; Carson et al., 2005) is a self-report scale where participants are asked to rate their real-world creative achievements in ten domains including visual art via a computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).

C: Creativity Scale for Different Domains (CDSS)

Operationalization: The Creativity Scale for Different Domains (CDSS; Kaufman & Baer, 2004; see also Silvia et al., 2009) is a ten-item questionnaire measuring the individual’s own view of themselves as creatives in nine areas including visual art via a computer-based survey with Likert-type scales (1 = “Strongly Agree”, 2 = “Strongly disagree”).

PD-related factors: Art experts score higher than non-experts in all three creative scales (CPS, CAQ, CDSS) Creative Scales (Rawlings & Locarnini, 2007). Further, Pelowski et al. (2018) demonstrated a positive correlation with realistic copying (novice judges only) and art quality. These scales may be additionally used to describe the PD patient study population and compare these with several other tests from the Drawing studies domain or perceptual and cognitive tests.

Appendix D: Artwork Rating Scales and Questions

Originally in German [English translation by author shown in brackets and italicized][30]

1. Willkommen *[Welcome]*:

Herzlich willkommen und vielen Dank für Ihre Teilnahme an dieser Studie!

Das Ziel dieser Studie ist es Zeichnungen anhand mehrerer Skalen (wie z.B. ästhetische Qualität oder formale Aspekte) zu bewerten. Wir sind daran interessiert Unterschiede zwischen Menschen in Bezug auf die Kunst die sie produzieren zu untersuchen - bzw. Veränderungen in der Kunstproduktion von Menschen in Bezug auf verschiedene Faktoren zu verstehen.

Wir bitten Sie um Ihre persönliche Einschätzungen. Bitte beachten Sie, dass viele der Zeichnungen von Laien, aber teilweise auch von Kunstinteressierten angefertigt wurden. Daher kann das Niveau der Kunst sehr unterschiedlich sein. Das ist in Ordnung. Wir bitten Sie nur darum, alle Zeichnungen sorgfältig zu behandeln und so konsistent und objektiv als möglich zu bewerten.

Der Fragebogen besteht aus einem Hauptteil, wobei Sie zu jedem Kunstwerk 1.) Fragen zum persönlichen Empfinden in Bezug auf dieses Kunstwerk und 2.) Fragen zu formalen Aspekten beantworten sollen. Abschließend werden Ihnen noch einige demographische Fragen gestellt.

Die Studie sollte in etwa 1.5 - 2 Stunden abgeschlossen werden. Sie können jederzeit eine Pause einlegen und später weitermachen (wir empfehlen dies sogar!), da wir an Ihrer sorgfältigen Aufmerksamkeit bei der Bewertung interessiert sind.

Gleichzeitig bitten wir Sie aber auch, Ihren unmittelbaren, spontanen Eindruck zu schildern und nicht zu lange über eine Frage nachzudenken.

Für Ihre vollständige Teilnahme an dieser Studie erhalten Sie 8 Lab-Credits.

Alle Angaben werden anonymisiert und vertraulich behandelt.

Vielen Dank für Ihre Zeit und Teilnahme!

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[30] Note, the English translated version is not a verbatim translation of the original German. With the translation, it was tried to best reproduce the underlying meaning and nuance of the original version. The translation of the questionnaire in English is included for the reader’s convenience, and has not been applied or validated in an actual study.

[Welcome and thank you for your participation in this study!

The aim of this study is to evaluate artwork on several scales (such as aesthetic quality or formal aspects). We are interested in investigating differences between people in relation to the art they produce - or to understand changes in people's art production in relation to different factors. We ask for your personal assessments. Please note that many of the drawings were made by amateurs, but some were also made by art enthusiasts. Therefore, the level of art may vary greatly. That is fine. We only ask that you treat all artwork with care and evaluate them as consistently and objectively as possible.

The questionnaire consists of a main section where you are asked to answer 1) questions about your personal feelings about each artwork and 2) questions about formal aspects. Finally, you will be asked some demographic questions.

The study should be completed in about 1.5 - 2 hours. You can take a break at any time and continue later (we actually recommend this!), as we are interested in your careful attention during the evaluation.

At the same time, we also ask you to describe your immediate, spontaneous impression and not to think too long about a question.

You will receive 8 lab credits for your complete participation in this study.

All information will be treated anonymously and confidential.

Thank you for your time and participation!]

2. **Instruktionen *[Instructions]:***

Vielen Dank. Lassen Sie uns nun beginnen.

Sie werden im ersten Teil der Umfrage eine Reihe von Zeichnungen sehen. Diese wurden von verschiedenen Personen mit unterschiedlicher künstlerischer Ausbildung oder Fertigkeiten angefertigt. Einige der Kunstwerke können auch von denselben Personen stammen, sie werden jedoch in zufälliger Reihenfolge gezeigt.

Dieser Fragebogen enthält Begriffe, die das persönliche emotionale/ästhetische Empfinden und die technische und intellektuelle Bewertung zu den Zeichnungen beschreiben. Wir bitten Sie, für jeden Begriff ihre persönliche Bewertung und Wahrnehmung anzugeben. Bei dieser Bewertung gibt es keine richtigen und falschen Antworten. Die Möglichkeit zur Ablehnung bzw. Zustimmung hat die folgende Form:

überhaupt nicht – 1 2 3 4 5 6 7 – äußerst

Bitte markieren Sie für jede Aussage diejenige Position, die dem Grad Ihrer Zustimmung am besten entspricht. Sie können dafür gerne immer wieder zum Bild hochscrollen und sich dieses so oft ansehen wie Sie möchten. Insgesamt umfasst dieser Fragebogen 70 Bilder, wir empfehlen daher ihn in mehreren kleinen Teilen mit Pausen dazwischen zu bearbeiten. Beachten Sie auch, dass es manchmal ein paar Sekunden dauert, bis das Bild geladen ist. Sollten Sie nur Fragen sehen, haben Sie bitte etwas Geduld.

[Thank you very much. Let us begin.

You will see a series of drawings in the first part of the survey. These were made by different people with different artistic training or skills. Some of the artworks may also be by the same people, but they are shown in random order.

This questionnaire contains terms that describe personal emotional/aesthetic feelings and technical and intellectual evaluations of the drawings. We ask you to indicate your personal evaluation and perception for each term. There are no right or wrong answers in this evaluation. The option to disagree or agree takes the following form:

not at all - 1 2 3 4 5 6 7 - extremely

For each statement, please mark the position that best corresponds to your level of agreement. You are welcome to scroll up to the picture and look at it as often as you like. This questionnaire comprises a total of 70 images, so we recommend that you work through it in several small parts with breaks in between. Please also note that it sometimes takes a few seconds for the image to load. If you only see questions, please be patient.]

3. Evaluationsskalen *[Evaluation scales]:*

Bitte geben Sie Ihre persönliche Bewertung der Zeichnung *ab [Please give your personal evaluation of the artwork]*:

a. Wie kreativ finden Sie die Zeichnung? *[How creative do you find the artwork?]*
b. Finden Sie die Zeichnung ein gutes Kunstwerk? *[Do you think the drawing is a good work of art?]*
c. Wie hoch bewerten Sie die technische Kunstfertigkeit des Künstlers/der Künstlerin? *[How high do you rate the technical skill of the artist?]*
d. Wie sehr gefällt Ihnen die Zeichnung persönlich? *[How much do you personally like the artwork?]*

4. Art Attribute *[Art Attributes]*:

Welche Attribute zeichnen dieses Kunstwerk ihrer Meinung nach aus? *[What attributes do you think characterize this work of art?]*

a. Balanciert, visuelle Harmonie *[balance, visual harmony]*
b. Dimensionale Tiefe *[depth]*
c. Feine fließende Pinselführung *[mark-making (fluent/skilled)]*
d. Abstrakt *[abstractness]*
e. Symbolisch *[symbolism]*
f. Realistisch *[realistic content/themes]*
g. Aktiv, lebendig *[active]*
h. Emotional expressiv *[emotional expressivity]*
i. Komplex *[complexity]*
j. Vollständige Ausnutzung der Zeichenfläche *[paper usage (employed all page)]*
k. (Foto-)realistische Darstellung *[photorealistic (like a picture)]*
l. Welche Stimmung löst die Zeichnung in Ihnen aus? (1 = negativ, 7 = positiv) *[emotional valence, which mood does the artwork evoke? (negative/positive)]*

5. Soziodemographische Fragen *[Sociodemographic questions]:*

a. Geben Sie bitte Ihr Geschlecht an. (weiblich; männlich; inter/divers/anders) *[Please indicate your gender. (female; male; inter/diverse/different)]*

b. Bitte geben Sie Ihren höchsten Bildungsabschluss, den Sie bisher erreict haben an. (Pflichtschule; Allgemeine Hochschule/Matura; Fachhochschul-Hochschulabschluss: Bachelor; Fachhochschul-/Hochschulabschluss: Master/Magister; Fachhochschul-/Hochschulabschluss: Doktorgrad/PhD; Berufsschule/Ausbildung/Lehre*) [Please state the highest educational qualification you have achieved to date. (Compulsory schooling; Bachelor's degree; Master's/Magister's degree; Doctorate*/PhD; Vocational school/training/apprenticeship)]
c. Bitte geben Sie Ihr Alter an. *[Please indicate your age.]*
d. Was ist Ihre Muttersprache? *[Please indicate your mothers language]*
e. Haben Sie irgendwelche visuellen Beeinträchtigungen? Bitte nennen Sie diese: *[Do you have any visual impairments? Please name them.]*

Appendix E: Between Scale-Correlations

Table 8

Pearson's Correlations between all Scales

			Pearson's r	p	Lower 95% CI	Upper 95% CI	Effect size (Fisher's z)	SE Effect size
Creativity	-	GoodWorkofArt	0.756***	<.001	0.691	0.809	0.987	0.070
Creativity	-	TechnicalAbility	0.630***	<.001	0.541	0.705	0.742	0.070
Creativity	-	PersonalLiking	0.634***	<.001	0.546	0.709	0.749	0.070
Creativity	-	Balance	0.427***	<.001	0.309	0.532	0.456	0.070
Creativity	-	Depth	0.323***	<.001	0.197	0.440	0.335	0.070
Creativity	-	MarkMaking	0.440***	<.001	0.323	0.543	0.472	0.070
Creativity	-	Abstractness	0.428***	<.001	0.311	0.533	0.457	0.070
Creativity	-	Symbolism	0.654***	<.001	0.569	0.725	0.783	0.070
Creativity	-	RealisticContent	-0.043	0.539	-0.177	0.093	-0.043	0.070
Creativity	-	Active	0.727***	<.001	0.656	0.785	0.923	0.070
Creativity	-	EmotionalExpressive	0.696***	<.001	0.619	0.760	0.860	0.070
Creativity	-	Complexity	0.796***	<.001	0.741	0.841	1.089	0.070
Creativity	-	PaperUsage	0.276***	<.001	0.147	0.397	0.284	0.070
Creativity	-	Photorealistic	-0.010	0.885	-0.145	0.126	-0.010	0.070
Creativity	-	EmotionalValence	0.470***	<.001	0.357	0.569	0.509	0.070
Creativity	-	FractalD	0.041	0.559	-0.095	0.175	0.041	0.070
GoodWorkofArt	-	TechnicalAbility	0.908***	<.001	0.880	0.929	1.514	0.070
GoodWorkofArt	-	PersonalLiking	0.902***	<.001	0.873	0.924	1.481	0.070
GoodWorkofArt	-	Balance	0.768***	<.001	0.707	0.819	1.016	0.070
GoodWorkofArt	-	Depth	0.487***	<.001	0.376	0.583	0.531	0.070
GoodWorkofArt	-	MarkMaking	0.728***	<.001	0.657	0.786	0.924	0.070
GoodWorkofArt	-	Abstractness	0.088	0.206	-0.048	0.220	0.088	0.070
GoodWorkofArt	-	Symbolism	0.424***	<.001	0.306	0.529	0.452	0.070
GoodWorkofArt	-	RealisticContent	0.396***	<.001	0.275	0.504	0.419	0.070
GoodWorkofArt	-	Active	0.622***	<.001	0.532	0.699	0.729	0.070

			Pearson's r	p	Lower 95% CI	Upper 95% CI	Effect size (Fisher's z)	SE Effect size
GoodWorkofArt	-	EmotionalExpressive	0.571***	<.001	0.473	0.656	0.650	0.070
GoodWorkofArt	-	Complexity	0.594***	<.001	0.499	0.675	0.684	0.070
GoodWorkofArt	-	PaperUsage	0.155*	0.025	0.020	0.284	0.156	0.070
GoodWorkofArt	-	Photorealistic	0.417***	<.001	0.298	0.523	0.444	0.070
GoodWorkofArt	-	EmotionalValence	0.758***	<.001	0.694	0.810	0.992	0.070
GoodWorkofArt	-	FractalD	0.048	0.485	-0.088	0.183	0.048	0.070
TechnicalAbility	-	PersonalLiking	0.763***	<.001	0.700	0.814	1.003	0.070
TechnicalAbility	-	Balance	0.677***	<.001	0.596	0.744	0.824	0.070
TechnicalAbility	-	Depth	0.565***	<.001	0.466	0.651	0.641	0.070
TechnicalAbility	-	MarkMaking	0.731***	< .001	0.661	0.788	0.931	0.070
TechnicalAbility	-	Abstractness	-0.009	0.899	-0.144	0.127	-0.009	0.070
TechnicalAbility	-	Symbolism	0.248***	<.001	0.116	0.371	0.253	0.070
TechnicalAbility	-	RealisticContent	0.498***	<.001	0.388	0.593	0.546	0.070
TechnicalAbility	-	Active	0.510***	<.001	0.403	0.604	0.563	0.070
TechnicalAbility	-	EmotionalExpressive	0.486***	<.001	0.375	0.583	0.531	0.070
TechnicalAbility	-	Complexity	0.550***	<.001	0.448	0.638	0.618	0.070
TechnicalAbility	-	PaperUsage	0.109	0.114	-0.027	0.241	0.110	0.070
TechnicalAbility	-	Photorealistic	0.542***	<.001	0.439	0.631	0.608	0.070
TechnicalAbility	-	EmotionalValence	0.629***	<.001	0.540	0.705	0.741	0.070
TechnicalAbility	-	FractalD	0.039	0.577	-0.097	0.173	0.039	0.070
PersonalLiking	-	Balance	0.845***	<.001	0.801	0.879	1.237	0.070
PersonalLiking	-	Depth	0.428***	<.001	0.310	0.532	0.457	0.070
PersonalLiking	-	MarkMaking	0.719***	<.001	0.647	0.779	0.906	0.070
PersonalLiking	-	Abstractness	-0.034	0.628	-0.168	0.102	-0.034	0.070
PersonalLiking	-	Symbolism	0.389***	<.001	0.268	0.498	0.411	0.070
PersonalLiking	-	RealisticContent	0.394***	<.001	0.274	0.503	0.417	0.070

			Pearson's r	p	Lower 95% CI	Upper 95% CI	Effect size (Fisher's z)	SE Effect size
PersonalLiking	-	Active	0.605***	<.001	0.512	0.684	0.701	0.070
PersonalLiking	-	EmotionalExpressive	0.449***	<.001	0.334	0.551	0.483	0.070
PersonalLiking	-	Complexity	0.420***	<.001	0.302	0.526	0.448	0.070
PersonalLiking	-	PaperUsage	0.104	0.133	-0.032	0.236	0.104	0.070
PersonalLiking	-	Photorealistic	0.379***	<.001	0.257	0.489	0.399	0.070
PersonalLiking	-	EmotionalValence	0.907***	<.001	0.880	0.928	1.511	0.070
PersonalLiking	-	FractalD	0.101	0.147	-0.035	0.233	0.101	0.070
Balance	-	Depth	0.464***	<.001	0.350	0.564	0.502	0.070
Balance	-	MarkMaking	0.844***	<.001	0.800	0.879	1.235	0.070
Balance	-	Abstractness	-0.045	0.517	-0.179	0.091	-0.045	0.070
Balance	-	Symbolism	0.235***	<.001	0.103	0.359	0.239	0.070
Balance	-	RealisticContent	0.399***	<.001	0.279	0.507	0.423	0.070
Balance	-	Active	0.360***	<.001	0.236	0.472	0.377	0.070
Balance	-	EmotionalExpressive	0.216**	0.002	0.083	0.341	0.219	0.070
Balance	-	Complexity	0.294***	<.001	0.165	0.413	0.303	0.070
Balance	-	PaperUsage	0.235***	<.001	0.103	0.359	0.239	0.070
Balance	-	Photorealistic	0.441***	<.001	0.325	0.544	0.474	0.070
Balance	-	EmotionalValence	0.824***	<.001	0.775	0.863	1.168	0.070
Balance	-	FractalD	0.063	0.362	-0.073	0.197	0.063	0.070
Depth	-	MarkMaking	0.370***	<.001	0.247	0.481	0.388	0.070
Depth	-	Abstractness	-0.285***	<.001	-0.405	-0.156	-0.294	0.070
Depth	-	Symbolism	0.009	0.902	-0.127	0.144	0.009	0.070
Depth	-	RealisticContent	0.570***	<.001	0.471	0.655	0.647	0.070
Depth	-	Active	0.273***	<.001	0.143	0.394	0.280	0.070
Depth	-	EmotionalExpressive	0.081	0.241	-0.055	0.214	0.081	0.070
Depth	-	Complexity	0.381***	<.001	0.259	0.491	0.402	0.070
Depth	-	PaperUsage	0.437***	<.001	0.320	0.540	0.468	0.070
Depth	-	Photorealistic	0.647***	<.001	0.561	0.719	0.770	0.070
Depth	-	EmotionalValence	0.438***	<.001	0.321	0.541	0.469	0.070
Depth	-	FractalD	0.054	0.433	-0.082	0.188	0.054	0.070
MarkMaking	-	Abstractness	0.100	0.148	-0.036	0.232	0.101	0.070
MarkMaking	-	Symbolism	0.243***	<.001	0.112	0.367	0.248	0.070

			Pearson's r	p	Lower 95% CI	Upper 95% CI	Effect size (Fisher's z)	SE Effect size
MarkMaking	-	RealisticContent	0.269***	<.001	0.139	0.390	0.276	0.070
MarkMaking	-	Active	0.285***	<.001	0.156	0.405	0.293	0.070
MarkMaking	-	EmotionalExpressive	0.259***	<.001	0.129	0.381	0.266	0.070
MarkMaking	-	Complexity	0.307***	<.001	0.179	0.425	0.318	0.070
MarkMaking	-	PaperUsage	0.078	0.258	-0.058	0.212	0.079	0.070
MarkMaking	-	Photorealistic	0.350***	<.001	0.226	0.464	0.366	0.070
MarkMaking	-	EmotionalValence	0.688***	<.001	0.610	0.753	0.844	0.070
MarkMaking	-	FractalD	0.001	0.986	-0.134	0.137	0.001	0.070
Abstractness	-	Symbolism	0.419***	<.001	0.301	0.525	0.447	0.070
Abstractness	-	RealisticContent	-0.781***	<.001	-0.829	-0.722	-1.048	0.070
Abstractness	-	Active	0.040	0.560	-0.095	0.175	0.040	0.070
Abstractness	-	EmotionalExpressive	0.223**	0.001	0.090	0.348	0.227	0.070
Abstractness	-	Complexity	0.557***	<.001	0.456	0.644	0.629	0.070
Abstractness	-	PaperUsage	0.092	0.186	-0.044	0.224	0.092	0.070
Abstractness	-	Photorealistic	-0.716***	<.001	-0.776	-0.643	-0.900	0.070
Abstractness	-	EmotionalValence	-0.173*	0.012	-0.301	-0.038	-0.174	0.070
Abstractness	-	FractalD	-0.041	0.558	-0.175	0.095	-0.041	0.070
Symbolism	-	RealisticContent	-0.202**	0.003	-0.328	-0.069	-0.205	0.070
Symbolism	-	Active	0.358***	<.001	0.234	0.471	0.375	0.070
Symbolism	-	EmotionalExpressive	0.526***	<.001	0.421	0.617	0.585	0.070
Symbolism	-	Complexity	0.444***	<.001	0.328	0.546	0.477	0.070
Symbolism	-	PaperUsage	-0.001	0.986	-0.137	0.134	-0.001	0.070
Symbolism	-	Photorealistic	-0.216**	0.002	-0.342	-0.084	-0.220	0.070
Symbolism	-	EmotionalValence	0.244***	<.001	0.113	0.368	0.249	0.070
Symbolism	-	FractalD	0.012	0.863	-0.124	0.147	0.012	0.070
RealisticContent	-	Active	0.191**	0.006	0.057	0.318	0.193	0.070
RealisticContent	-	EmotionalExpressive	0.010	0.889	-0.126	0.145	0.010	0.070
RealisticContent	-	Complexity	-0.152*	0.028	-0.281	-0.017	-0.153	0.070

		Pearson's r	p	Lower 95% CI	Upper 95% CI	Effect size (Fisher's z)	SE Effect size
RealisticContent	- PaperUsage	0.034	0.627	-0.102	0.168	0.034	0.070
RealisticContent	- Photorealistic	0.938***	<.001	0.919	0.952	1.720	0.070
RealisticContent	- EmotionalValence	0.438***	<.001	0.322	0.542	0.470	0.070
RealisticContent	- FractalD	0.025	0.724	-0.111	0.159	0.025	0.070
Active	- EmotionalExpressive	0.717***	<.001	0.644	0.777	0.901	0.070
Active	- Complexity	0.529***	<.001	0.424	0.620	0.589	0.070
Active	- PaperUsage	0.259***	<.001	0.128	0.381	0.265	0.070
Active	- Photorealistic	0.129	0.063	-0.007	0.259	0.129	0.070
Active	- EmotionalValence	0.523***	<.001	0.417	0.615	0.581	0.070
Active	- FractalD	0.080	0.249	-0.056	0.213	0.080	0.070
EmotionalExpressive	- Complexity	0.535***	<.001	0.430	0.625	0.597	0.070
EmotionalExpressive	- PaperUsage	0.113	0.102	-0.022	0.245	0.114	0.070
EmotionalExpressive	- Photorealistic	0.010	0.889	-0.126	0.145	0.010	0.070
EmotionalExpressive	- EmotionalValence	0.270***	<.001	0.140	0.391	0.277	0.070
EmotionalExpressive	- FractalD	0.029	0.677	-0.107	0.164	0.029	0.070
Complexity	- PaperUsage	0.429***	<.001	0.311	0.533	0.458	0.070
Complexity	- Photorealistic	-0.080	0.250	-0.213	0.056	-0.080	0.070
Complexity	- EmotionalValence	0.248***	<.001	0.116	0.371	0.253	0.070
Complexity	- FractalD	0.085	0.219	-0.051	0.218	0.085	0.070
PaperUsage	- Photorealistic	0.180**	0.009	0.045	0.308	0.182	0.070
PaperUsage	- EmotionalValence	0.132	0.056	-0.003	0.263	0.133	0.070
PaperUsage	- FractalD	-0.035	0.612	-0.170	0.101	-0.035	0.070
Photorealistic	- EmotionalValence	0.424***	<.001	0.306	0.529	0.452	0.070
Photorealistic	- FractalD	-5.374×10^{-4}	0.994	-0.136	0.135	-5.374×10^{-4}	0.070
EmotionalValence	- FractalD	0.095	0.172	-0.041	0.227	0.095	0.070

Note. * p < .05, ** p < .01, *** p < .001

Appendix F: Mean subjective rating for each scale per image between HC and PD

Table 9

Mean subjective rating for each scale per image between HC and PD

Group	Image	Creativity	Good work of art	Technical ability	Personal liking	Balance/ visual harmony	Depth	Mark making (Fluent/ skilled)	Abstractness	Symbolism	Realistic Content/ themes	Active	Emotional expressive	Complexity	Paper usage (employed all page)	Photo-realistic (like a picture)	Emotional valence	Fractal D/ Complexity
HC																		
	Visual Cue 1																	
	1	3,16	3,00	2,47	3,06	3,28	2,28	2,34	5,31	3,31	1,22	2,72	2,41	3,06	3,44	1,19	3,44	1,61
	2	4,44	3,09	2,81	2,94	2,66	3,75	2,72	3,56	4,84	2,22	3,69	2,84	3,22	5,47	2,34	3,25	1,54
	3	4,47	3,84	4,22	3,91	3,81	4,25	3,91	3,25	2,88	3,19	3,34	2,47	3,31	5,06	2,84	4,88	1,51
	4	2,59	2,31	1,91	2,22	2,78	2,25	2,25	2,88	2,53	2,25	1,88	1,75	1,50	4,47	1,88	3,28	1,33
	5	4,28	3,50	3,44	3,66	3,44	2,88	3,97	3,78	4,28	2,34	3,50	2,88	2,88	2,16	2,03	4,34	1,38
	6	2,16	2,13	2,34	2,06	2,53	4,09	2,72	3,56	2,50	2,34	1,75	1,69	2,69	2,44	2,06	2,94	1,62
	7	1,47	2,31	2,25	2,53	3,50	1,56	3,06	2,00	2,69	2,94	1,75	1,63	1,25	2,97	2,34	3,50	1,41
	8	3,00	3,19	3,06	3,47	3,38	3,34	2,88	2,47	2,66	3,13	2,09	1,88	2,41	1,88	2,66	3,84	1,48
	9	2,94	3,13	2,88	3,59	3,38	2,66	3,13	2,28	2,88	2,78	3,50	2,69	1,97	2,63	2,06	4,44	1,39
	10	3,31	2,91	2,66	2,91	3,50	2,84	2,69	5,41	2,78	1,22	2,97	2,34	3,56	5,19	1,22	3,50	1,60
	11	2,34	2,13	2,09	2,91	2,69	1,88	2,22	2,03	2,13	2,44	3,69	2,56	1,69	2,81	1,75	3,97	1,39
	12	3,00	2,88	3,28	3,09	3,59	2,38	3,88	3,03	3,56	2,56	2,16	1,84	2,09	3,13	2,28	3,91	1,42
	13	2,50	2,47	2,63	2,94	3,75	3,66	4,13	2,13	2,88	3,34	2,19	1,66	1,66	4,72	2,78	3,81	1,36
	14	4,47	2,91	2,66	2,56	2,53	1,97	2,38	5,34	3,63	1,66	4,28	4,34	3,38	5,59	1,44	3,19	1,61
	15	3,47	2,06	2,00	3,16	3,03	2,06	2,56	2,47	2,63	2,38	4,13	2,81	1,91	3,59	1,84	4,00	1,54
	16	3,91	3,34	3,38	3,44	3,97	4,44	3,47	2,31	2,94	3,47	4,16	2,19	2,53	5,53	2,97	4,00	1,52
	17	2,16	2,19	2,44	2,19	3,03	3,19	3,16	2,06	2,34	3,34	1,81	1,34	1,53	2,69	2,50	3,06	1,48
	18	3,31	3,66	3,28	3,94	4,09	3,34	3,69	2,22	2,94	3,34	3,50	2,34	2,03	2,78	2,50	4,56	1,55
	19	2,25	2,34	2,03	2,84	3,41	2,53	3,38	1,91	2,75	3,38	2,81	1,81	1,75	4,97	2,66	4,06	1,42
	20	2,81	3,00	2,91	3,63	4,22	2,72	3,59	1,91	2,75	3,34	2,75	1,94	1,94	4,06	3,03	4,72	1,45
	21	4,50	2,78	2,41	2,69	2,94	1,97	2,66	4,75	4,13	1,75	3,19	2,38	2,84	3,53	1,44	3,66	1,53
	22	5,16	3,78	3,50	3,56	3,44	3,66	3,50	4,94	4,78	1,75	4,38	4,44	3,75	4,63	1,75	4,16	1,47
	23	3,84	4,28	4,56	4,28	4,41	4,69	4,28	3,50	3,13	3,63	3,59	3,41	3,28	3,31	3,31	4,78	1,54
	24	2,41	2,97	3,25	3,47	3,59	3,06	3,56	1,88	3,88	3,97	2,53	2,41	2,06	2,88	2,94	4,78	1,52
	25	2,00	2,48	2,55	2,45	3,32	1,71	2,74	1,81	3,39	3,71	1,81	1,74	1,74	2,39	2,74	3,35	1,40
	26	1,77	2,03	2,39	2,29	2,74	3,32	2,45	1,48	2,48	3,77	1,61	1,61	1,58	3,19	3,16	3,42	1,44
	27	3,23	3,19	2,71	4,13	4,13	3,19	2,94	2,16	2,81	3,23	4,71	2,65	2,52	5,06	2,42	4,90	1,35
	28	3,61	3,13	3,10	3,03	3,26	2,71	2,77	4,58	3,19	1,87	2,58	2,00	2,52	3,48	1,45	3,71	1,39
	29	2,74	3,00	2,45	2,97	3,16	2,94	2,45	2,06	2,94	3,26	3,19	2,35	1,87	4,26	2,52	3,90	1,45
	30	2,97	3,23	2,71	3,74	3,61	2,45	3,29	2,19	3,52	3,42	3,81	2,90	1,97	3,26	2,39	4,71	1,50
	31	2,84	2,23	2,00	2,71	3,13	2,06	1,94	2,23	3,26	3,00	3,71	2,32	2,03	3,16	2,00	3,71	1,55
	32	2,03	2,10	2,39	2,32	2,65	3,52	2,39	1,94	2,81	3,48	1,90	1,71	1,68	2,65	2,58	3,61	1,50
	33	2,55	2,65	2,45	3,52	3,74	3,13	2,65	1,81	2,52	3,55	3,45	2,16	1,77	4,39	2,52	4,48	1,42
	34	3,06	2,77	2,65	2,68	2,87	2,32	2,90	3,71	3,23	1,94	2,10	1,74	2,45	2,58	1,84	3,58	1,54
	35	2,87	2,87	2,42	2,87	2,90	3,42	2,19	2,39	2,55	3,58	3,52	1,97	2,61	4,84	2,42	3,81	1,42
	Visual Cue 2																	
	36	2,65	3,55	2,94	4,13	4,16	1,74	2,97	2,23	3,26	3,52	3,13	2,16	1,74	3,84	2,94	4,71	1,55
	37	4,29	4,48	4,06	5,13	4,84	4,16	4,03	2,42	3,26	3,52	4,03	3,00	2,87	5,19	3,10	5,32	1,53
	38	5,16	4,42	4,00	5,19	4,42	3,55	3,61	3,16	3,68	2,48	5,61	3,77	3,13	3,90	2,03	5,68	1,46
	39	2,77	2,58	2,45	2,65	2,71	1,81	2,45	2,32	3,45	3,39	2,90	2,48	1,71	3,87	2,65	3,84	1,42
	40	5,26	4,71	4,55	4,81	4,71	2,45	4,74	4,68	4,45	2,58	3,84	4,00	3,48	1,58	1,58	4,97	1,28
	41	3,71	3,35	3,10	3,87	4,29	1,81	4,00	4,84	3,39	1,48	3,26	2,74	2,48	3,81	1,35	4,39	1,54

42	2,65	2,84	2,42	3,03	2,90	1,94	2,55	2,13	2,90	3,03	3,23	2,06	1,68	2,10	1,94	3,90	1,47
43	2,94	3,29	2,71	3,74	3,65	3,32	3,23	1,87	2,55	3,77	2,94	2,00	1,81	2,42	2,71	4,48	1,45
44	3,55	3,39	3,35	4,23	3,65	2,13	4,10	3,48	3,55	2,10	4,39	3,65	2,13	2,45	1,71	4,87	1,45
45	3,45	3,52	3,19	3,87	3,97	2,00	3,77	2,94	3,23	2,74	3,61	2,35	2,06	3,32	1,87	4,52	1,64
46	5,35	4,68	4,06	4,90	4,84	2,45	4,13	4,48	5,06	2,23	4,61	5,16	3,39	3,39	1,81	4,45	1,46
47	2,71	4,10	3,97	4,39	4,55	2,29	4,48	2,10	3,61	3,81	3,10	2,48	1,84	2,52	2,97	4,94	1,38
48	3,00	2,75	2,56	2,97	3,13	3,22	2,97	2,56	2,44	2,72	3,19	2,28	1,97	5,28	2,41	4,13	1,42
49	3,72	2,66	2,81	2,41	2,03	2,28	2,31	4,34	3,28	1,56	3,94	3,56	3,25	5,06	1,34	3,16	1,55
50	2,44	2,06	1,72	2,50	2,44	1,66	1,94	2,16	2,66	2,25	3,31	3,22	1,56	2,56	1,56	3,84	1,49
51	3,81	2,88	2,63	3,00	2,72	1,94	2,53	3,03	4,91	1,56	4,03	4,41	2,25	4,50	1,50	3,38	1,52
52	2,75	2,66	2,25	2,94	3,13	1,53	3,00	2,75	3,25	2,31	2,69	2,13	1,56	2,06	2,06	3,91	1,41
53	3,41	3,13	2,59	3,50	3,09	1,81	2,75	2,94	3,06	2,25	3,88	3,22	1,69	1,66	1,72	4,53	1,44
54	2,78	2,53	2,31	2,78	2,91	3,50	2,94	2,22	3,06	2,66	2,50	2,16	1,75	5,00	2,41	3,81	1,37
55	3,28	3,16	3,06	3,56	3,72	1,88	4,66	4,19	3,19	1,81	3,25	2,50	2,09	1,81	1,56	4,50	1,39
56	2,63	2,38	2,00	2,44	2,69	2,38	2,56	2,69	2,72	2,00	2,59	1,94	1,81	4,91	1,94	3,56	1,32
57	5,16	3,75	3,47	3,81	3,09	3,88	3,53	4,19	4,72	2,00	4,00	4,72	3,81	2,88	1,59	3,72	1,44
58	3,28	4,28	4,66	4,25	4,00	3,72	4,44	2,19	2,81	4,47	2,53	2,09	2,44	2,22	3,84	4,75	1,45
59	1,81	1,78	1,63	1,94	2,13	1,84	2,09	2,31	1,91	2,41	1,84	1,50	1,44	2,22	1,75	2,81	1,34
60	2,50	2,72	2,34	3,63	3,94	1,31	4,22	2,97	3,13	2,19	2,50	2,00	1,53	1,75	1,59	4,19	1,35
61	2,91	2,78	2,84	3,47	3,53	2,38	3,25	1,91	3,13	3,09	3,72	2,16	1,69	1,84	2,31	4,38	1,39
62	4,44	4,06	3,84	3,72	4,22	3,16	4,13	2,91	3,34	3,91	5,09	2,97	2,44	5,31	3,28	4,59	1,37
63	2,69	2,97	2,59	3,31	4,06	3,94	3,59	2,13	2,94	3,59	3,06	2,44	1,75	4,53	2,94	4,47	1,29
64	3,03	3,16	2,69	3,38	3,28	2,28	3,09	2,78	3,50	2,81	2,56	2,22	1,94	5,34	2,50	3,75	1,41
65	3,09	2,91	2,84	2,66	2,59	1,69	2,88	3,38	3,22	2,53	2,97	3,31	1,88	1,75	2,06	3,53	1,40
66	4,22	2,88	2,38	2,69	3,03	2,03	2,88	4,81	3,81	1,94	2,88	2,00	2,97	3,56	1,44	3,19	1,36
67	3,19	2,75	2,41	2,63	2,63	1,63	2,47	2,28	3,34	2,78	3,38	3,00	1,69	1,78	2,13	3,72	1,41
68	3,75	2,91	2,56	3,09	3,78	3,03	3,66	4,97	3,34	1,91	4,06	2,53	2,81	6,47	1,56	3,81	1,39
69	3,50	3,75	3,25	4,06	4,72	3,00	4,16	3,13	3,22	3,16	3,41	2,28	2,16	4,84	2,66	4,91	1,50
70	4,72	3,22	2,94	3,16	3,31	3,78	3,47	4,34	4,34	2,00	4,34	3,25	3,06	5,41	2,00	3,84	1,43
Visual Cue 3																	
71	2,97	2,81	2,50	3,31	3,69	2,69	3,69	2,78	2,84	2,59	3,72	2,28	1,94	5,09	2,19	4,41	1,50
72	4,47	4,75	5,34	4,38	4,28	3,88	4,19	3,06	2,97	4,25	4,31	4,88	3,84	4,84	3,69	4,16	1,57
73	4,91	4,13	4,22	4,63	4,19	3,09	4,09	2,97	4,19	3,78	5,06	4,66	3,28	4,72	3,00	4,75	1,45
74	3,13	2,75	2,78	2,41	2,97	2,25	3,09	2,56	2,91	2,88	3,69	3,53	2,13	3,06	2,22	3,00	1,44
75	4,59	4,16	4,19	4,22	3,84	2,97	4,25	4,00	3,66	3,28	4,06	3,03	3,06	2,66	2,56	4,38	1,45
76	3,59	3,16	3,16	3,03	3,22	2,25	3,66	3,25	3,31	2,88	4,13	3,69	2,34	2,16	2,19	3,59	1,54
77	3,56	2,63	2,72	2,50	2,88	1,72	3,34	3,09	3,06	2,47	3,06	3,31	2,00	2,41	1,97	3,44	1,45
78	3,81	3,03	3,13	3,22	3,34	2,38	3,34	2,94	2,94	2,44	4,13	2,50	2,38	2,63	2,03	3,88	1,48
79	2,94	3,34	3,22	3,69	3,69	1,91	4,09	2,66	3,22	3,13	2,69	1,88	1,75	1,75	2,44	4,56	1,46
80	2,75	2,63	2,25	3,50	4,00	2,38	3,53	2,34	3,09	2,75	4,13	3,00	1,75	6,22	2,19	4,38	1,48
81	3,31	3,50	3,66	3,13	3,63	2,59	3,84	2,91	2,59	3,56	4,38	3,63	2,47	2,50	2,91	3,84	1,63
82	2,94	2,84	2,66	3,19	3,69	2,56	3,16	1,94	2,66	3,09	3,59	2,06	1,91	4,31	2,47	3,94	1,34
83	3,77	3,58	3,45	3,97	3,23	2,32	3,06	2,61	2,74	3,55	4,35	2,87	2,06	3,81	2,42	4,16	1,44
84	4,58	3,58	3,23	3,42	2,87	2,55	2,65	5,61	3,90	1,52	5,03	4,03	4,65	4,90	1,16	3,87	1,57
85	3,74	2,81	2,19	3,35	2,48	2,00	2,13	2,74	2,94	2,74	4,39	2,87	2,32	2,52	1,84	4,29	1,49
86	3,00	3,19	2,71	3,06	2,94	1,87	2,61	2,19	2,23	3,39	3,77	3,81	1,90	3,94	2,42	3,71	1,42
87	3,81	2,77	2,65	3,13	2,90	1,58	2,77	5,16	4,03	1,48	3,19	2,65	2,26	1,68	1,13	3,45	1,36
88	3,26	3,58	3,06	3,77	3,23	2,68	3,10	2,55	3,45	3,06	4,45	3,06	2,19	1,87	2,13	3,77	1,56
89	3,55	3,00	2,77	3,10	3,00	2,19	3,16	3,55	3,13	2,03	3,71	2,84	2,06	4,03	1,84	4,10	1,47
90	4,19	3,94	3,29	4,45	4,77	2,13	4,90	5,29	3,58	1,45	3,71	2,68	3,03	2,13	1,32	5,00	1,60
91	3,71	3,52	2,90	4,00	4,00	1,97	3,39	5,42	3,32	1,35	3,65	2,97	3,13	5,84	1,19	4,42	1,64
92	5,19	4,52	4,06	4,10	3,90	3,42	3,61	4,42	4,71	3,00	4,58	4,74	4,16	4,81	2,58	4,61	1,46
93	4,84	4,84	4,06	4,94	4,74	2,39	4,68	5,65	3,87	1,55	3,97	3,35	3,48	3,81	1,35	5,10	1,49
94	2,81	3,23	3,03	3,32	3,23	2,45	2,97	2,06	3,35	3,90	3,74	2,26	1,84	2,16	2,65	4,26	1,46
95	2,47	2,69	2,78	2,78	3,03	2,09	3,31	2,53	2,63	2,81	2,63	1,91	1,66	1,88	1,91	3,56	1,42
96	4,03	3,31	2,91	3,22	3,03	2,03	3,13	4,19	4,63	1,72	3,84	3,81	2,66	3,69	1,56	3,50	1,46
97	3,91	3,16	3,38	2,69	2,53	2,53	2,84	3,94	3,22	2,00	3,91	3,13	2,69	3,09	1,78	3,59	1,45
98	3,16	2,94	2,78	3,28	3,94	2,19	3,97	5,13	2,69	1,19	3,31	2,84	2,53	3,50	1,16	4,28	1,42
99	4,09	3,19	3,03	3,06	3,38	2,47	3,28	5,38	3,09	1,19	3,34	3,00	3,66	3,41	1,19	3,50	1,61
100	2,72	2,22	2,09	3,19	2,88	2,72	2,38	2,00	2,34	2,16	3,81	2,78	1,59	3,38	1,63	4,16	1,41
101	2,84	2,34	2,03	2,75	3,09	2,06	2,44	2,56	3,25	2,03	3,28	2,56	1,91	4,03	1,75	3,63	1,43
102	2,50	2,75	2,41	3,06	2,50	2,00	2,47	2,59	2,31	2,69	2,53	2,00	1,81	1,84	2,16	3,88	1,44

	103	2,50	2,47	2,78	2,19	2,38	2,09	2,38	2,53	2,22	2,59	2,94	2,53	1,75	2,22	2,03	3,13	1,46
	104	2,25	2,50	2,84	2,31	2,88	2,06	2,88	1,97	1,97	3,22	3,19	3,00	2,03	4,56	2,66	3,25	1,52
	105	3,53	3,44	3,34	3,47	3,44	3,16	3,19	2,75	2,47	2,81	3,88	2,78	2,16	4,59	2,28	4,31	1,54
PD																		
Visual Cue 1																		
	106	2,66	2,88	2,94	2,72	3,44	4,53	3,06	2,47	2,38	3,41	2,50	1,91	2,09	4,25	2,88	3,72	1,42
	107	2,19	1,91	1,84	2,19	2,31	2,00	2,31	2,63	2,63	1,84	2,41	1,84	1,63	1,97	1,56	3,25	1,32
	108	2,69	2,84	3,25	3,00	2,53	2,09	2,38	2,50	2,44	2,88	2,47	1,63	1,84	1,63	2,38	3,31	1,48
	109	2,22	2,56	2,66	2,72	3,19	3,56	3,03	2,25	2,84	2,94	2,13	2,06	1,56	3,91	2,50	3,66	1,42
	110	3,13	2,47	2,41	2,16	2,16	2,31	2,31	3,69	3,50	2,28	2,53	3,13	2,72	2,44	1,88	2,44	1,34
	111	4,38	3,50	3,34	3,25	3,25	3,22	3,72	4,78	3,09	1,91	3,31	2,75	3,44	5,25	1,72	3,91	1,39
	112	3,78	3,22	2,78	3,59	2,97	2,53	3,22	3,16	3,56	2,28	4,34	2,81	2,19	3,31	1,72	4,31	1,39
	113	2,91	2,88	2,84	2,81	3,13	3,13	2,75	3,00	3,53	2,59	3,16	2,91	2,44	4,22	2,06	3,59	1,36
	114	1,81	1,41	1,53	1,44	2,19	2,19	2,31	4,59	2,63	1,19	1,63	1,28	1,50	2,50	1,06	2,16	1,44
	115	3,75	2,25	2,06	2,50	2,13	2,25	1,97	3,81	3,50	1,78	3,47	2,84	2,59	4,75	1,69	3,22	1,42
	116	2,94	3,13	2,78	3,34	3,44	3,50	2,94	2,25	3,28	3,13	3,03	2,91	2,59	3,94	2,41	3,88	1,44
	117	3,13	3,31	3,41	3,09	3,34	2,47	3,03	2,97	3,53	2,81	2,56	2,56	1,91	3,06	2,34	3,56	1,28
	118	3,88	2,47	2,00	2,84	3,44	1,84	2,78	3,72	4,84	1,56	2,31	3,44	2,25	2,94	1,56	3,81	1,55
	119	3,38	2,41	2,16	2,59	3,06	3,31	2,63	2,41	2,50	2,72	3,53	1,91	2,31	5,38	2,44	3,78	1,47
	120	1,75	1,44	1,31	1,75	2,41	1,25	1,88	4,69	3,13	1,50	1,22	1,19	1,28	4,09	1,25	2,53	1,38
	121	3,75	3,75	3,91	3,44	3,81	4,53	3,88	3,56	3,47	3,03	3,91	3,00	2,63	3,31	2,31	4,50	1,33
	122	4,09	3,06	2,81	3,44	3,59	1,78	3,41	3,50	3,69	2,88	3,69	2,88	2,34	3,97	2,09	4,13	1,30
	123	2,66	3,34	3,97	3,66	4,09	4,56	4,38	2,03	2,38	4,25	2,09	1,69	2,31	3,31	3,53	4,19	1,64
	124	4,38	3,63	3,38	3,31	3,31	3,78	3,28	3,16	3,69	3,09	4,38	2,91	3,06	4,72	2,69	4,09	1,38
	125	3,69	3,06	2,44	3,59	3,22	1,78	3,28	4,38	4,38	1,50	2,47	3,41	1,88	1,56	1,44	4,28	1,33
	126	1,81	2,34	2,00	2,69	3,50	1,97	3,41	2,06	3,13	2,47	2,06	1,50	1,31	2,22	1,88	3,63	1,46
	127	2,81	2,59	3,19	2,53	3,16	4,16	3,03	2,19	2,38	3,53	3,16	2,03	2,38	5,03	3,06	3,16	1,36
	128	2,66	3,22	3,81	3,16	3,16	2,22	2,94	2,75	3,38	3,59	3,34	2,38	2,19	1,81	2,66	3,78	1,48
	129	3,47	2,91	3,03	2,81	2,84	2,78	2,69	2,66	2,59	2,81	3,69	2,16	2,03	2,47	2,06	3,72	1,46
	130	3,32	2,32	1,81	2,42	2,19	1,26	1,71	4,03	3,00	1,68	3,35	2,48	1,71	1,81	1,23	3,52	1,49
	131	4,13	3,71	3,58	4,00	3,48	3,74	3,03	2,42	2,81	4,03	4,23	2,71	3,13	4,19	3,03	4,61	1,56
	132	3,45	2,84	2,55	2,90	3,94	2,06	2,94	4,65	3,23	1,55	2,65	2,13	2,58	4,42	1,16	3,48	1,49
	133	1,74	1,84	1,71	1,77	2,29	1,48	1,87	3,10	2,77	2,71	1,45	1,35	1,26	2,13	2,06	3,19	1,46
	134	3,68	3,29	2,74	3,55	3,19	3,52	2,52	2,81	4,23	3,29	3,52	3,77	2,35	3,58	2,42	4,00	1,39
	135	3,03	2,61	2,39	2,74	2,23	2,32	1,94	2,71	3,39	2,97	3,45	2,84	2,19	3,10	1,94	3,48	1,46
	136	2,55	2,74	2,45	2,45	2,45	2,35	2,03	2,55	2,74	2,74	2,81	2,45	2,26	5,13	2,52	3,32	1,49
	137	3,42	3,35	3,00	3,87	4,03	3,90	3,06	2,13	3,26	4,00	3,87	2,48	2,48	4,97	2,90	5,13	1,44
	138	4,32	3,68	3,74	3,71	3,45	4,00	3,13	3,68	3,32	2,94	4,39	3,29	3,52	5,35	2,32	4,23	1,14
	139	2,71	2,29	2,13	2,32	2,84	2,00	2,42	4,87	2,52	1,29	2,35	2,16	2,94	4,81	1,13	3,39	1,18
	140	3,06	2,84	2,39	3,23	3,19	3,03	2,19	2,06	2,58	3,19	4,19	2,00	2,29	3,55	2,13	4,06	1,49
Visual Cue 2																		
	141	3,90	4,71	4,84	4,77	4,42	4,13	4,10	2,45	2,77	4,87	4,58	3,39	2,90	4,65	3,74	5,06	1,26
	142	3,58	3,71	3,16	3,74	3,52	1,68	3,26	3,58	3,10	3,00	3,61	4,19	1,94	2,19	2,19	3,65	1,44
	143	2,42	2,35	2,42	2,48	2,13	1,97	2,23	3,74	2,84	2,13	2,42	1,97	1,97	1,45	1,65	3,23	1,31
	144	2,42	2,35	2,42	2,48	2,13	1,97	2,23	3,74	2,84	2,13	2,42	1,97	1,97	1,45	1,65	3,23	1,29
	145	2,77	2,55	2,48	2,26	2,32	2,13	1,87	3,39	2,97	2,26	3,81	2,65	2,23	1,94	1,35	2,84	1,43
	146	4,87	4,06	3,42	3,90	3,81	3,35	3,52	3,90	4,39	2,74	4,48	4,32	3,26	4,74	2,13	4,29	1,22
	147	2,74	2,03	1,68	2,00	2,45	1,55	1,90	3,94	3,13	1,65	2,16	1,87	1,94	3,45	1,55	3,29	1,32
	148	3,48	2,81	2,23	2,97	2,68	2,48	2,19	2,16	4,19	3,32	4,06	3,90	1,94	3,03	2,19	3,13	1,41
	149	3,55	2,71	2,48	2,81	2,90	1,71	3,35	4,94	3,52	1,58	2,94	2,32	2,19	2,35	1,29	3,71	1,39
	150	3,10	2,52	2,16	2,35	2,16	1,84	1,97	2,52	3,19	2,32	3,58	3,03	2,03	2,26	1,81	2,94	1,36
	151	4,97	3,55	3,19	3,84	3,32	2,81	2,55	3,65	4,00	2,29	4,90	3,19	3,45	4,61	1,77	4,23	1,37
	152	4,19	4,10	4,00	4,32	3,71	3,48	3,29	2,90	3,39	3,61	4,77	3,00	2,87	3,61	2,58	4,71	1,58
	153	4,19	4,10	4,00	4,32	3,71	3,48	3,29	2,90	3,39	3,61	4,77	3,00	2,87	3,61	2,58	4,71	1,31
	154	3,69	2,84	2,66	3,16	2,31	1,91	2,47	3,41	3,44	2,50	4,09	2,88	2,09	2,16	1,69	3,66	1,48
	155	2,53	2,34	2,19	2,47	3,00	1,69	3,13	5,25	3,00	1,16	2,47	2,38	1,91	3,19	1,25	3,22	1,33
	156	3,94	3,63	3,47	3,94	3,16	2,34	3,38	3,81	3,00	1,97	3,34	3,41	2,72	2,69	1,78	4,38	1,32
	157	3,03	2,44	2,63	2,28	2,88	3,31	2,88	3,16	2,63	2,47	2,97	1,84	2,38	4,63	2,06	3,38	1,27
	158	3,09	3,63	4,25	3,53	3,69	2,97	3,88	2,16	1,94	3,69	3,34	3,13	2,25	3,19	3,19	4,22	1,43
	159	2,66	2,31	2,09	2,50	2,59	3,09	2,16	3,06	2,47	2,25	3,22	2,75	2,41	4,97	1,94	3,25	1,47
	160	3,50	3,19	2,91	2,84	3,44	1,59	3,81	5,56	3,19	1,28	3,00	3,19	3,25	4,84	1,16	3,59	1,40
	161	1,88	1,78	1,63	2,31	2,34	1,34	2,75	4,16	3,28	1,63	1,78	1,88	1,47	1,63	1,56	2,97	1,38

162	2,31	2,25	2,53	2,28	2,75	3,47	2,44	2,59	2,00	2,91	2,34	1,81	2,06	5,06	2,59	3,28	1,31
163	2,28	1,78	1,69	1,91	2,16	1,44	1,78	3,94	3,00	1,50	2,06	1,88	1,50	1,72	1,31	2,66	1,44
164	3,31	2,56	2,78	2,50	2,28	2,34	2,38	3,44	3,06	2,09	2,56	2,09	3,00	2,25	1,53	3,25	1,58
165	2,69	2,50	2,44	2,63	3,00	1,78	3,16	2,84	2,81	2,56	2,47	1,63	1,84	2,44	2,13	3,41	1,41
166	2,59	2,06	2,44	1,78	2,13	1,78	2,28	3,03	2,53	2,69	2,97	3,44	1,88	3,41	1,97	2,31	1,44
167	3,56	3,59	3,53	3,53	3,28	2,38	3,00	2,53	3,94	3,63	3,66	4,00	2,25	2,28	2,72	3,75	1,39
168	2,56	2,72	2,19	2,88	2,84	1,56	2,81	2,59	3,44	2,47	3,16	2,59	1,50	1,50	1,91	3,72	1,27
169	4,00	3,97	4,00	4,31	4,16	3,13	3,81	2,97	3,66	3,41	2,97	2,72	2,53	3,00	2,47	4,59	1,28
170	4,25	3,44	3,66	2,94	3,28	2,72	3,25	4,59	3,63	2,22	3,09	2,91	3,25	4,06	1,84	3,13	1,44
171	3,47	3,28	3,13	2,69	3,28	3,06	3,00	2,66	2,66	3,09	2,91	2,09	2,44	5,31	2,81	3,50	1,45
172	3,50	3,53	3,19	4,19	4,59	4,03	3,75	2,16	2,69	3,94	3,47	2,16	2,06	3,88	2,97	4,78	1,53
173	4,31	3,66	3,78	3,56	4,03	4,34	3,66	3,69	3,75	2,78	3,47	2,56	2,59	4,97	2,31	4,22	1,45
174	4,16	3,13	2,34	3,06	2,88	1,97	2,66	5,78	3,81	1,25	3,06	2,66	3,31	5,94	1,31	3,38	1,01
175	2,91	2,81	2,31	2,91	3,25	2,94	2,81	2,28	2,69	3,03	2,28	1,84	1,94	4,53	2,97	3,69	1,40
Visual Cue 3																	
176	4,03	4,44	4,50	4,63	4,72	4,22	4,69	2,22	2,63	4,38	4,81	2,97	2,88	4,31	3,63	5,50	1,27
177	3,56	3,13	2,72	2,56	2,69	2,13	3,22	4,00	2,88	2,22	2,81	3,38	2,06	2,31	1,97	3,22	1,43
178	3,41	2,94	3,56	2,63	2,91	2,81	3,25	3,44	3,41	3,38	3,13	1,88	2,19	2,09	2,34	3,22	1,37
179	3,19	3,50	3,34	3,19	4,06	2,72	4,25	2,91	2,97	3,38	4,16	3,56	2,19	3,63	2,75	4,13	1,17
180	3,66	3,31	3,84	2,88	2,97	2,44	3,25	3,34	2,91	2,69	4,31	3,56	2,75	1,94	2,22	3,06	1,22
181	5,00	3,91	3,34	3,91	4,19	2,44	3,66	5,47	4,56	1,81	4,53	3,19	3,66	4,31	1,72	4,53	1,16
182	4,34	3,31	3,34	2,81	2,81	2,28	3,59	4,53	4,06	1,91	3,56	3,88	2,47	4,03	1,56	3,78	1,36
183	2,94	2,25	2,19	1,97	2,19	2,16	2,69	3,44	2,66	2,31	2,84	2,94	1,84	3,59	2,00	2,81	1,32
184	3,41	2,19	1,78	2,16	2,38	1,56	2,81	4,34	3,03	1,44	3,19	2,44	2,00	3,44	1,47	3,34	1,37
185	2,59	1,84	2,13	1,56	2,22	1,59	2,19	2,75	2,28	2,31	3,63	3,41	2,00	3,56	2,13	2,22	1,29
186	3,97	3,63	3,72	3,25	4,03	4,34	3,63	2,25	3,00	3,78	2,66	2,13	2,50	5,16	3,34	4,13	1,27
187	3,78	3,75	3,97	3,59	4,00	4,13	4,00	2,19	3,03	4,00	4,41	3,06	2,53	3,38	3,03	4,94	1,50
188	4,13	3,90	3,52	3,77	3,52	2,58	2,87	2,87	3,10	3,35	4,45	4,58	2,35	2,94	2,77	4,03	1,29
189	3,94	3,23	2,65	3,48	3,58	2,06	3,52	4,45	3,58	1,68	3,84	3,19	2,84	3,65	1,61	4,23	1,57
190	2,32	2,10	1,61	2,23	2,81	1,77	2,58	4,58	3,10	1,45	2,13	1,71	1,84	2,97	1,23	3,10	1,44
191	2,84	2,55	2,26	2,71	2,65	2,16	2,10	3,29	3,35	2,84	3,00	2,13	1,81	2,13	1,71	3,74	1,35
192	2,81	3,42	2,90	3,42	3,52	3,68	2,58	1,81	2,61	3,74	2,48	1,97	2,03	3,58	3,23	3,81	1,38
193	4,23	3,87	3,61	4,23	3,45	3,48	3,19	2,19	4,65	3,65	4,87	4,74	2,29	2,26	2,65	4,97	1,48
194	3,90	3,13	2,94	3,42	2,97	2,87	2,16	2,52	3,52	3,10	4,26	3,19	2,71	3,94	2,26	3,81	1,45
195	2,61	2,81	2,55	3,10	3,65	1,42	3,68	5,23	3,52	1,16	2,87	2,26	1,65	2,00	1,10	3,90	1,34
196	2,26	2,74	2,32	2,87	3,32	1,58	2,97	2,68	2,42	2,94	2,94	2,61	1,42	2,35	2,26	3,48	1,37
197	3,26	3,00	2,39	2,74	2,90	2,77	2,65	3,84	3,00	2,32	3,39	2,58	2,97	5,23	1,71	3,68	1,42
198	3,23	3,39	3,55	2,97	2,68	1,68	2,74	2,94	2,55	3,03	2,55	3,19	1,84	1,61	2,26	3,58	1,50
199	3,61	2,48	2,29	2,32	2,10	2,32	1,94	3,32	3,19	2,42	3,74	2,84	3,06	4,00	1,74	3,29	1,59
200	3,09	2,75	2,69	2,66	2,66	1,78	3,44	5,47	2,84	1,19	2,78	2,41	3,22	3,63	1,09	3,56	1,36
201	2,75	1,94	1,97	1,94	2,03	2,38	2,03	3,44	2,78	1,94	2,88	1,91	2,19	4,63	1,72	2,63	1,52
202	2,53	2,47	2,78	2,44	2,81	2,06	2,84	2,34	1,78	2,38	3,09	2,88	2,16	3,44	2,19	3,25	1,39
203	2,59	2,06	1,91	2,00	2,16	2,00	2,09	3,22	2,84	2,06	2,69	1,91	2,22	3,22	1,72	2,72	1,22
204	2,50	1,97	1,97	2,06	2,38	2,16	2,03	3,34	2,72	2,13	2,97	1,94	2,28	3,13	1,59	3,00	1,33
205	2,69	2,09	2,31	1,97	1,88	2,31	2,09	3,47	2,72	1,84	3,28	2,34	2,63	3,97	1,69	2,75	1,48
206	2,69	2,63	3,03	2,53	3,09	2,31	2,75	2,72	2,19	2,59	3,53	3,44	2,28	5,66	2,41	3,75	1,41
207	3,22	2,84	2,66	2,78	2,69	2,19	2,59	2,88	2,88	3,03	3,47	2,72	2,03	3,78	2,31	3,50	1,43
208	3,75	3,78	4,31	3,59	3,56	3,28	3,88	2,78	2,50	3,34	3,59	3,47	2,97	5,72	3,28	4,44	1,15
209	2,88	2,38	2,31	2,44	2,97	1,56	2,69	5,47	2,53	1,19	2,50	2,16	3,00	4,94	1,09	2,84	1,34
210	3,69	2,69	2,22	3,19	2,66	2,13	2,41	2,81	2,91	2,09	4,31	2,97	2,41	3,16	1,59	4,22	1,47

Appendix G: Abstract

Currently, the prevalence of the neurodegenerative disease Parkinson's is 0.3%, expected to double by the year 2040. Consequently, there is a need to understand the neurobiological mechanisms underlying Parkinson’s disease and to develop new strategies for early detection that do not rely solely on identifying motor dysfunctions. Recent studies suggest that up to 41% of people diagnosed with Parkinson’s disease exhibit changes in produced drawings, such as alterations in creativity, quality, technique and style, emotional expressiveness, and color use. However, it remains unclear in which direction these changes occur. Despite evidence of art-related changes, the limitations of past studies must be considered (such as the lack of systematic methods, small sample sizes, poorly defined cohorts, and inconsistent collection of artwork data). This study aims to develop an initial systematic approach for assessing art-related aspects in individuals with Parkinson’s disease. Furthermore, using this new approach, an exploratory question if there are any systematic differences in drawings between individuals with Parkinson’s and healthy psychology students was investigated. The drawings (N=210) were evaluated by laypersons (N=95) using various scales for aesthetic quality and general art factors. Results indicate that artworks by individuals with Parkinson's were rated lower compared to the control group on scales including quality, personal liking, balance and visual harmony, fluent or skilled mark-making, emotional valence (more negative), and complexity (computer-based analysis). These observed differences only partially replicate previous findings. Limitations and opportunities for future research are discussed.

Appendix H: Abstract German/Deutsch

Die Prävalenz der neurodegenerativen Erkrankung Parkinson beträgt derzeit 0.3%, wobei sie sich bis zum Jahr 2040 verdoppeln soll. Aus diesem Grund ist es notwendig, die neurobiologischen Mechanismen von Parkinson zu verstehen und gleichzeitig neue Strategien zur Früherkennung von Parkinson zu entwickeln, die nicht auf der Feststellung von motorischen Dysfunktionen basiert. Aktuelle Studien deuten darauf hin, dass sich bei bis zu 41% der Menschen, die mit Parkinson diagnostiziert wurden, Veränderungen in produzierten Zeichnungen (Kreativität, Qualität, Technik und Stil, emotionalen Ausdruckskraft, Farben) zeigen. Es bleibt jedoch unklar in welche Richtung die Veränderung geht. Trotz der Belege für kunstbezogene Veränderungen, müssen die Limitationen der verschiedenen vergangenen Studien berücksichtigt werden (Fehlen systematischer Methoden, kleine Stichproben, klar definiere Kohorte, fehlende konsistente Erhebung von produzierten Kunstwerken). Ziel dieser Studie, einen ersten systematischen Ansatz für die Erhebung kunstbezogener Aspekte bei Personen mit Parkinson zu entwickeln. Weiters wurde unter Verwendung dieses neuen Ansatzes anhand einer explorativen Fragestellung untersucht, ob es systematische Unterschiede in Zeichnungen zwischen Personen mit Parkinson und gesunden Psychologiestudierenden gibt. Die Zeichnungen (N=210) wurden von Laien (N=95) anhand verschiedener Skalen zur ästhetischen Qualität und generellen Kunstfaktoren beurteilt. Die Ergebnisse zeigen eine geringere Bewertung von Kunstwerken von Personen mit Parkinson im Vergleich zur Kontrollgruppe in den Skalen Qualität, persönliche Vorliebe, Balance und visuelle Harmonie, feine fließende Pinselführung, Stimmung (negativer) und Komplexität (computer-basierte Analyse). Diese aufgezeigten Unterschiede replizieren nur zum Teil vorangegangene Ergebnisse. Limitationen und zukünftige Forschungsmöglichkeiten werden diskutiert.