MASTERARBEIT | MASTER'S THESIS

Titel | Title

Self-Expression in Autistic Adults: Differences in Art and Cognition

verfasst von | submitted by

Nesrin Koca BSc

angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien | Vienna, 2025

Studienkennzahl lt. Studienblatt | Degree programme code as it appears on the student record sheet:	UA 066 840
Studienrichtung lt. Studienblatt | Degree programme as it appears on the student record sheet:	Masterstudium Psychologie
Betreut von | Supervisor:	Assoz. Prof. Matthew Pelowski PhD

Table of Contents

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that manifests as persistent difficulties in social communication and social interaction and as restricted, repetitive patterns of behavior, interests, or activities as stated in the Diagnostic and statistical manual of mental disorders (5th ed.; American Psychiatric Association, 2013). These differences extend to many aspects of the lives of individuals who are autistic, causing difficulties in relationships (Elmose, 2019; Müller et al., 2008; Umagami et al., 2022) in the workplace (Hayward et al., 2016; Szechy et al., 2023) and in understanding and being understood by others (Sperry & Mesibov, 2005).

In the past, these difficulties have been studied extensively. However, while understanding and being understood is reciprocal, much of the research has focused on how individuals without ASD communicate and how autistic individuals deviate from that, instead of focusing on how individuals with ASD communicate and express themselves. Furthermore, much of the existing research aims to assess how face-to-face communication might present itself in autistic individuals, with a focus on eye contact being especially prevalent (Brewer et al., 2015, Castelli, 2005; Trevisan et. al, 2018). Using a modality that has been reported as problematic for autistic individuals (Senju & Johnson, 2009) might create an inaccurate and incomplete image of the abilities of autistic individuals to express themselves. The aim of this research project is to shed light on how expressing oneself might or might not look different in autistic individuals using art, instead, as a medium to communicate.

While it has been explored that individuals with ASD might struggle with expressing themselves, including their thoughts, emotions and ideas, using spoken language (Pirinen et al., 2023) and facial expressions (Trevisan et. al, 2018) the question of how they express themselves through other modalities has remained largely beyond much empirical study. Previous research has shown that while individuals with ASD may struggle with correctly decoding facial expression in humans, they are as able as non-autistic individuals to decode the emotion behind facial expressions of stylized drawings (Atherton & Cross, 2021). The modality of art seemingly facilitated the decoding of emotions, and this might be a first, meaningful nudge towards art perhaps being a more accessible tool for people with ASD to also express themselves more easily. Additionally, art therapy has often been found to be a useful tool to improve communication skills in autistic children (Schweizer et al., 2014). To understand whether self-expression through art might really be an approach building on autistic peoples´ strengths, rather than the areas where they experience difficulties, one first needs to examine if and how the art produced by autistic individuals differs from that created by non-autistic individuals. In this vein I will explore drawings produced by both autistic people and people who are not autistic and analyze whether the differences in perception and cognition between these two groups manifest themselves in the drawings created or whether differences in art as a modality of self-expression might be associated with underlying cognitive structures, such as perceptual processing style and executive function, rather than diagnostic status.

Differences in other forms of self-expression between individuals with and without ASD have been found before. The research extends to, but is not exclusive to speech (Hubbard et al., 2017), written language (Shevchuk-Hill et al., 2022), facial expressions (Faso et al., 2014) and body language (Morett et al., 2015).

In this thesis I will first examine how autistic individuals express themselves across all modalities – including speech, written language, body language, facial expressions and art – to establish that self-expression in autistic individuals is unique and might differ from how typically developed peers express themselves. In a subsequent step I will review different theories and frameworks trying to offer insight into autistic functioning and cognition which have been proposed as the cause of the observed, quantifiable differences in self-expression. Then, I will analyze drawings created by autistic and non-autistic individuals to assess whether art is yet another modality for which differences in self-expression can be observed. The drawings will be analyzed on an objective image property level, with quantifiers for each assessed image property. Qualities such as symmetry, balance, contrast, complexity, fractality and texture will be the focal point of the analyses. Lastly, it will be examined whether the differences we might or might not observe can be related back to the diagnostic status of the individuals, or rather specific styles in perceptual processing and cognition.

Autism Spectrum Disorder

The Diagnostic and Statistical Manual of Mental Disorders classifies autism spectrum disorder as a neurodevelopmental disorder. These disorders include intellectual developmental disorders, communication disorders, autism spectrum disorder, attention-deficit/hyperactivity disorder, specific learning disorder and motor disorders (5th ed.; DSM–5; American Psychiatric Association, 2013).

Neurodevelopmental disorders are characterized by deficits and differences in development that can cause difficulties in personal, social, academic, or occupational performance. The severity of symptoms differs from individual to individual and presents rather as a spectrum than a uniform manifestation across affected individuals (5th ed.; DSM–5; American Psychiatric Association, 2013).

Autism in particular is a neurodevelopmental disorder that greatly affects aspects of social functioning, causing difficulties in social interaction and communication. These difficulties extend to social reciprocity, nonverbal communicative behaviors and skills required for peer relationships (Elmose, 2019; Müller et al., 2008; Umagami et al., 2022). The reported struggles can cause significant distress in autistic individuals´ lives and affect their quality of life, with one analysis finding that quality of life was significantly lower for autistic individuals, when compared to age matched peers (Oakley et al., 2020). Autistic adolescents report higher perceived loneliness and social isolation (Hickey et al., 2017; Müller et al., 2008; Umagami et al., 2022). They furthermore report higher rates of perceived stress (Gillott & Standen, 2007; Hirvikoski & Blomqvist, 2014; Moseley et al., 2021) and a particularly high lifetime prevalence of depression (Au-Yeung et al., 2018; Croen et al., 2015; Fombonne et al., 2020)

Some affected individuals may make efforts to mitigate the problems caused by differences in development, functioning, and perception by using compensatory strategies, also referred to as “masking” or “social camouflaging” (Hull et al., 2017; Lai et al., 2016), in which autistic individuals try to appear more “neurotypical” or non-autistic. This may be achieved by following a set of self-imposed rules to maintain the “appropriate” amount of eye contact during a conversation, avoiding stimming and in more severe cases, studying and copying mannerism and attitudes of peers to curate a persona that they will use whenever needed in a social situation. These camouflaging efforts were found to be related to higher IQ and executive functioning but also to higher self-reported anxiety (Lei et al., 2023; Livingston et al., 2018).

Even though autistic individuals feel a sense of obligation to camouflage or mask in order to avoid alienation or scrutiny (Mandy, 2019), studies still report differences in the way autistic people express themselves in almost all modalities, when compared to neurotypical counterparts.

Differences in Self-Expression

The differences in self-expression in autistic adults which were examined for a comprehensive overview range from differences in facial expressions, speech, writing, art and to body language. The aim of this overview is to contextualize autistic self-expression and demonstrate that the observed differences appear across almost all modalities examined, rather than being specific to just one. Comparing studies and literature offers further insight on previous research, which has often neglected artistic self-expression as a field of exploration in which substantial differences, or similarities, between autistic and non-autistic individuals might emerge.

Differences in Facial Expressions

The findings on differences in facial expressions between autistic and non – autistic adults are partly contradicting and inconclusive. While the clinical descriptions of autism first written by Kanner in 1943 include flat affect and studies have been able to further quantify and support this claim (Bieberich and Morgan 2004; Czapinski and Bryson 2003; Stagg et al., 2013; Trevisan et al., 2018) studies providing contradictory findings also exist.

Facial expressions posed by autistic individuals have been reported to be recognized with greater accuracy by non - autistic individuals and furthermore described as more intense than those of their neurotypical counterparts (Faso et al., 2014) which can in turn affect the quality of the social interactions (Webster et al., 2021).

Another study found that facial expressions tended to be less socially congruous and less accurate to the emotion they were supposed to express. Notably the facial expressions were labeled as “awkward, odd, unusual, mechanical” (Trevisan et. al, 2018). Turan et al. (2023) found that the number of spontaneous facial expressions in autistic individuals when compared to non - autistic individuals was significantly lower. However, higher levels of intelligence seemed to be associated with a superior ability to recognize and express facial expressions, which might suggest a moderating effect of intelligence on symptom severity in autistic individuals.

In summary the findings across reviews and different studies suggest that, while autistic individuals might not show less emotions, the way they emote using facial expressions does differ from non-autistic individuals across a range of criteria such as intensity, social congruousness, salience and frequency.

Differences in Speech

In examining the characteristics of how autistic adults express themselves verbally, a pattern similar to that of expressing emotions through facial expressions emerges. While it is a common stereotype that autistic individuals speak in a monotone or flat voice (Atkinson et al., 2024), empirical research suggests otherwise, with one study reporting greater intensity for emotional speech produced by autistic individuals (Hubbard et al., 2017).

Findings support the hypothesis that autistic individuals differ from non-autistic individuals in volubility (Shriberg et al., 2001) and prosody (McCann & Peppé, 2003). While it is a topic of discussion which aspects of speech are considered as prosodic features, the studies used for this overview refer to phrasing, stress and loudness, and pitch. In particular, studies have found that where autistic individuals place the stress on a word, their intonation, the phrasing and their affective prosody differs when compared to non-autistic individuals (McCann & Peppé, 2003; Paul et al., 2005; Shriberg et al., 2001; Vogindroukas et al., 2022). While this may not create severe problems in being able to recognize which emotional state it is that autistic speakers are trying to convey (Gibson et. al, 2023) it does affect the quality of communication between autistic and non-autistic individuals, with differences in phrasing, stress and intonation being perceived as incongruous with that of typically developed participants. This might include not knowing which phrasing is the appropriate one for a setting and sounding "pompous" or disordered prosody leading to being perceived as sounding different, or as a paper by Vogindroukas et al. (2022) states "odd and robotic".

Furthermore, current research also points towards autistic individuals struggling with verbally expressing themselves, given that more speech disfluencies such as stuttering, revisions, abandoned word beginnings and revised speech are reported than for typically developed (TD) individuals (Pirinen et al., 2023).

Regarding differences in pitch, one meta-analysis examining 39 studies found that mean pitch, pitch range, pitch variability and voice duration all differed significantly from that of their neurotypical counterparts, whereas no differences were found for intensity and speech rate. Autistic individuals exhibited greater variability in their pitch range and pitch variability. Additionally, a higher mean pitch was reported for autistic individuals and longer voice duration, signifying that on average, it took autistic individuals longer to produce vocalizations (Asghari et al., 2021).

Differences in Written Language

The differences in written language are typically analyzed on two levels: firstly, the mechanical aspects of writing and secondly the contents of the texts produced. For the research question at hand, the issue of whether the contents differ contains the more relevant information pertaining to self-expression.

It should be noted here that this field of research seems largely unexplored, as most studies among the few that exist deal with children and adolescents. Finnegan and Accardo (2022), for example reviewed 25 studies in a meta-analysis, of which 22 were done with children or adolescents. The meta-analysis at hand categorizes the mechanical aspects of written language as including the legibility of handwriting, grammar and the size and speed with which participants write. There seems to be no conclusive research on the legibility of handwriting. The same authors for example who found in a 2017 meta – analysis that the handwriting of autistic individuals was significantly harder to read, reported in a 2022 meta – analysis that they found no differences in the legibility (Finnegan & Accardo, 2017, 2022). They further reported that autistic individuals write at a slower pace and produce larger letters.

Studies report that autistic individuals produce shorter expository texts when compared to non-autistic peers, this difference however disappears when individuals are instructed to write narrative texts (Finnegan & Accardo, 2017; Price et al., 2019). Brown and Klein (2011) also report that the narrative writing of autistic individuals is of lower quality, with autistic participants receiving poorer ratings on the scales of structure, quality, context, number of locally coherent phrases, and “balance between the landscape of consciousness and the landscape of action (narrative only)” (Brown & Klein, 2011, p. 4). However, another study found that the amount of adjectives or emotional language used did not differ between the two groups when instructed to write short stories, after having been analyzed using a qualitative coding scheme, which amongst others included a simple count of adjectives present in a text (Shevchuk-Hill et al., 2022).

An additional aspect in which autistic individuals received lower ratings on quality of the writing produced was writing coherence, structure of the written texts and writing organization (Brown & Klein, 2011; Finnegan & Accardo, 2017, 2022; Price et al., 2019).

To summarize, the differences in the production of written language range from the appearance of the writing to the coherence, structure and length of it. The syntactic aspects however, such as the number of adjectives used, do not seem to differ.

Differences in Body Language

Nonverbal cues, such as facial expression and body language, play a vital role in expressing oneself and communicating socially. It has already been established, that there are differences in the facial expressions produced by autistic individuals, seeing as it is listed, amongst others, as a diagnostic criterion in the Diagnostic and statistical manual of mental disorders (5th ed.; American Psychiatric Association, 2013) .

Autistic individuals have been reported to produce fewer metaphorical and beat gestures while speaking, than non - autistic individuals do, to communicate emotions or abstract ideas (Morett et al., 2015). It has also been reported that autistic individuals not only produce gestures that are more ambiguous and harder to interpret for non-autistic individuals

(De Marchena et al., 2018), they also seem to engage less in social mimicry, such as experiencing yawns as contagious or mirroring facial expressions of their conversational counterparts (Eigsti, 2013). This finding was also supported in a later study (Glass & Yuill, 2023) in which autistic individuals had lower social motor synchrony (SMS). This effect however, seemed to disappear in low stakes, spontaneous situations. Social motor synchrony (SMS) refers to the physical synchronization movement and gestures of people in a social exchange and is a subtype of interpersonal synchrony (Fitzpatrick et al., 2017). Similar to the findings related to self-expression through speech, self-expression through gestures also appears to be more effortful for autistic individuals, since the gestures produced by autistic individuals were found to have longer pauses in them (Trujillo et al., 2021). For this finding too, recorded differences were labeled as less severe when the interactions were spontaneous.

In conclusion, while the differences found were reduced when the situation was low pressure and familiar to the autistic individuals, findings still point toward atypical motor coordination, including gait abnormalities, reduced motor synchrony, and distinct gesture kinematics (Trujillo et al., 2021; Weiss et al., 2013). Furthermore, the frequency, synchrony and clarity of gestures produced when expressing oneself differed significantly in autistic individuals (Braddock et al., 2016; De Marchena et al., 2018; Morett et al., 2015).

Differences in Art

As stated before, the research on art created by autistic adults is extremely limited as the topic in general appears to be largely unexplored. What little research exists focuses on autistic children therefore the overview presented here will reflect this by largely reporting findings on drawings created by children and adolescents who are autistic and comparing these findings to those reported in the studies with participants who are autistic adults.

The finding that seems to be most consistent across studies is that autistic individuals produce drawings with more repetitive patterns, structured compositions, and symmetry than do non-autistic individuals. This was not only found in a study in which autistic adults produced artworks (Bergmann et al., 2020) but also in a subsequent study with autistic children (Shi et al., 2021). One characteristic that seemed to differ in autistic children and adults is that of a focus on details or precision. Bergmann et al. (2020) found that autistic adults seemed to focus more on structure, suggesting a focus on details, whereas autistic children were less likely to complete lines or fill their paintings all the way to their borders, suggesting that the more minute details of paintings were neglected (Shi et al., 2021). Consistent with the finding of a focus on details in autistic adults, an earlier study reports that autistic adults who are skilled artists exhibit a bias for local processing, thus focusing on the finer, smaller aspects of a painting (Drake & Winner, 2010). Interestingly Smith et al. (2016) did not find this preference for producing more local features in autistic children, further providing evidence in favor of the notion that autistic children focus less on the details while producing artworks, than autistic adults.

Another point of dissimilarity between autistic children and adults was found in page usage. Autistic children seemed to draw their objects in atypical positions on the page, producing less symmetric and centrally organized drawings, compared to non - autistic children (Shi et al., 2021). Autistic adults produced more organized drawing, structured around central motives (Bergmann et al., 2020). Interestingly, autistic children, when prompted to create drawings, also were found to include less expressive facial features (Martin, 2008) or more abstract faces, that did not emphasize the facial expressions of the people drawn (Shi et al., 2021).

In conclusion autistic individuals seem to produce more repetitions and patterns in their drawings. This finding seems to be consistent across age groups. Other findings however, such as page usage, a local processing bias and a focus on details could not be consistently replicated.

Several theories attempt to explain how these differences might come to be, often beginning at a neurophysiological or cognitive level.

“Autistic” Cognition

When discussing what might contribute to the differences in the modalities of self-expression that were elaborated above the exploration of processes in cognition that are characteristic for autistic individuals is often a starting point (Baron-Cohen et al., 1985; Frith, 1985; Pellicano & Burr, 2012). Frequently proposed are differences in executive functioning and perceptual organization.

Executive Function in Autism

The term executive function refers to a set of cognitive abilities necessary to attain goals, such as inhibition control, cognitive flexibility, solving of problems, working memory, reasoning and planning (Diamond, 2012).

While deficits in executive functioning have been researched and findings replicated across multiple studies (Hill, 2004; Johnston et al., 2019; Xie et al., 2020) one meta-analysis including 235 studies and 14,081 participants found that, after analyzing results for six domains of executive function including concept formation, mental flexibility, fluency, planning, response inhibition, and working memory, the deficits did not seem to be domain specific but rather a diffuse general phenomenon across all domains suggesting a global executive function impairment (Demetriou et al., 2018).

The domain of concept formation describes the ability to form abstract concepts and shift between them based on rules, feedback and task demands changing. This requires cognitive flexibility and the ability to adapt to new information. These abilities might be quantified using the Wisconsin Card Sorting Test (WCST, Grant & Berg, 1948) as done by the studies in this meta-analysis (Demetriou et al., 2018). The test requires participants to sort cards based on a specific distinct feature, which then is changed to another distinguishing feature. Autistic individuals often struggle with the cognitive flexibility required for these tasks (Lage et al., 2023).

Mental flexibility refers to the ability to switch between tasks or mental sets. Mental sets are cognitive structures, which were created to solve a problem and are automatically used when confronted with a new problem, that might be solved by applying the same mental set (Bilalić et al., 2008). Often used to assess this ability is the Trail Making Test (TMT) Part B, in which participants switch between counting and listing a letter of the alphabet after each number or letter respectively (Stebbins, 2007). Transitioning between tasks has often been noted as a challenge in autistic individuals (Sterling-Turner & Jordan, 2007), which might be explained by the deficits in mental flexibility.

The domain of fluency refers to the cognitive ability to generate ideas, words and responses that belong to a category and can be extended to doing so under restrictions. The studies in the meta-analysis above (Demetriou et al., 2018) used verbal fluency tasks. In these tasks the participants are instructed to produce words belonging to a specific category within a set amount of time (Hall et al., 2010). The reduced fluency observed in autistic individuals might contribute to the difficulties experienced when communicating (Spek et al., 2008).

The domain of planning refers to the organizing, sequencing, and executing of steps to fulfill a task or achieve a goal, requiring problem-solving and strategic thinking (Mezzacappa, 2011). The task included in the studies above was the Tower of London task (TOL; Shallice, 1982), during which participants had to move plates from their initial arrangement to a goal arrangement. The deficits in this domain might manifest themselves as challenges in organizing task and time management.

Inhibiting automatic or predominant responses fall under the domain of response inhibition (Hunt et al., 2022). This ability greatly influences self-control and impulse regulation and was measured using Go/No-Go Tasks. In Go/No-Go Tasks participants are instructed to perform a response when presented with a specific stimulus and to withhold the response, when presented with another (Menon et al., 2001). Response inhibition is often underdeveloped in individuals with ASD, contributing to difficulties in controlling behavior (Schmitt et al., 2017).

Lastly the domain of working memory refers to the ability to maintain and manipulate information over short delays and is often measured using N-Back Tasks, in which participants are told to recall a certain stimulus that lies a specific number of stimuli back while being shown a sequence of stimuli (Maricle & Johnson, 2016).

These deficits might cause a cascade of difficulties in the demands of everyday life and functioning and might account for some of the differences in how autistic individuals express themselves. Differences in executive function have been researched as a possible cause for differences in self-expression before. It has been found that impairments in executive function might be responsible, in part, for the difficulties with producing novel ideas leading to less creativity observed in art created by autistic individuals (Craig & Baron-Cohen, 1999), with the domain of cognitive flexibility being suggested as the biggest contributor (Pasarín-Lavín et al., 2023).

Perceptual Organization

When analyzing how perceptual organization differs in autistic individuals, local-global processing is often examined. Local processing refers to the early stages of visual processing and to the analysis of fine details, whereas global processing refers to the integration of information into a unified percept (Kimchi, 1992). The theory of Weak Central Coherence is an attempt to explain the type of perceptual organization characteristic for autistic individuals and was first proposed by Uta Frith in 1989. She suggested that autistic individuals “fail to see the forest for the trees" (Frith, 2003). Particularly she refers to the processing of information by autistic individuals and claims that it is done by focusing on individual aspects of a whole, meaning local stimuli and thus neglecting it in its wholeness and failing to process it globally (Frith, 2003).

While much research has been done to provide further information on this theory, the results are not conclusive. Studies have in fact found a superior ability to process information locally in individuals with ASD, assessed by administering tasks such as the Embedded Figures Task (EFT; Witkin, 1971) and Block Design Test (BDT; Bettcher et al., 2010) (Plaisted et al., 2003). The Embedded Figures Task requires participants to find small figures hidden in larger figures (Almeida et al., 2010). The block design test requires participants to replicate a design with cubes which have specific patterns printed on them (Happé, 1999). Song et al. (2015) found that the functional field of view, referring to the part of the visual field, from which information can be extracted without having to move the head or eyes first (Ball et al., 1988), is narrower when compared to non-autistic controls, which further supports the hypothesis of a local processing bias.

However, neglecting of processing of stimuli on a global level, as suggested by Frith has not been found in research. In a meta-analysis, which encompasses 56 articles, Van der Hallen et al. (2014) concluded that while autistic individuals did not necessarily perform worse on tasks assessing global processing, they did exhibit slower reaction times, especially when the local information was incongruent with the global information. Another study reported that autistic individuals displayed a global preference under most conditions (Bernardino et al., 2012) and yet another study found that the effect of visual illusions, which only are effective when the person viewing them, views the image globally, did not differ significantly between autistic individuals and non-autistic individuals (Hoy et al., 2004).

In conclusion, while the theory of Weak Central Coherence is often used to explain differences, the underlying assumption on which it stands – a bias for local processing of information and a deficit in global processing – cannot be confirmed by the current research. Current research much rather suggests superior local processing and average global processing of information. This is the framework that the Enhanced Perceptual Functioning (EPF) model proposes, which was first formulated by Mottron and Burack in 2001. In a later, updated version of the Enhanced Perceptual Functioning (EPF) model, they suggest that autistic individuals tend to focus on local features, rather than global patterns (Mottron et al., 2006).

This difference in how visual input is organized might contribute to the differences in how autistic individuals express themselves through art as well, seeing as how a focus on details, rather than the whole, is unlike how TD individuals process perceptual information.

The Rey - Osterrieth Complex Figure Test

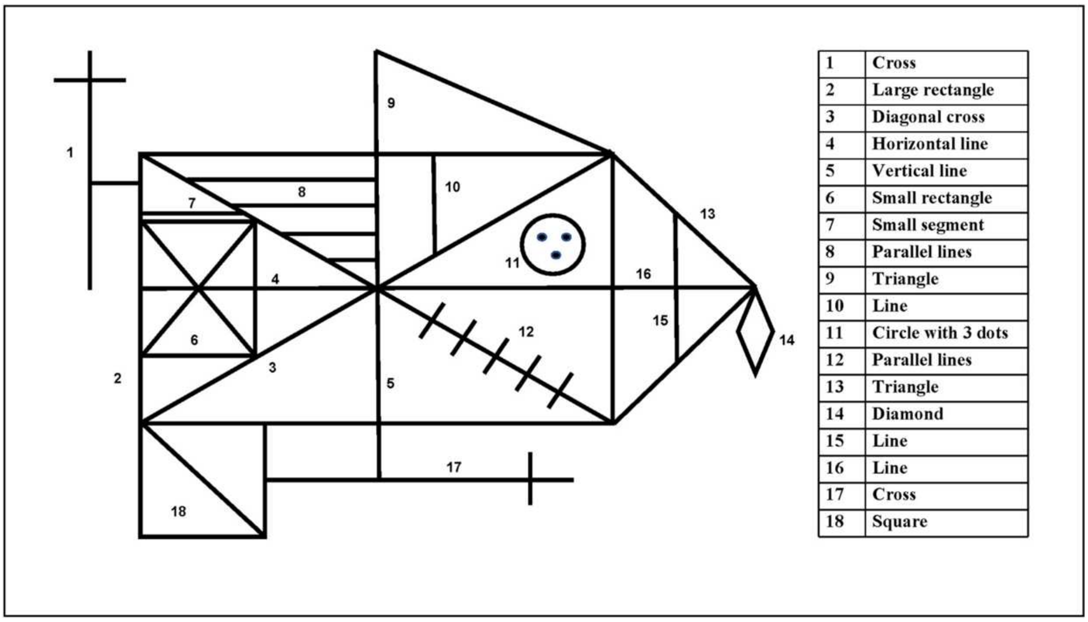
While many different tools and test are available to measure executive functioning and perceptual organization styles, the Rey-Osterrieth Complex Figure Test (Rey & Osterrieth, 1941; ROCF) offers a tool to assess both at once. Seeing as both measures have often been proposed as key drivers in the differences observed in autistic peoples' perceptual processing and functioning, including their self-expression, using the ROCF provides the data needed to relate possible differences in drawings back to processes in cognition. The data collected through the ROCF will be used to assess whether diagnostic status or perceptual processing styles and executive functioning are predictive of differences observed in artistic self-expression, specifically drawings.

The test is structured so that participants are presented with a complex figure which consists of 18 distinct elements, which they are then instructed to copy as accurately as they can in the so-called copy condition. After, during the "immediate retention" condition, the figure is removed from the participants' view and they are asked to once again draw the same figure as accurately as possible. Lastly, in the "delayed retention" condition, participants are prompted to produce the same drawing of the same figure as accurately as they can from memory, 20 to 30 minutes later (Zhang et al., 2021).

The Rey-Osterrieth Complex Figure (ROCF) was first developed by André Rey (1941) as a tool for assessing visuospatial processing and memory abilities in individuals who had suffered brain damage. Later, the test was refined by Paul Osterrieth (1944) who formulated a standardized scoring system that evaluated the accuracy and placement of the 18 components of the figure. It was originally created to evaluate memory deficits, perceptual organization, and constructional abilities, and was therefore primarily used for individuals with neurological impairments, such as those recovering from traumatic brain injury, stroke, and dementia (Zhang et al., 2021).

Later, the ROCF was found to offer a useful tool for assessing executive functioning and cognitive processing styles, which prompted its use in research involving conditions such as Parkinson's disease, Alzheimer's disease, attention deficit hyperactivity disorder, and autism spectrum disorder (Cardillo et al., 2022; Scarpina et al., 2016).

Figure 1



Note. The Rey - Osterrieth Complex Figure and its´ 18 scoring units. From "Overview of the Complex Figure Test and Its Clinical Application in Neuropsychiatric Disorders, Including Copying and Recall" by X. Zhang, L. Lv, R. Gonzalés, G. Min, Q. Wang. *Frontiers in Neurology, 12*. https://doi.org/10.3389/fneur.2021.680474. Copyright 2021 by Frontiers in Neurology.

The ROCF has been widely used since its validity, reliability, and inter-rater reliability have been shown to be mostly strong. Research has demonstrated strong construct validity for the ROCF, as it is able to effectively differentiate between memory deficits, deficits in executive functioning, and visuospatial impairments across neurological and psychiatric conditions (Zhang et al., 2021). It has also demonstrated discriminant validity, as studies have shown that its results can distinguish Parkinson´s disease from Alzheimer's disease and differentiate right hemisphere brain damage from left hemisphere damage (Poreh & Shye, 1998; Scarpina et al., 2016).

The Boston Qualitative Scoring System (BQSS)

While the traditional scoring system developed by Paul Osterrieth (1944) was first used to score the ROCF the Boston Qualitative Scoring System (Stern et al., 1999; BQSS) was later developed, amongst others, to offer an alternative that can help administrators analyze drawing strategies and organization of the drawing. It can be used to assess executive functions (Somerville et al., 2000), differentiate between right hemisphere and left hemisphere damage (Poreh & Shye, 1998), distinguish ADHD participants from participants who do not suffer from ADHD (Schreiber et al., 1999), detect cognitive deficits symptomatic for Parkinson´s disease (Scarpina et al., 2016) and measure whether a local or a global processing style was dominant while completing the ROCF (Cardillo et al., 2022). Beyond it being able to offer more detailed assessments it has also been found to have high internal consistency (r = 0.77 - 0.91) and high inter-rater reliability for the planning score (κ = .85, 95% *CI* [.78, .91], $p < .001$) and the Fragmentation score (κ = .82, 95% *CI* [.74, .89], $p < .001$). Regarding the asymmetry score however, inter-rater reliability was moderate (κ = .53, 95% *CI* [.40, .67], $p < .05$), suggesting potential variability (Stern et al., 1999).

Uses in Autism Research

The ROCF has been used in autism research to assess both visuospatial processing and executive functioning (Kim et al. 2020; Davids et al., 2020), as well as in research trying to connect artistic ability to cognitive and perceptual profiles (Pelowski et al., 2018). While research has been done suggesting that there is no difference in task performance between autistic and non-autistic children (Kuschner et al., 2009) results suggesting the opposite have been found too. It has been reported that individuals on the spectrum show poorer accuracy on the ROCF, than when being tasked to copy figures with simpler designs. Furthermore, the reduction in accuracy in autistic individuals when the designs became more complex, was greater than in non-autistic participants (Minshew et al., 1997). One explanation for these contradicting results was the age of the people tested. It seems that children, regardless of if they are autistic or not, show a local processing bias (Harrison & Stiles, 2008), which might negatively affect the accuracy and organization of the drawing.

A preference for local processing has been reproduced in later research. In a 2020 study, Kim et al. found that autistic children displayed a preference for a more fragmented approach when tasked with the ROCF. A similar result was reported for autistic adults. While their copies of the ROCF were not less accurate than that of non-autistic counterparts, it did take them longer to complete the drawings, which might also be indicative of a preference for local processing. This might offer an explanation as to why autistic participants took longer to complete the ROCF, seeing as it may have demanded switching attention from local features to its whole gestalt (Davids et al., 2020).

Research Questions and Hypotheses

As has become apparent in the literature review above, autistic individuals´ self-expression differs in all modalities reported and examined. These differences might or might not be explained by processes in cognition that are unlike those reported for non-autistic individuals. Current research reflects a trend in which autistic people are the receptors of output produced by non-autistic individuals. This becomes especially obvious in the number of studies analyzing whether autistic individuals "understand" what non-autistic individuals are showing, be it on their faces, with their art or with their speech. Studies examining the flip side, meaning how autistic individuals express themselves are very limited and while it is a pattern that autistic children are the focus of much of said research, this is especially pronounced in the modality of art. Thus, this research project aims to offer insights on two research gaps in the current literature. The study will examine how the artworks created by autistic individuals differ from those created by non-autistic individuals, pushing the group that is being researched into the focus and will further exclusively analyze autistic adults, bridging the current gap in the research. Consequently, the following research question has been set:

Are there quantitative differences in abstract drawings produced by autistic and non-autistic individuals?

Based on the current research, the hypothesis stands that some of the characteristics of the drawings will differ, depending on whether the drawings were created by autistic or non-autistic individuals. In line with the diagnostic criteria listed in the DSM – 5 (American Psychiatric Association, 2013) stating that autistic individuals exhibit restricted and repetitive behavior and the already existing research (Bergmann et al., 2020; Shi et al., 2021) we predict, that the art created by autistic individuals will include more repetitions of patterns and designs.

Do the results from the Rey-Osterrieth Complex Figure Test differ between the groups of autistic individuals and non - autistic individuals and in which aspects?

Research points towards favoring of local processing as opposed to global processing in autistic individuals (Chen et al., 2012; Lebreton et al., 2021). However, findings are not conclusive seeing as both preference for local and global processing (D´Souza et al., 2015; Plaisted et al., 1999) and no preference for local processing have been reported (Nayar et al., 2017; Smith et al., 2016; Van Der Hallen et al., 2014). To further provide data on these contradicting results, the aforementioned research question will include an analysis of a preference of local or global perceptual processing used during the completion of the ROCF drawings. Furthermore, deficits in executive functioning, which can also be analyzed using the ROCF (Poreh & Shye, 1998), will also be assessed. The research question that follows is contingent with the previous research question and pertains to group differences.

Since research is largely inconclusive, there will be no directional hypothesis formulated. The ROCF offers both executive functioning and drawing style measures which could further serve as potential explanation for what processes in cognition and perceptual processing might be associated with differences in drawing properties between two groups, should they emerge.

Do the results from the Rey – Osterrieth Complex Figure Test predict outcome scores across quantitative image properties?

Since this research question is of a purely exploratory nature, this hypothesis is also non-directional. This research question serves to assess whether rather than group belonging being associated with a certain drawing style, certain aspect of cognition and perceptual processing predict how participants create their drawings.

Methods

The research project at hand is a small part of a larger 4-year research project and not all of the data gathered during the data collection procedures for the study will be included in the final data analyses of this study.

Study Design

The research project that this study is a part of employed a between-participants experimental design to investigate emotion recognition, communication, and neural synchrony in autistic and non-autistic adults. The participants were divided into an autistic group and a non-autistic group based on whether they could provide a formal diagnosis or conversely indicated that they had not been diagnosed with ASD. Participants were matched for age and gender for the most part, but the number of autistic individuals who identified as nonbinary or gender non-conforming in the autistic group was ten, whereas there were no nonbinary or gender non-conforming individuals in the non-autistic group, which resulted in the matching for gender being incomplete. The independent variable was whether the participants were autistic or not, whereas there were multiple dependent variables including behavioral, neurophysiological, and psychophysiological measures related to emotion recognition and communication. For this research project, the dependent variables were the drawings which the participants produced, the characteristics of said drawings, and the BQSS scores on the ROCF.

The study was conducted in a lab at the University of Vienna in a calm and controlled environment and was approved by the University of Vienna Ethics Committee. All participants were provided with an information sheet pertaining to the procedure and data handling, for which they then provided informed and written consent. All participants were monetarily compensated and received 30 € after the experiment. They were also informed that they had the option to withdraw at any time during the experiment without having to provide a reason for their withdrawal and still receive the same compensation. Lastly participants were informed, that if they wanted their data deleted at any point after the study, they could send an email, and the research team would see to that.

Participants

The final sample consisted of 62 individuals, of which three had to be excluded. One was excluded as they had a suspicion of having autism without an official diagnosis, while another participant was excluded as they reported having brain damage, which could influence their performance on the tasks. A last participant was excluded due to their data having been corrupted. The number of autistic participants reached 29, whereas the number of non - autistic participants reached 30. They were recruited through convenience sampling via social media, such as autism-related Facebook pages and Instagram story posts, university subject pools, flyers, and an already pre-existing email list of autistic individuals, whose contact information was available through a previous study. The inclusion criteria required participants in the autistic group to be able to provide a formal diagnosis of autism spectrum disorder. The non-autistic control group consisted of individuals with no history of neurological or psychiatric conditions and a score of <17 on the Autismus-Spektrum-Quotienten Kurzversion (AQ-k; Freitag et al., 2007) questionnaire, ensuring that the chance of them being autistic but undiagnosed was as small as possible. On average the non-autistic individuals in this sample scored 7 on the AQ-k questionnaire, whereas participants in the autistic group scored 23.

All 59 participants were adults, between the ages of 18 and 65 (mean age = 29.7, *SD* = 10.5). Of the autistic group, 13 participants identified as female, 6 as male and 10 as nonbinary or gender non-conforming. Of the non-autistic group 20 identified as female, 10 identified as male and none identified as nonbinary or gender non-conforming. Of all participants 55.9% (33) were female, 27.1% (16) identified as male and 16.9% (10) indicated that they were nonbinary or gender non-conforming.

Out of the 59 participants, 35.6% (21) reported having attained a high school diploma, another 33.9% (20) reported having acquired a bachelor’s degree, 10.2% (6) reported having, completed a Master´s degree, 6.7% (4) indicated compulsory schooling as their highest educational attainment, 5.1% (3) reported having had vocational training, 3.4% (2) had a PhD, another 3.4% (2) had finished a diploma program and lastly one person (1.7%) preferred not to disclose what their highest completed level of education was.

Twelve of the participants in the autistic group reported comorbid attention deficit/hyperactivity disorder, ten indicated having suffered or suffering symptoms of depression, four participants reported suffering from anxiety disorder and one participant reported having been diagnosed with anorexia nervosa. All participants were fluent in German and had normal or corrected-to-normal vision. Individuals were excluded if they reported regular use of illegal drugs, intellectual disabilities, or eczema on the scalp or other scalp sensitivities that would interfere with physiological recordings.

Materials, Instruments and Physiological Measurements

Tests and Questionnaires

The following measures were assessed as part of a larger research project and used to capture various aspects related to artistic self-expression, autism and their interaction. While each test and questionnaire has its own theoretical rationale, the data assessed, save the ROCF, is not relevant to the study at hand, which focuses solely on self-expression through drawings and was omitted from further analyses.

Autismus-Spektrum-Quotienten Kurzversion (AQ-k). All participants were required to fill out the AQ-k, or Autismus-Spektrum-Quotienten Kurzversion (Freitag et al., 2007), consisting of 33 items. This was to ensure diagnostic status and that no one in the non - autistic group displayed symptoms above the AQ-k cutoff of 17, which was set as the score indicative of possible autism. The sensitivity of AQ-k was reported as 88.9% and the specificity at 91.6% at a cutoff of 17, with a retest reliability of 0.79 (Freitag et al., 2007).

Raven´s Standard Progressive Matrices (RSPM). The Raven´s Standard Progressive Matrices (RSPM; Raven, 1938) is a non-verbal intelligence test designed to measure abstract reasoning and cognitive ability, specifically fluid intelligence. It is centered around pattern recognition tasks which require participants to complete visual patterns by selecting the missing piece from a set of options after having been presented with a sequence of patterns that change following a specific rule or multiple rules. The participants must first recognize these rules and then apply them to find the missing piece, while the difficulty of the items increases as the test progresses. It primarily measures fluid intelligence but can also assess cognitive flexibility and pattern recognition (Raven, 2000). In this study the 9-item short version was used (Bilker, 2012). The RSPM is often used in autism research, as previous research has shown, that autistic individuals score significantly higher on the RSPM, when compared to other intelligence tests, such as Wechsler intelligence scales, indicating that it might be more suited to assess autistic individuals' intelligence levels than other tests (Dawson et al., 2007).

Mehrfachwahl-Wortschatz-Intelligenztest-B (MWT-B). The MWT-B (Mehrfachwahl-Wortschatz-Intelligenztest-B; Lehrl, 2005) is a German intelligence test designed to assess vocabulary knowledge and verbal intelligence consisting of 37 items. It is an adaptation of the Multiple-Choice Vocabulary Intelligence Test (MWT; Lehrl et al., 1995), which is widely used in German-speaking countries to evaluate the crystallized intelligence of individuals. The test presents participants with multiple-choice questions where each item consists of an existing word and four nonsensical constructions. The participants are tasked with identifying the known word among all options, which do not constitute real words. The items are arranged in increasing order of difficulty (Lehrl, 2005).

Revised Comprehensive Autistic Trait Inventory (CATI-R). The Revised Comprehensive Autism Trait Inventory (CATI-R; Hechler et al., 2025) was developed as a psychometric tool to measure a broad range of autistic traits. It specifically aims to include individuals who may not meet the diagnostic criteria for autism spectrum disorder but display traits similar to those of individuals with the condition. Other assessment tools such as the Autism-Spectrum Quotient (AQ; Baron-Cohen, 2001) have been reported as being limited in capturing the full spectrum of autistic traits, particularly sensory sensitivities and social camouflaging. English et al. (2021) first aimed to address these shortcomings in the Comprehensive Autistic Trait Inventory (CATI; English et al., 2021) by including the additional six subscales of Social Interactions, Communication, Social Camouflage, Repetitive Behaviours, Cognitive Rigidity, and Sensory Sensitivity. This screening was later revised in collaboration with autistic individuals to increase clarity for users, seeing as it is a self-report scale. The CATI-R is not intended to be used as a diagnostic tool.

Toronto Alexithymia Scale-20 (TAS-20). The Toronto Alexithymia Scale-20 (TAS-20; Bagby et al., 1994) is a tool to assess the construct of alexithymia. Alexithymia encompasses difficulties in identifying and describing emotions, as well as a focus on external events rather than internal emotions. It is associated with various psychological disorders, including depression, anxiety, and eating disorders, influencing emotional regulation and interpersonal functioning (Bagby et al., 1994). The TAS-20 is composed of 20 items which can be classified into three subscales of Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF) and Externally Oriented Thinking (EOT). These subscales are intended to assess the core features of alexithymia, with higher scores indicating greater difficulty in emotional awareness and expression (Bagby et al., 1994). The results for the factorial validity of the TAS-20 across different subscales are inconsistent, with one study reporting Cronbach's alpha values of 0.91 for DIF and 0.79 for DDF but only 0.51 EOT (Preece et al., 2020). However, a Cronbach's alpha of 0.88 was reported for the full scale (Preece et al., 2020). Alexithymia has been reported to be especially prevalent in autistic individuals and while this connection still requires further research a connection between the disability and alexithymia traits has been observed in autistic populations (Skotalczyk et al., 2024; Vuillier et al., 2020).

SPF-IRI (Saarbrücken Personality Questionnaire - Interpersonal Reactivity Index). The Saarbrücken Persönlichkeits-Fragebogen (SPF-IRI) is the German adaptation of the Interpersonal Reactivity Index (IRI; Davis, 1980). The original IRI by Mark H. Davis (1980) conceptualized empathy as a multidimensional construct that includes both cognitive empathy (understanding another's perspective) and emotional empathy (feeling another's emotional state). The SPF-IRI follows this structure and adapts it for German-speaking populations. It measures both emotional and cognitive aspects of empathy and encompasses four subscales, which aim to assess Empathic Concern, Perspective Taking, Personal Distress, and Fantasy, similar to the original IRI. The Empathic Concern subscale is intended to assess an individual's feelings of compassion and concern for another person´s emotional states. Perspective Taking assesses the ability to understand another person's perspective or emotional experience, Personal Distress the discomfort one might experience when witnessing another's distress and lastly, Fantasy measures the degree to which one identifies with characters in fiction. The internal consistency of the SPF-IRI subscales varies as reported by Paulus (2009) who found Cronbach's alpha coefficients ranging from 0.66 for Personal Distress to 0.74 for Fantasy. Autism research has found a discrepancy between cognitive and emotional empathy reported by autistic individuals. The empathy imbalance hypothesis (EIH) proposes that autistic individuals might present lower cognitive empathy, but higher levels of emotional empathy (Rueda et al., 2014). This test helps further collect data and contextualize previous findings.

Adult ADHD Self-Report Scale (ASRS). The Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005) is a tool for screening attention-deficit/hyperactivity disorder (ADHD) in adults. High internal consistency has been reported across various populations, with a Cronbach's alpha of 0.885 of the Korean version and a two-week test-retest reliability coefficient of 0.87 (Kim et al., 2013).For this study the 6-item short version was used. ADHD symptoms are often assessed in autism research due to the high rates of comorbidity reported in literature (Rong et al., 2021).

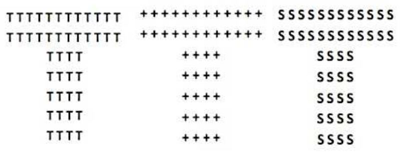
Beck Depression Inventory-Fast Screen (BDI-FS). The Beck Depression Inventory-Fast Screen (BDI-FS) is a seven-item self-report tool derived from the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), used to assess the severity of depressive symptoms. It excludes somatic complaints to prevent physical symptoms confounding the assessment of symptoms of depressive episodes or depressive disorders. The reliability of the test has been reported to be strong, with one study reporting a coefficient α of .84 for the BDI-FS total-scores (Kliem et al., 2013). The BDI is often used to assess depressive symptoms in autistic individuals since it has been found to be a reliable tool that excludes somatic symptoms while still assessing an overall profile of depressive symptoms (Cassidy et al., 2018).

Mini-Social Phobia Inventory (Mini-SPIN). The Mini-Social Phobia Inventory (Mini-SPIN; Connor et al., 2001) is a three-item self-report assessment tool designed to screen for social anxiety disorder (SAD), derived from the longer Social Phobia Inventory (SPIN; Connor et al., 2000). The psychometric properties of the MINI – SPIN have been reported as strong, with Fogliati et al. (2016) reporting a discriminative validity of 0.85. and a retest-reliability of r = .82. Autistic individuals often report elevated rates of social anxiety, which influences social skills and social motivation (Spain et al., 2018).

Aesthetic Responsiveness Assessment (AReA). The Aesthetic Responsiveness Assessment (AReA; Schlotz et al., 2021) is a screening tool designed to measure individual differences in responsiveness to art across various domains, which was developed both in English and German and consists of the three subscales Aesthetic Appreciation (AA), Intense Aesthetic Experience (IAE) and Creative Behavior (CB). Strong overall reliability has been reported, with a Cronbach's alpha of .82 for the overall scale (Schlotz et al., 2021).

Navon Task. The Navon Task (Navon, 1977) is aimed at assessing processes in the perception of visual stimuli by examining how individuals perceive global and local features within a Gestalt. The task assesses whether individuals prioritize global (overall shape) or local (component details) visual information when interpreting complex stimuli and provides insights into cognitive processing styles, particularly how individuals switch between focusing on global and local features when interpreting visual information (Navon, 1977). Navon figures on the global level are large letters, which on a local level, consist of many small letters.

Figure 2



Note. Navon Task Example.

Group Embedded Figures Test (GEFT). The Group Embedded Figures Test (GEFT; Witkin et al., 1971), is a tool developed to assess field dependence and independence, a cognitive style that reflects the ability to process information in relation to its surrounding context. Field-independent individuals tend to focus on local features, while field-dependent individuals display a preference for the global appearance of a stimuli. The test requires individuals to identify simple shapes embedded within complex figures (Cakan, 2003). Superior performance on the GEFT has been found to be predictive of ability to produce realistic drawings in research (Drake, 2014) and has been previously used to assess whether performance on the GEFT was connected to the quality of art produced by individiuals (Pelowski et al., 2018).

Edinburgh Handedness Inventory (EHI). The Edinburgh Handedness Inventory (EHI; Oldfield, 1971) is a self-report questionnaire which assesses hand preference for everyday tasks. It was first developed by Oldfield (1971) and serves as a standardized measure for determining left-handedness, right-handedness, or mixed handedness. It consists of a list of common activities, such as brushing teeth, writing or throwing, for which participants indicate which hand they prefer to use. Responses are scored on a laterality index (LI), which ranges from -100 (strong left-handedness) to +100 (strong right-handedness), with scores near zero indicating mixed handedness (Dragovic, 2004).

Rey-Osterrieth Complex Figure (ROCF). For a comprehensive overview of the ROCF see Chapter 3 below. The BQSS (Stern et al., 1999) offers 17 qualitative scores for each condition – copy, immediate retention and delayed retention. These qualitative scores include configural presence, configural accuracy, cluster presence, cluster accuracy, cluster placement, detail presence, detail placement, fragmentation, planning, neatness, vertical expansion, horizontal expansion, reduction, rotation, perseveration, confabulation and asymmetry. Furthermore, there are 6 quantitative scores – copy presence accuracy, immediate presence accuracy, delayed presence accuracy, immediate retention, delayed retention and organization.

Research suggests that while the six summary scores represent broader cognitive domains, the scores for planning, organization, fragmentation, and neatness are most suited to assess executive functioning (Shin et al., 2006; Somerville et al., 2000), therefore these scores will be analyzed in addition to the six summary scores (which include organization) to assess aspects of executive functioning more accurately and address the issue of research not finding the six summary scores to be predictive of executive function (Ogino et al., 2008; Temple et al., 2006; Shin et al., 2006; Somerville et al., 2000). To assess perceptual processing biases and examine whether autistic participants' results indicate a local or global processing bias the summary scores (Kuschner et al., 2009) will be analyzed, as well as fragmentation scores. For all quantitative scores lower scores mean worse performance on the ROCF task, implying more compromised executive functioning, or a more local preference for perceptual processing.

Instruments and Physiological Measurements

functional Near-Infrared Spectroscopy (fNIRS). Functional near-infrared spectroscopy (fNIRS) is a brain imaging method which is non – invasive and can assess increases in neural activity in specific brain regions. If an area of the brain is more active the demand for energy and oxygen rises, which then in turn is met by an increased supply of oxygen-rich blood. This leads to a relative increase in the concentration of oxygenated hemoglobin compared to deoxygenated hemoglobin. These changes can be measured using light-emitting diodes (sources) and light-sensitive detectors (receivers). A near-infrared light is projected from a source into the tissue beneath the scalp and the intensity of the reflected light is then assessed using detectors. Since oxygenated and deoxygenated hemoglobin have different optical properties, their concentrations can be determined through the amount of reflected light. When fluctuations in oxygen consumption are tracked over time, it becomes possible to infer the activity of cortical areas (Pasquini, 2018; Wilcox & Biondi, 2015). The NIRSport2 (NIRSport2®; NIRx Medical Technology, Berlin, Germany) and the Aurora software system were used for recordings in this study. Though neural activity in specific brain regions was measured throughout all sessions, the data at hand will not be used for this specific study, which only focuses on behavioral data.

Facial Electromyography (fEMG). Facial Electromyography (fEMG) measures electrical activity in facial muscles. It is often used in research to assess emotional and cognitive states based on subtle muscle activation. fEMG can detect electrical signals generated by facial muscles during contraction. These signals can be measured by placing electrodes on the skin above the targeted muscle groups. The recorded electrical potential reflects muscle activation, which can be used to determine affective and cognitive states (Tassinary et al., 2009).

Electrodermal Activity (EDA). EDA is seen as an indicator of emotional arousal, stress and activity, and cognitive workload. The premise of EDA measurements is that sweat gland activation is primarily controlled by sympathetic nervous system activity and increases in skin conductance are therefore related to increases in the activity of the sympathetic nervous system. EDA is measured by placing electrodes on skin which can then assess skin conductance (Banganho et al., 2022). In this study the electrodes were attached to the index and middle finger of the participants using Velcro strips.

Procedure

Pre-Screening

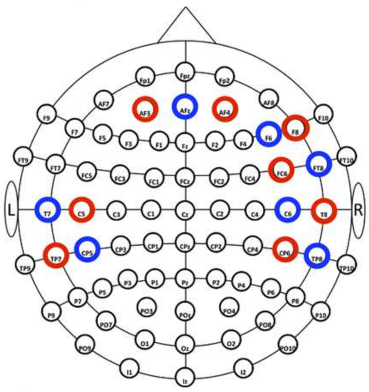
Before participating in the study, all potential participants were required to complete a pre-screening first. The participants filled out the pre-screening independently via Qualtrics (Qualtrics, Provo, UT). In total 306 people filled out the pre-screening. The pre-screening questionnaire assessed what gender individuals identified with, their age, and whether they had a formal autism diagnosis and additionally, if any other diagnoses were present. The participants also completed the German AQ-k (Freitag et al., 2007). If the participants fit all the criteria described in the “participants” section above, they were sent an invitation link to the experiment, which included a link to book a date that was convenient for them. All participants were sent an email - reminder for the appointment 24 – 48 hours before the booked date.

Experiment

Of the 306 individuals who completed the pre-screening questionnaire, 62 partook in the experiment, which was set in Liebiggasse 5, in a laboratory in the faculty of psychology of the University of Vienna. Upon arrival, participants were greeted and given a short oral overview of the study procedure before being provided with an information sheet, containing details as to the assessments and the procedure, and a consent form. The participants were seated in front of a large display for the entire duration of the experiment. After the participants had signed the consent sheet and in case that they were on the autism spectrum provided proof of diagnosis, the experiment began. First, the physiological measurement equipment was set up. The EMG ground electrode on the right mastoid was first fitted to the participant. Then the functional Near-Infrared Spectroscopy (fNIRS) cap was fitted, after having measured the head circumference of each participant to ensure that the right cap size was chosen.

Afterwards, the midpoint of the head was assessed by finding the midpoint between the preauricular points of the left and right ear and the midpoint between the nasion and the inion. Then, the cap was installed on the heads of the participants. The optodes were placed so that the activity in the medial prefrontal cortex (mPFC), right inferior frontal gyrus (rIFG), right dorsolateral prefrontal cortex (rdlPFC), and bilateral temporoparietal junctions (TPJ) could be recorded.

Figure 3



Note. Positions of sources (red) and detectors (blue)

Next, to assess electrodermal activity, electrodes were fit on the index and middle finger of the participants´ non-dominant hands. This was done so that the electrodes would not interfere with any of the subsequent task, which required the participants to draw and type.

After the fNIRS cap and the electrodes to measure EDA on the hands were fitted, a baseline measure was recorded. All participants were instructed to focus on a black fixation cross on a white background on the display before them for one minute while not thinking about anything specific.

Once the baseline measurement was completed, the tasks which were designed to record the way participants expressed emotions across different modalities began. These tasks will be referred to as emotion expression tasks hereon after. The modalities assessed in this study were that of expressing emotions through facial expressions, expressing emotions through written language and through abstract drawings. Each emotion expression task began with a baseline measurement and a practice round. For each modality, the emotion for the practice round was set as surprise. Then every participant was presented with the actual tasks. These tasks consisted of expressing the emotions of happiness, sadness, anger and fear, which appeared in a random order. Participants were also informed that another group of participants would, after this study was finished, view the emotion expression tasks and must try to guess which emotion it was that they had been expressing. Each emotion that participants were instructed to express would appear on the same display that they were completing the tasks and answering questions on.

The first emotion expression task for all participants was that of expressing emotions through facial expressions. For this task participants were sat on a chair, with their backs to the wall, facing a camera. To keep lighting consistent for all participants, the curtain was drawn, the lights installed in the lab were turned off, and instead two studio lights facing the participants were used. Before starting, all participants were provided with an oral instruction, during which they were told to face toward the camera but that they did not have to look directly into it. They were informed that they had to remove their glasses to ensure that all facial expressions were fully visible and to avoid any reflections which might appear in the glasses and to also not cover their face with their hands. The participants first completed the baseline, which lasted 30 seconds and during which participants were again instructed to relax, while not thinking about anything specific and face towards the camera. After, the practice round began, which could be repeated as often as necessary for each modality. Then the actual emotions were presented. For each emotion participants had to hold the facial expression for eight seconds, seeing as anything exceeding eight seconds was found to feel unnatural and difficult to maintain for participants. Following each emotion expression task the participants answered questions about how they performed the task and how they felt about it. These questions were rated on a 7-point Likert scale and were translated from English to German. Rating a question as one was indicative of the lowest rating and seven of the highest.

1. How expressive do you think your facial expression was?

   Wie ausdrucksstark denken Sie, war Ihr Gesichtsausdruck?

2. How strongly do you agree that the facial expression will evoke the intended emotion in the viewer?

   Wie stark denken Sie, dass der Betrachter die Emotion empfinden wird, die Sie kommunizieren wollten?

3. How hard was this task for you?

   Wie schwer finden Sie diese Aufgabe?

4. How much did you think about the viewer while making the expression?

   Wie sehr dachten Sie an den Betrachter, während Sie den Gesichtsausdruck zeigten?

5. Did you feel the emotion while making the expression?

   Fühlten Sie die Emotionen während dem Zeigen des Gesichtsausdruckes?

6. How positive or negative is the emotion you have been instructed to express in your opinion? (1=negative, 7=positive)

   Wie positiv oder negativ ist die Emotion, die Sie ausdrücken sollten, Ihrer Meinung nach?

After completion of the facial expression tasks the fEMG was fitted to the participants, with two electrodes placed above the corrugator supercilii and two along the zygomatic major. For the last two modalities, writing and art, the order in which they were presented was randomized.

The writing task began with a baseline measurement, during which participants were instructed to place their hands on the keyboard as though they were going to type while again trying to not think about anything specific for thirty seconds. After the practice - round commenced. All participants were informed that they had ninety seconds to express the presented emotion through writing, such as writing about how the emotion feels or something that might make someone feel the emotion, or writing poetry about it. They were advised not to mention the emotion itself or synonyms of emotion, since another group of participants was going to read their writing and try to guess which emotion it was that they had written about. However, they were given the option to do so nonetheless in case notmentioning the word was obstructive to task fulfilment. For this task the process of writing was screen recorded. Participants received oral instructions as to how long the minimum requirement for writing was, which was set as 60 seconds, after which an automated voice would inform them, that they had thirty seconds left. At this point they had the option to move on to the rating questions, which again were rated on a 7-point Likert scale, with one indicating the lowest, and seven the highest rating. All questions were translated from English to German.

1. How creative do you find the writing?

   Wie kreativ finden Sie Ihr Schreiben?
2. How expressive do you find the writing?

   Wie ausdrucksstark finden Sie Ihr Schreiben?
3. How strongly do you agree that the writing will evoke the intended emotion in the viewer?

   Wie stark denken Sie, wird das Schreiben die von Ihnen kommunizierte Emotion im Betrachter auslösen?
4. How hard was this task for you?

   Wie schwer fanden Sie diese Aufgabe?
5. How much did you think about the viewer while writing?

   Wie sehr dachten Sie an den Betrachter beim Schreiben?

6. Did you feel the emotion while writing?

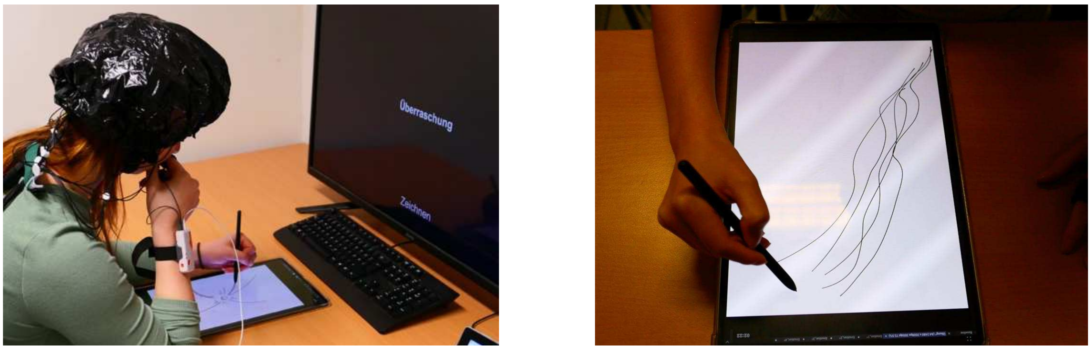
   Fühlten Sie die Emotion, die Sie kommunizieren wollten, beim Schreiben?

7. How positive or negative is the emotion you have been instructed to express in your opinion? (1=negative, 7=positive)

   Wie positiv oder negativ ist die Emotion, die Sie ausdrücken sollten, Ihrer Meinung nach?

The drawing task was structured the same way. All drawings were created on a Galaxy Tab S8 Ultra using an SPen and the software Clip Studio Paint. The brush type and thickness of the brush were predefined, and pressure sensitivity was enabled. To minimize the influence of uncontrolled variables, the ability to change colors or erase was disabled. The entire drawing process was screen-recorded for later analysis, as well as recorded by a camera, which was placed above the Galaxy Tab S8 Ultra, so that both the tablet and the hands of the participants could be seen in the video recorded.

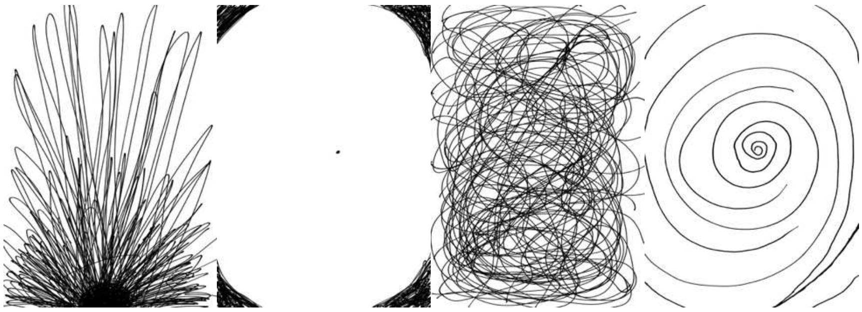
Figure 4



Note. Setup of drawing task (left) and recording of drawing task (right)

Participants first completed a 30-second baseline measurement for which they were instructed to lean forward, over the tablet, in a drawing position. After the baseline measurement the practice round began. They were given 90 seconds to create an abstract drawing that represented the presented emotion. Before beginning the tasks, participants were explicitly instructed to avoid representational art or symbols and offered the opportunity to ask after the practice round if what they created was in fact abstract art.

Figure 5



Note. Examples of drawings created by participants.

For the drawing tasks too, participants were asked to answer rating questions on a 7-point Likert scale, with one indicating the lowest, and seven the highest rating. All questions were translated from English to German.

1. How good do you think your drawing technique was for this drawing?
   Wie gut finden Sie, war Ihre Zeichentechnik für diese Zeichnung?
2. How aesthetically appealing as an artwork do you find the drawing?
   Wie ästhetisch ansprechend finden Sie Ihre Zeichnung?
3. How creative do you find the drawing?
   Wie kreativ finden Sie Ihre Zeichnung?
4. How expressive do you find the drawing?
   Wie ausdrucksstark finden Sie Ihre Zeichnung?
5. How strongly do you agree that the drawing will evoke the intended emotion in the viewer?
   Wie stark denken Sie, wird die Zeichnung die von Ihnen kommunizierte Emotion im Betrachter auslösen?

6. How hard was this task for you?

   Wie schwer fanden Sie diese Aufgabe?

7. How much did you think about the viewer while drawing?

   Wie sehr dachten Sie an den Betrachter beim Zeichnen?

8. Did you feel the emotion while drawing?

   Fühlten Sie die Emotion, die Sie kommunizieren wollten, beim Zeichnen?

9. How positive or negative is the emotion you have been instructed to draw in your opinion? (1=negative, 7=positive)

   Wie positiv oder negativ ist die Emotion, die Sie zeichnen sollten, Ihrer Meinung nach?

After completion of the emotion expression tasks participants were offered a break, snacks and water.

Post-Test Questionnaires and Tasks

After the break, participants completed the RSPM, followed by the MWT-B. Then they moved on to the Navon Task. This task consisted of two conditions, once recognizing the letter on a local level and once on a global level. Each condition consisted of 40 trials. A fixation cross was presented for 1 second and each stimulus for 180 milliseconds. The Navon Task was followed by the GEFT, which was also completed on the Galaxy Tab S8 Ultra using an SPen, as was the ROCF, of which the copy and immediate retention condition followed right after. For all these tasks erasing was prohibited and the process of drawing the ROCF was screen recorded. To ensure that the delay of 20-30 minutes between the immediate retention condition and the delayed retention condition of the ROCF were given, participants then filled out the Edinburgh Inventory for Handedness, the CATI-R, the TAS-20, the SPF-IRI, the ASRS, the BDI-FS, the Mini-SPIN, the AReA and questions regarding art knowledge, engagement with it and proficiency in creating it. These questions aimed to assess participants' interest in art, their knowledge of it, how often they created art, which type of art it was that they created (e.g. comics, photography, oil paintings,…), how they would rate their skills, if they had studied art in an academic setting, and if so, what level that was on. Lastly participants were asked to disclose if they were taking medication, if they were undergoing therapy or social training, their age, occupation, academic major, and country of origin before being asked to once again draw the ROCF from memory.

Assessment of Drawings

To ensure objectivity all drawings were assessed using an open-access toolbox, which was designed to measure quantitative visual image properties. The toolbox called the "Aesthetics Toolbox" (Redies et al., 2025) analyzes a range of characteristics which will be discussed in this chapter.

Image Size, Aspect Ratio and Lightness Entropy

Image size is defined as the sum of image width and image height, whereas aspect ratio is calculated as the width-to-height ratio. The authors (Redies at al., 2025) argue that it is the convention used for describing the format of displays.

Root mean square (RMS) contrast. Contrast is calculated as the Root Mean Square Contrast. Contrast is defined as higher if pixel values appear over a larger range of Lightness values, meaning that an image has stark separations between light and dark areas, whereas low RMS values imply little variations in intensity across an image.

Lightness Entropy. Entropy refers to measure of unpredictability of information (Shannon, 1948). Consistent with this definition Lightness entropy is described as high if an image has many details and variations in brightness. Lightness entropy would be referred to as low if an image and its distribution of lightness appears uniform.

Complexity and Colorfulness

Complexity. The authors define image complexity as “the quantity and variety of information in an image” (Redies at al., 2025). Both the (Pyramid-)Histogram of Oriented Gradients ([P-]HOG) method and edge density are provided as measures of complexity. The Histogram of Oriented Gradients method divides images into channels based on L*a*b* color space and then calculates a mean value over the gradient image. Since this study only uses black and white images, the a* and b* channels, which assess hue and chroma, are obsolete. The L* channel, which analyses luminance, or the perceived brightness of an image, however, still provides structural information, therefore this measure will be included in the final analysis for comparisons between drawings. The second measure for image complexity measured by the toolbox is that of edge density in Gabor-filtered images. This measure represents the density and strength of edges in images and correlates with perceived complexity.

Colorfulness. Though this toolbox can assess the colorfulness of an image, this measure is obsolete for this study, since all drawings were created in black and white. The channels which will be excluded range from the RGB channel, which indicates which hue an image has overall, to the H and S channels from HSV analyses. The H and S channels indicate the hue values and saturation of images, respectively, whereas the V channel offers information about whether an image appears bright or dark overall. From L*a*b* analyses the A and B channels will be excluded, as elaborated above. These, too, assess the overall color of an image. The L channel will be included in analyses, as it offers information on lightness intensity in images. The L*a*b channels are used both for computations of colorfulness and complexity, which is why they appear in both subsections.

Symmetry and Balance

The toolbox offers pixel-based measures as well as convolutional neural network (CNN) based measures. The three pixel-based measures are mirror symmetry, balance and deviation of the center of mass (DCM). Mirror symmetry in rectangular images is defined as the mean symmetry around the vertical, horizontal and orthogonal axis for rectangular, non-quadratic images and the mean symmetry around the vertical and horizontal axis for square images. Balance is measured by first dividing the image along its horizontal, vertical and diagonal axes, and columns and lines. After, the number of black pixels in each of these same sized areas is assessed and a mean value for all axes calculated. A mean score, or “balance score” which is closer to 0% indicates high balance, whereas one closer to 100% reflects high or complete asymmetry. Lastly, the deviation of the center of mass is also assessed. The DCM is based on the assumption that each image has center of “perceptual mass” and a geometric center of the frame. The perceptual mass of each black pixel is 1, whereas that of a white pixel is set as zero. The euclidian distance of the center of perceptual mass and that of the geometric center of mass is then calculated for each axis and computed as a percentage of the maximum possible distance possible from the geometric center of mass in the image. This percentage is then referred to as the DCM score. As for the convolutional neural network-based symmetry assessments, the toolbox uses the first layer of a CNN and its filter responses, which capture features such as edges, splotches of different colors and spatial frequencies. Based on these filter responses the toolbox assesses left-right (LR) symmetry, up-down (UD) symmetry and a symmetry score combined for all four directions (left-right-up-down, LRUD).

Fractality

Fourier Spectrum Slope. One way in which the toolbox assesses fractality is through the fourier spectrum slope. Fractality refers to how similar smaller parts of an image are to the whole image. One of the ways in which fractality is measured is through the fourier spectrum slope. The toolbox measures the power rather than the amplitude of slopes, with all values being negative. Slope power values can be interpreted as a measure of complexity, seeing as it allows for inferring how many intricate details are present in an image. The "shallower" a slope is, or the less negative a slope value is, the less detailed the drawing appears. It can also be read as a measure of fractality. It indicates how much the spatial structure of an image changes as one might zoom in or out of the image.

Fourier Spectrum Sigma. Another measure analyzing the details of images is that of the fourier spectrum sigma. This measure is based on the assumption that in nature and traditional artworks the log – log plot of the fourier power spectrum would fit a straight line. The fourier spectrum sigma inspects data points within an image and analyses how much they deviate from this expected linear trend. In line with the assumption mentioned above, when analyzing traditional artworks or images of nature not much deviation would be found, with low sigmas indicating smooth, harmonious images. Images with more deviations and higher sigma values would indicate more chaotic, less harmonious visual patterns.

2D Fractality. The toolbox also offers 2D and 3D fractal dimensions as measures of fractality. 2D fractality measures the spatial complexity of an image by analyzing the edge structure or boundary patterns after first having converted the image to black and white. The image is then divided into a grid of boxes and using the box-counting method the number of boxes containing part of an edge structure is counted. As the box size decreases, the rate at which the number of boxes containing the detail of interest increases is used to calculate the fractal dimension D. The 2D values range from 1, which signifies simple structures, to 2, which is indicative of more complex patterns. This measure assesses the scale-invariant properties of the image, reflecting how much detail exists at different spatial scales and focusing on the complexity of edge structures.

3D Fractality. 3D fractality extends this concept by incorporating lightness (L) variations from the CIELAB color space as a third dimension. The lightness values are treated as a height map, where darker regions are "lower" and lighter regions are "higher." A 3D box-counting method is applied, dividing the image into 3D cubes at multiple scales and counting the number of cubes intersecting this 3D surface. The rate of increase in the number of cubes as the cube size decreases is used to calculate the 3d fractal dimension D, which ranges from 2, indicating simple and smooth surfaces to 3, reflecting complex, detailed surfaces. Using 3d fractality, both spatial and tonal variations are measured.

Self-Similarity

(P)HOG-based Self-Similarity. PHOG-based self-similarity quantifies how much smaller parts of an image resemble the whole image. It is based on the Pyramid Histogram of Oriented Gradients (PHOG), which analyses structural patterns and textures at different levels of detail. First the image is converted into the CIELAB color space, which separates lightness from color, and then gradient images for each channel are computed. These gradients represent the strength and direction of changes in lightness and color.

Next, the image is divided into sections which become increasingly smaller, creating a hierarchical pyramid of levels. Beginning at level 0, the entire image is analyzed. At level 1, the image is split into four equal sections, which would be a 2×2 grid, then at level 2, or a 4x4 grid. This process continues at higher levels, such as level 3, where the grid becomes 8×8, splitting the image into 64 parts. For each section at every level, a Histogram of Oriented Gradients (HOG) is computed, which allows for comparison of orientation of edges across all parts, at different Levels. To assess self-similarity, the HOG features computed at levels 1, 2, and 3 are compared to the HOG features at level 0. This comparison is performed using a Histogram Intersection Kernel, which quantifies how similar the gradient distributions in the smaller sections are to the global distribution of the entire image. If the patterns at different levels closely resemble those at level 0, the image exhibits high self-similarity. The final self-similarity score is obtained by averaging the similarity values across all levels, with a higher score indicating strong self-similarity and a score closer to 0 indicating weak self-similarity.

CNN-Based Self-Similarity. CNN-based self-similarity is a method for measuring how much smaller parts of an image resemble the whole image using features extracted from a convolutional neural network. First the image is fed into a pre-trained CNN, such as AlexNet, which processes the image through multiple layers to extract hierarchical features. For self-similarity analysis, analyses are done on the first convolutional layer (conv1), which captures low-level features such as edges, color-opponent blobs, and spatial frequencies.

After the image has been processed by the CNN, the responses of the filters in the first convolutional layer are used to construct histograms. These histograms represent the distribution of feature activations of the CNN, representing how often features such as edges and textures appear in different parts of the image. To quantify self-similarity, the histogram computed from the entire image is compared to the histograms of smaller subsections. The more similar the histograms of the subsections are to the histogram of the whole image, the higher the self-similarity. The final self-similarity score is obtained by calculating the median similarity value across all comparisons between the whole image and its subsection, with a higher score indicating high self-similarity and a lower score indicating low self-similarity.

Feature Distribution Entropy

Homogeneity. Homogeneity quantifies how uniformly pixel intensities are distributed across an image, on both the levels of evenness and of lightness and it´s spatial arrangement. Homogeneity is measured by first converting the image to black and white. To do this the Otsu Method is used, which determines an optimal threshold to split the image into foreground and background regions, which are then translated into black and white respectively. After, a 10×10 grid is laid over the image, resulting in 100 same-sized fields. For each of these parts, the number of black pixels is counted, resulting in a 10×10 matrix which reflects the distribution of black pixels across the image. Next, the sums of black pixels are computed separately for each row and each column, producing two histograms and the Shannon Entropy of each histogram is calculated. These entropy values are then divided by the maximum possible entropy and converted into a percentage from 0 to 100. In a final step the homogeneity score is calculated by computing the average of the normalized horizontal and vertical entropy values, with a homogeneity value of 100 indicating perfect uniformity and all black pixels being evenly distributed, and a value of 0 indicating complete inhomogeneity.

Anisotropy of Gradient Orientation. Anisotropy of gradient orientation reflects how evenly, or unevenly gradient strengths are distributed across different orientations. The gradients represent changes in lightness and color, while anisotropy quantifies whether specific orientations dominate over others. To compute anisotropy, a gradient representation of the image is created, capturing variations in lightness and color. The image is then divided into 64 parts at level 3 of a Histogram of Oriented Gradients (HOG) pyramid. For each of these 64 parts, a Histogram of Oriented Gradients (HOG) is computed, which represents the distribution of gradient strengths across different orientations. The gradients strengths are then binned for each orientation. These separate values are summed and normalized and in a subsequent step the standard deviation is calculated for each orientation bin, which is the final anisotropy output. Low anisotropy value indicates that gradient strengths are evenly distributed across orientations, meaning no single direction dominates and they are homogenous across different subregions, indicating more uniform patterns in images. A high anisotropy value suggests that certain orientations have stronger gradients than others, representing more complex images.

Edge-Orientation Entropy. First-order edge-orientation Entropy (EOE) and second-order edge-orientation entropy (EOE) describe the distribution and spatial relationships of edge orientations. To assess these properties, each image is first processed by 24 Gabor filters, which extract edge information and compute a set of edge-filtered images and the strengths of edges at various angles. The toolbox offers both first-order and second-order EOE. First-order EOE quantifies how evenly distributed edge orientations are across an image. High first-order EOE is indicative of evenly distributed edge orientations, whereas it is low when certain edge orientations dominate.

Second-order EOE extends this by examining how edge orientations appear relative to each other in images, measuring whether edge orientations occur independently of one another or follow structured patterns. To ensure that local regularities do not confound these results, edges within 20 pixels of each other are excluded. A high second-order EOE is indicative of orientation differences appearing independently and equally often, making for an intricate image, whereas low second-order EOE indicates that edges follow a structured pattern. The second-order EOE calculation is limited to the 10,000 strongest edge responses in an image.

CNN Feature Variances

Sparseness and Variability. Sparseness and variability are both computed through the filter responses of the first layer of a Convolutional Neural Network (CNN). Sparseness refers to how distributed details of the image are, whereas variability refers to how much these details differ from each other. To measure these image properties each image is first processed by the CNN, which extracts filter responses detecting low-level visual features such as oriented edges, color-opponent blobs, and spatial frequencies. Then it is divided into $n \times n$ subregions, and for each subregion, a max-pooling operation records the strongest response from each filter. Sparseness indicates how concentrated the filter responses are and is calculated as the total variance of the filter responses across all 96 filter maps within subregions. If responses are concentrated in a small number of subregions, sparseness is high. Sparseness is low, when many subregions exhibit similar response strengths, indicating a more evenly distributed set of features. To assess whether the filters detect similar low level visual features, the median of the variances of each filter´s response across all subregions is computed. This outcome is then interpreted as variability. If filter responses vary across different filters, variability is high. Conversely if responses remain similar across filters, variability is low, suggesting features to be more homogeneous across the image.

Results

ROCF Analyses

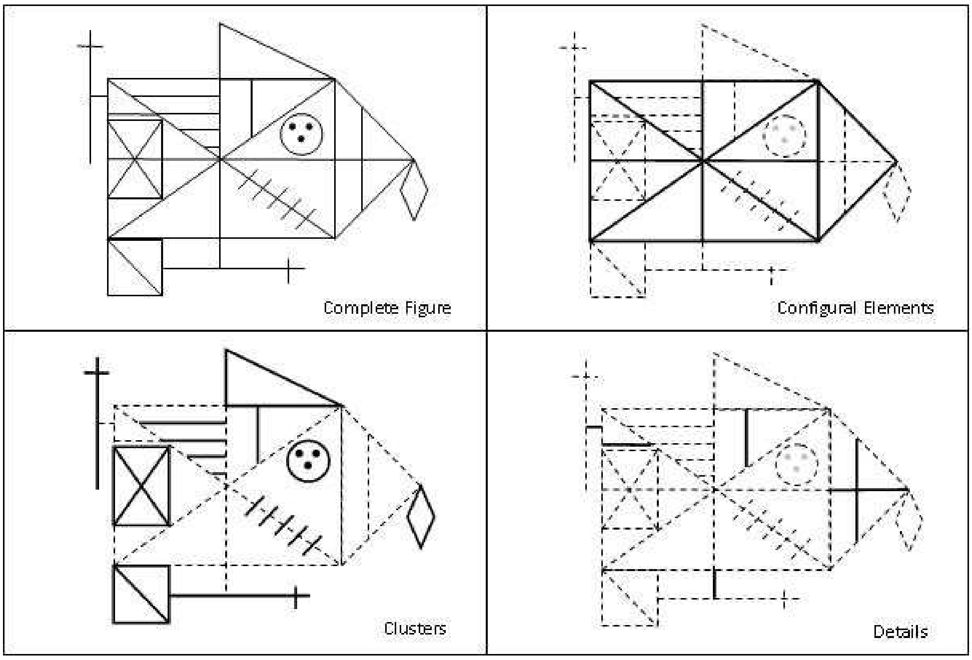
The ROCF drawings were analyzed to examine if differences in cognition and functioning as well as perceptual biases would emerge between autistic and non-autistic individuals. In particular, the six summary scores as a measure of executive functioning (Somerville et al., 2000) and the fragmentation scores to assess whether the drawing process was approached in a more fragmented manner, indicating a more local processing style, in either of the groups were analyzed. The final sample size for the ROCF analyses was reduced to 55 participants, since three participants´ drawings had to be excluded due to non – compliance with instructions and for a fourth participant technical issues prevented the drawing process from being recorded which made accurate scoring of the drawing impossible. Although using standardized scores are recommended for comparing across age groups and genders, raw scores were used for all analyses since there was a large number of nonbinary people in this sample for which no standardized scores are available. However, autistic and non-autistic participants were, where possible, deliberately age and gender matched, so differences due to age and gender should be minimized. All statistical analyses were conducted using R (R Core Team, 2024).

Analysis Summary Scores

For the six summary scores, independent t-tests were used. Model diagnostics revealed violations of assumptions of normality for all summary scores except for delayed retention (DR), making a Welch´s t-test for independent samples the analysis model for the scores copy presence and accuracy (CPA), immediate presence and accuracy (IPA), delayed presence and accuracy (DPA) and organization (ORG). For DR an independent samples Student´s t-test was conducted.

Each drawing is scored across configural elements, clusters and details. For all these dimensions of the drawing a score between zero and four is assigned for the accuracy and the placement of each element, with zero indicating that the element is not present or highly inaccurate in its form or placement, and four indicating that the element is highly accurate to the original ROCF.

Figure 6



Note. Boston Qualitative Scoring System (BQSS) of the Rey-Osterrieth Complex Figure divided by its´ three scoring dimensions configural elements, clusters and details. From "Estrategias de organización en la Figura Compleja de Rey en niños con TDAH" by J. Rubiales, D. Russo, R. Gonzalés, L. Bakker European *Journal of Investigation in Health Psychology and Education, 7*(2), 99. https://doi.org/10.30552/ejihpe.v7i2.199. Copyright 2018 by European Journal of Investigation in Health, Psychology and Education.

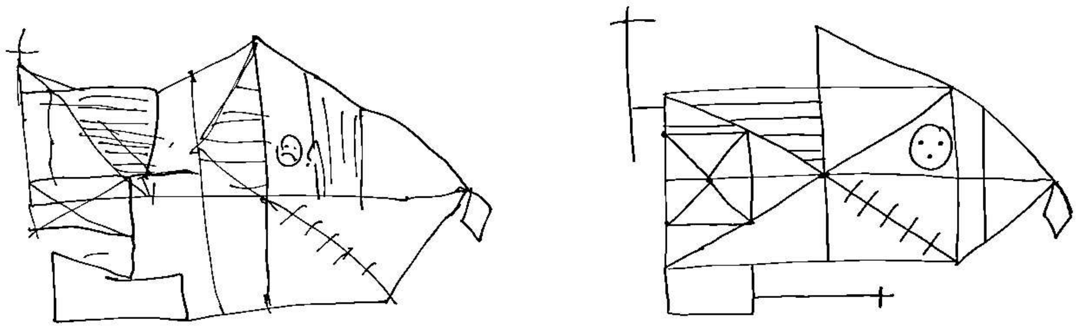
In addition to scoring the drawings´ configural elements, clusters and accuracy, the approach which participants used to reproduce the ROCF was also scored. For each image a score for fragmentation and organization was assessed. Fragmentation scores range from zero to four and quantify how often participants fragmented configural elements and clusters specified in the BQSS while drawing them. This could mean that participants started drawing the bottom of a rectangle, then continued with any other element of the figure, before returning to the rectangle. The higher the fragmentation score assessed for a drawing, the less interruptions were observed in completing a structural element of the figure.

The planning score quantifies how logical the order in which the drawing was approached is. Highly haphazardous approaches, where larger, framing elements were drawn later, received lower scores than those which followed a well-structured approach, where elements were building upon each other. The exact order and subsequent scoring is detailed in the Boston Qualitative Scoring System and is defined as zero being representative of a completely haphazardous approach and four being the approach labeled as most ideal in the scoring manual.

Both the fragmentation and plannig scores were also added to each other to calculate the organization score, which ranged from zero, indicating a highly fragmented drawing created using an erratic approach, to eight, indicating a well-structured composition.

Lastly a neatness score was assessed for each drawing. The neatness score ranged from zero to four as well. Drawings with a high number of overshoots in lines, gaps in elements and overdrawn elements received lower scores, than drawings which appeared neater and cleaner.

Figure 7



Note. Comparison and examples of two ROCFs drawn in the immediate retention condition. The image on the left was drawn using a highly haphazardous approach and contains many neatness violators, as well as lacking configural elements and details. The image on the right contains very few neatness violators and the drawing approach is well-organized. All elements were retained in the immediate retention condition, albeit not completely accurately reproduced.

The summary scores CPA, IPA and DPA are constituted of both the accuracy and the presence of the configural elements, the clusters and the details in their respective condition. These three summary scores can range from zero to twenty with higher scores indicating better performance. Participants scored high on the CPA score, with thirteen of the 55 participants (23.6%) reaching a score of 20, indicating a clear ceiling effect. The mean score computed for CPA is M =17.95 and SD = 1.69. For IPA and DPA no ceiling or floor effects were observed. The participants´ performance was moderate with the IPA mean score being M = 13.69 and SD = 3.42 and the DPA mean score being M = 12.96 and SD = 3.62.

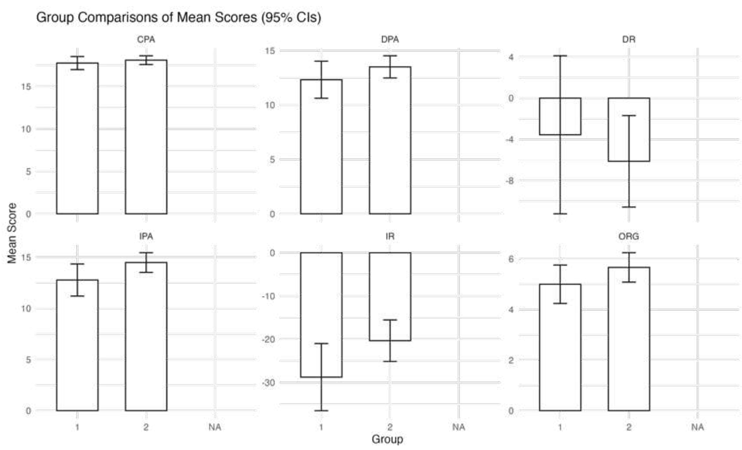
Immediate retention and delayed retention scores range from ≥ 7 to -100 and ≥ 141 to -100 respectively, with -100 indicating that none of the elements of the ROCF were retained and reproduced in an adequate manner from one condition to the next. For both conditions low to moderate performance was observed, meaning that participants tended to fail to reproduce the same amount of elements, as they did in the earlier condition. No ceiling or floor effects were observed in either condition. In the immediate retention condition the highest score achieved was five and the lowest -67, with the mean score being *M* = -24.16 and *SD* = 26.98. Scores were well distributed and did not cluster on either end of the range. For the delayed retention score a similar pattern emerged. The highest score achieved by a participant for the delayed retention was 43, whereas the lowest was -50. Here too, both extremes were not approached and scores evenly distributed, with the mean score being *M* = -5 and *SD* = 15.95.

For the organization scores the perfomance across all participants was moderate, with the mean score being *M* = 3.79 and *SD* = 0.94. Five (8.9%) out of the 55 participants reached the highest organization score, eight, indicating no strong ceiling effect. No floor effect was found for the organization score.

Results Summary Scores

No significant effects were found at an alpha = 5 % significance level across all analyses, although the non-autistic group appeared to score marginally higher for all outcomes.

Figure 8



Note. Group comparisons of mean scores for all summary scores. Autistic participants are indicated in group 1 (left) and non - autistic participants in group 2 (right).

Table 1

Summary Score	Group 1		Group 2		*t*	*p*	Cohen´s *d*
	M	*SD*	*M*	*SD*			
CPA	17.76	1.96	18.10	1.45	-0.72	0.48	-0.20
IPA	12.76	3.99	14.47	2.69	-1.82	0.08	-0.50
DPA	12.32	4.34	13.50	2.85	-1.17	0.25	-0.32
IR	-28.76	19.80	-20.33	13.39	-1.81	0.08	-0.50
DR	-3.56	19.56	-6.13	12.40	0.57	0.57	0.16
ORG	5.00	1.94	5.67	1.63	-1.37	0.18	-0.37

Note. Results of Welch´s and Student´s Independent Samples t-test at an alpha = 0.5. Group 1 refers to autistic individuals, whereas group 2 is indicative of healthy controls. CPA = copy presence and accuracy, IPA = immediate presence and accuracy, DPA = delayed presence and accuracy, IR = immediate retention, DR = delayed retention, ORG = organization.

Fragmentation, Planning and Neatness Scores Analysis

Each participant provided three ROCF drawings for which fragmentation, planning and neatness scores were assessed separately resulting in three outcomes per participant.

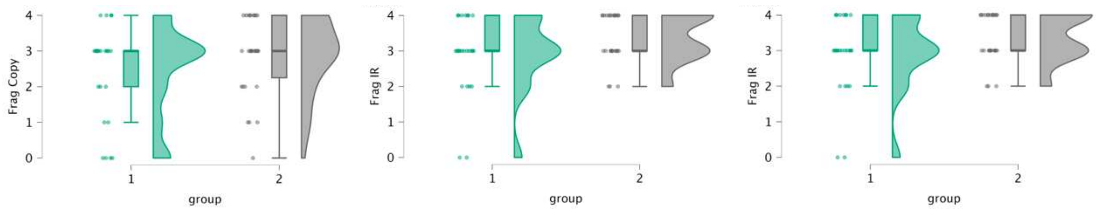
To account for repeated measures, a linear mixed model (LMM) was chosen for analysis. Fixed effects were specified as group and timepoint (copy, immediate retention, delayed retention). A random intercept was included for subject resulting in the following model: Score ~ group x timepoint + (1|ID).

To assess whether all assumptions were met for a LMM analysis this model was used to assess normality, heteroscedasticity and Variance Inflation Factors (VIF). A Breusch Pagan test revealed no violations of homoscedasticity and all VIFs were below 2 indicating an acceptable level of multicollinearity, however the Shapiro Wilk test revealed departure from normality of residuals. Given the non-normal distribution of residuals, a robust model was fitted using the rlmer function from the robustlmm package (Koller, 2016). The emmeans package (Lenth, 2017) was used to obtain estimated marginal means and compute group contrasts and standard normal approximation was used to assess approximate *t*-values and *p*-values.

Results Fragmentation Score Analysis

Lower fragmentation scores indicate a more fragmented drawing style, whereas higher scores signify less fragmentation.

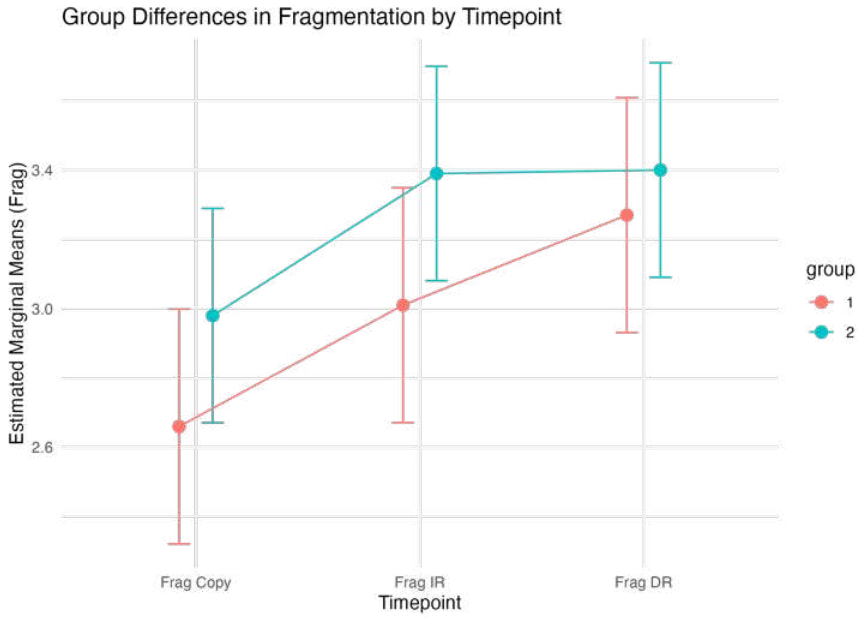
Figure 9



Note. Raw fragmentation scores across both groups. Group 1 = ASD group, Group 2 = TD group

No significant differences were found at any timepoint for the main effect of group; however, autistic participant (group 1) scored lower across all timepoints.

Figure 10



Note. Group differences in fragmentation scores. All scores range between 0 and 4, with 4 indicating low levels of fragmentation across the drawing. Autistic participants are represented in group 1, non-autistic participants in group 2.

Table 2

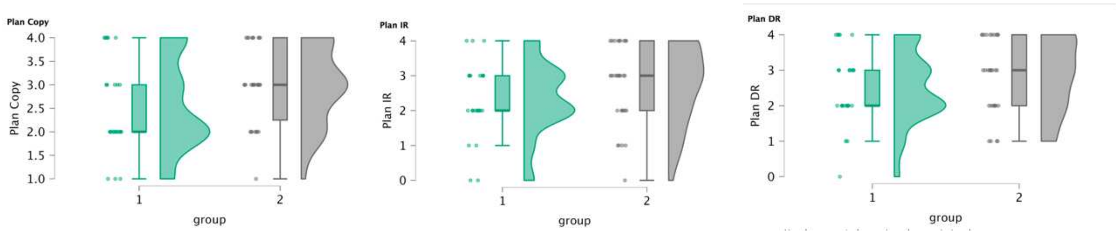
Condition	*B*	*SE*	*t*	95% *CI*	*p*
Fragmentation Copy	-0.32	0.23	-1.36	[-0.78, 0.14]	0.173
Fragmentation IR	-0.38	0.23	-1.61	[-0.84, 0.08]	0.107
Fragmentation DR	-0.13	0.23	-0.57	[-0.59, 0.33]	0.569

Note. Estimated group differences in fragmentation scores across conditions from the robust linear mixed model (rlmer). Outcome scores represent Group 1 - Group 2 differences. *t*-values were computed as the ratio of the estimated coefficient to its standard error. Group 1 = ASD group, group 2 = TD group.

Results Planning Score Analysis

The same approach that was used for the analysis of fragmentation scores was applied to the analysis of planning scores. Higher scores can be interpreted as participants employing more planning strategies while drawing the ROCF, whereas lower planning scores indicate a more haphazard approach.

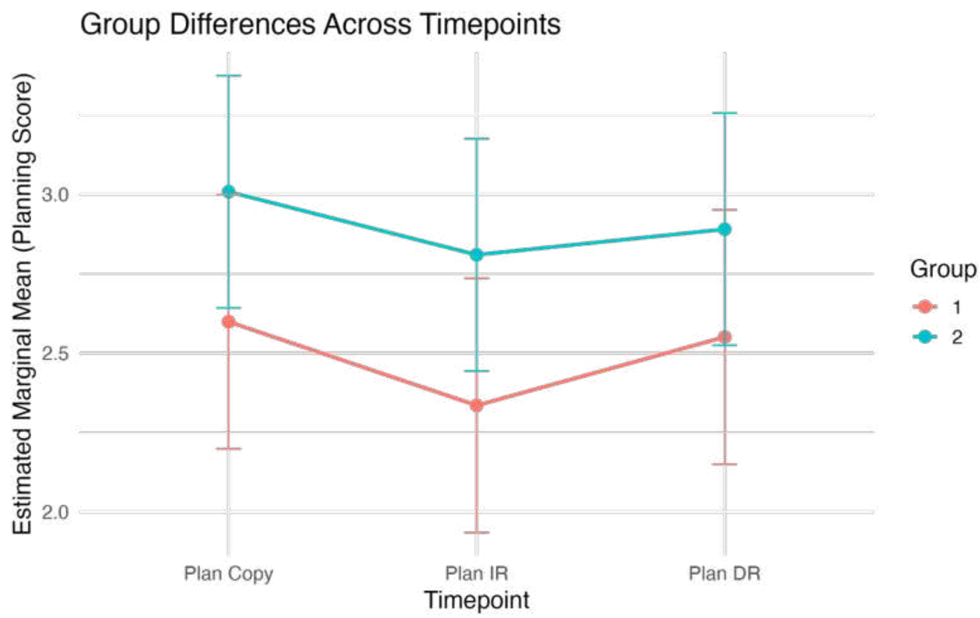
Figure 11



Note. Distribution of raw planning scores across both groups. Group 1 = ASD group. Group 2 = TD group.

No significant results were found for the main effect of group (group 1 – group 2) at any time point, however group 2 (non-autistic individuals) outperformed group 1 across all conditions, although this difference was not statistically significant.

Figure 12



Note. Group differences in planning scores. All scores range between 0 and 4, with 4 indicating the highest degree of planning implemented while approaching the drawing process and 0 indicating a haphazard drawing approach. Group 1 = ASD participants, group 2 = TD participants.

Table 3

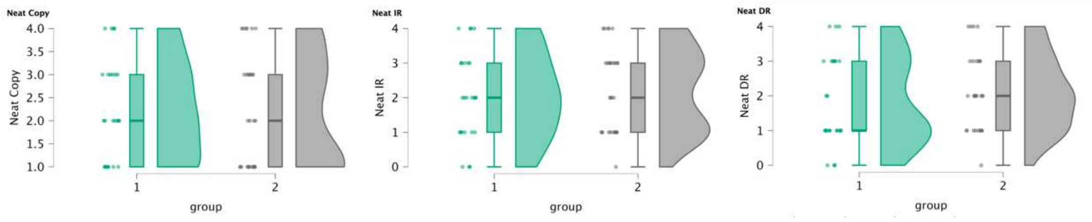
Condition	*B*	*SE*	*t*	95% *CI*	*p*
Planning Copy	-0.41	0.28	-1.48	[-0.95, 0.13]	0.14
Planning IR	-0.47	0.28	-1.71	[-1.02, 0.07]	0.09
Planning DR	-0.34	0.28	-1.23	[-0.88, 0.2]	0.22

Note. Estimated group differences in planning scores across conditions from the robust linear mixed model (rlmer). Outcome scores represent group 1 - group 2 differences. *t*-values were computed as the ratio of the estimated coefficient to its standard error. Group 1 = ASD participants, group 2 = TD participants.

Results Neatness Score Analysis

Differences in neatness scores were computed as in the analyses above. A higher neatness score indicates that a drawing contains less neatness violators such as overshoots, gaps and overdrawn items and corners, making the figure appear “neater”, whereas lower scores are indicative of drawings containing these neatness violators.

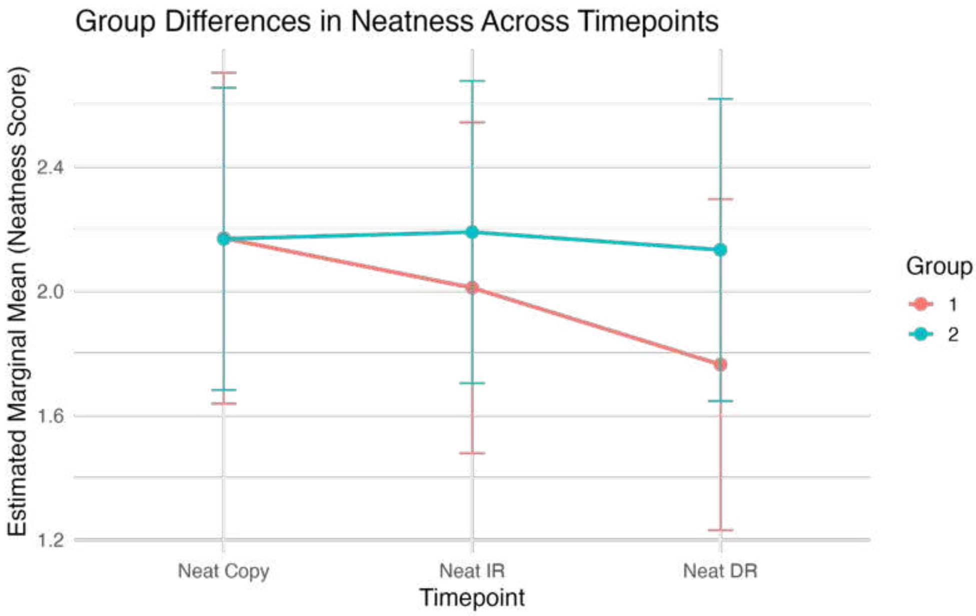
Figure 13



Note. Distribution of raw neatness scores across both groups. Group 1 = ASD group. Group 2 = TD group

No significant results were found for the main effect of group at any time point, although neatness scores in autistic participants (group 1) deteriorated much more than those in non-autistic participants (group 2), however there was no significant interaction between group and time point .

Figure 14



Note. Group differences in neatness scores. All scores range between 0 and 4, with 4 indicating very neat drawings and 0 indicating neatness violators across almost all aspects of the drawing. Group 1 = ASD participants, group 2 = TD participants.

Table 4

Condition	*B*	*SE*	*t*	95% *CI*	*p*
Neat Copy	0.00	0.37	0.01	[-0.72, 0.72]	1.00
Neat IR	-0.18	0.37	-0.49	[-0.9, 0.54]	0.63
Neat DR	-0.37	0.37	-1.00	[-1.09, 0.35]	0.32

Note. Estimated group differences in neatness scores across conditions from the robust linear mixed model (rlmer). Outcome scores represent group 1 - group 2 differences. *t*-values were computed as the ratio of the estimated coefficient to its standard error. Group 1 = ASD participants, group 2 = TD participants.

Drawing Analyses

The goal of analyzing the drawings created was to assess whether systematic differences would emerge in the quantitative image properties of the drawings created by autistic individuals and non-autistic individuals. Out of the 59 participants one participant's drawings had to be excluded due to the participant's failure to produce abstract art, which reduced the number of participants in the ASD group (group 1) to 28, whereas the number of participants in the non-ASD group remained 30 (group 2).

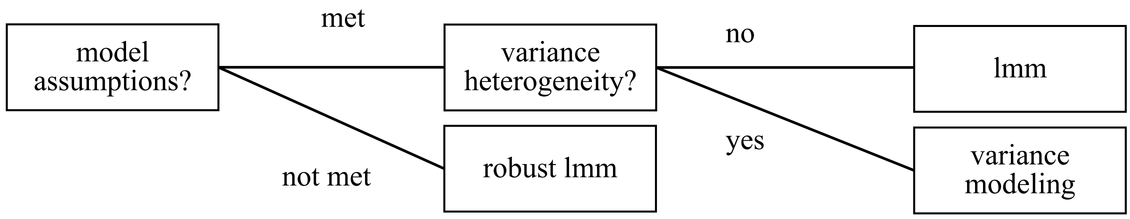
All participants created 4 black and white drawings, with each drawing depicting a different emotion. The 4 emotions which participants were tasked to draw were fear, happiness, sadness and anger. In the subsequent data analyses these emotions were coded as 1=fear, 2=happiness, 3=sadness, 4=anger. All drawings' image properties were first analyzed using the Aesthetics Toolbox (Aesthetics Toolbox v1.0.2, Redies et al., 2025), which generated a total of 46 outcome variables. After excluding those variables which were not viable for analysis, since they were the same across all participants and a result of the study design, 43 remained. The 3 variables excluded in this first step were dummy coded and solely provided information on whether the drawings were grayscale, upscaled and what their color profile was. In a subsequent step all remaining image properties pertaining to color were removed. Those encompassed the means of the R channel, the G channel and the B channel, as well as all standard deviations for said channels for all RGB analyses. Furthermore, the means and the standard deviations of the H and S channels were removed and so were the standard deviations and means for the a and b channels of all L*a*b* analyses. Lastly, the color entropy channel outputs were dropped from all further analyses. The remaining 28 variables were all analyzed using R (R Core Team, 2024) and are listed below.

RMS Contrast	Lightness Entropy	Complexity	Edge Density
Mean L Channel	Mean V Channel	Mirror Symmetry	Balance
DCM Distance	DCM X Position	DCM Y Position	CNN Symmetry LR
CNN Symmetry UD	CNN Symmetry LRUD	Fourier Slope	Fourier Sigma
2 D Fractal Dimension	3 D Fractal Dimension	Self-Similarity CNN	PHOG Self-Similarity
Homogeneity	Anisotropy	1st-order EOE	2nd-order EOE
Sparseness	Variability	SD L Channel	SD V Channel

Given that every participant created 4 drawings each, a statistical model had to be used, which accounted for within participant repeated measures. In a first step an LMM was fitted for each outcome variable, using the lme4 package (Bates et al., 2015) in R. This model included the fixed effects emotion and group, fixed effects for the interaction groupxemotion and one random intercept per subject, specified as (1 | ID). The resulting model was outcome~group×emotion+ (1|ID). Even though it was first attempted to include random slopes for each of the four emotions, due to the number of observations per participants being limited, these models did not converge or resulted in overparameterization.
In a second step residual normality was tested using Shapiro Wilk tests, outliers were assessed using the z-score method, and lastly variances were analyzed using residual plots. A Levene´s test was used to assess homogeneity of variances across factors. The outcomes of these tests for all image properties then dictated whether a LMM was going to continue being used,

whether variance modeling had to be implemented, or whether a robust LMM was the best option.

Figure 15



Note. Statistical model choice rationale. The decision tree in this figure was formulated to standardize the analysis workflow across a large number of outcome variables (28). It was created following standard practice for LMM analyses, which first requires assumption checks for multicollinearity using Variance Inflation Factor (VIF), normality of residuals and variance homogeneity (Zuur et al., 2009). In a subsequent step an analysis of variance homogeneity across factors (emotions) was required. If variance homogeneity across factors was violated variance modeling was applied as suggested by Rönnegård et al. (2010).

If all model assumptions were met a standard LMM was implemented using lmer() from the lme4 package (Bates et al., 2015). For a full overview of the model diagnostics see table "model actions" in the appendix. If the variances across factors were heterogenous variance modeling was applied using varident structures from the nlme package (Pinheiro et al., 2021). If non-normal residuals were found using the Shapiro Wilk test, or outliers were detected, a robust LMM was used with rlmer from the robustlmm package (Koller, 2016). For each model the fixed effect (group, emotion, interaction) remained the same. For rlmer models estimated marginal means and comparisons were computed. Given the large number of tests across multiple variables controlling the False Discovery Rate (FDR) was necessary. The Benjamini-Hochberg Procedure (Benjamini & Hochberg, 1995) was used to do this rather than the Bonferroni Correction, due to its´ stringent and conservative nature. The FDR-corrected *p*-values were collected for all outcome variables. In these initial outcomes some *SE*s were unusually large, indicating skewed distributions, heterogenous variances and strong influence of outliers. Log-transformations were applied to outcomes for which Shapiro-Wilk *p*-values showed strong deviation from normality ($p < .001$). Heterogenous variances were accounted for in the robust models. Furthermore, all emotionxgroup interactions were removed from subsequent models to further simplify the models and keep *SE*s from reaching large numbers. This was done after finding no significant emotionxgroup interactions while inspecting initial outcomes.

Results Drawing Analyses

Across all 28 analyses of image properties, one showed a significant outcome for the main effect of group at an alpha = 5 % significance level, suggesting that there were no significant differences between the image properties of the drawings produced by autistic and non-autistic individuals for almost all image properties analyzed.

Table 5

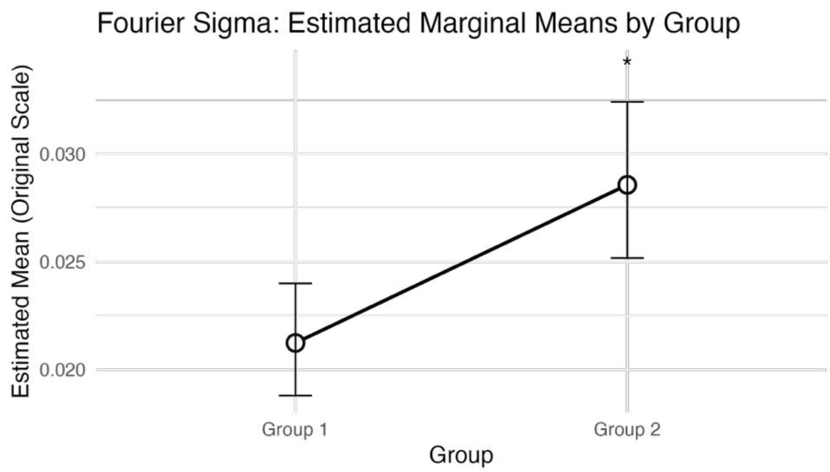
Outcome	*B*	*SE*	*t*	95% *CI*	*p*
RMS Contrast	-0.15	0.09	-1.68	[-0.32, 0.02]	0.24
Lightness Entropy	-1.17	0.68	-1.72	[-2.51, 0.16]	0.24
Complexity	-0.44	0.40	-1.11	[-1.21, 0.34]	0.47
Edge Density	-15,167.67	16,716.04	-0.91	[-47931.1, 17595.77]	0.57
Mean L Channel	0.38	0.30	1.30	[-0.2, 0.96]	0.37
Mean V Channel	0.02	0.01	2.02	[0, 0.05]	0.24
SD L Channel	-0.15	0.09	-1.68	[-0.32, 0.02]	0.24
SD V Channel	0.03	0.02	1.83	[0, 0.06]	0.24

Outcome	*B*	*SE*	*t*	95% *CI*	*p*
Mirror Symmetry	-576.05	304.31	-1.89	[-1172.5, 20.4]	0.24
Balance	0.08	0.10	0.81	[-0.12, 0.29]	0.58
DCM Distance	0.14	0.17	0.86	[-0.18, 0.47]	0.58
DCM X Position	0.01	0.01	2.28	[0, 0.02]	0.24
DCM Y Position	-0.02	0.01	-1.42	[-0.04, 0.01]	0.34
CNN Symmetry LR	-0.01	0.02	-0.41	[-0.05, 0.03]	0.76
CNN Symmetry UD	-0.03	0.03	-1.06	[-0.08, 0.02]	0.47
CNN Symmetry	0.01	0.03	0.47	[-0.04, 0.06]	0.76
Fourier Slope	-25.24	54.66	-0.46	[-132.36, 81.89]	0.76
Fourier Sigma	0.30	0.09	3.30	[0.12, 0.47]	0.03*
2D Fractal Dimension	-0.03	0.02	-1.73	[-0.06, 0]	0.24
3D Fractal Dimension	0.01	0.01	0.41	[-0.02, 0.03]	0.76
Self-Similarity PHOG	0.05	0.03	1.40	[-0.02, 0.11]	0.34
Self-Similarity CNN	-0.11	0.07	-1.45	[-0.25, 0.04]	0.34
Homogeneity	2,654.05	4,019.80	0.66	[-5224.75, 10532.85]	0.68
Anisotropy	0.01	0.05	0.24	[-0.09, 0.12]	0.84
1st order EOE	0.02	0.01	2.12	[0, 0.05]	0.24
2nd order EOE	-0.10	0.29	-0.36	[-0.68, 0.47]	0.78
Sparseness	0.00	0.00	-1.75	[0, 0]	0.24
Variability	0.00	0.00	-0.06	[0, 0]	0.95

Note. Estimated group differences in quantitative image properties. Outcome scores represent differences between groups (Group 2 - Group 1). Estimates (*B*) reflect the mean difference in the outcome variable between groups. All *p* - values reflect FDR corrected *p* - values and were approximated based on large sample *z* - values. *t*-values were computed as the ratio of the estimated coefficient to its standard error. Since a robust estimation method was used for some models, degrees of freedom and exact *p*-values were not available for all models. To see which models used rlmer refer to the table "model actions" in the appendix. Group 1 = ASD participants, group 2 = TD participants.

The image property fourier sigma revealed significant group differences. Fourier sigma was significantly higher in non-autistic individuals (group 2) than autistic individuals (group 1) (B = 0.30, SE = 0.09, t= 3.30, 95% CI [0.12 , 0.47], p = 0.03). This result suggests that the participants in the autistic group created more harmonious, less complex images, whereas the non-autistic participants tended to create images with more mixed patterns.

Figure 16



Note. Estimated marginal means for group differences for fourier slope image property. Fourier slope channel outputs were significantly larger in non-autistic individuals (group 2) than in autistic individuals (group 1). 95% *CI*s are included in the plot.

Quantitative Image Properties and ROCF Scores Interrelation Analyses

To assess whether differences in perceptual processing and executive functioning might predict quantitative image qualities outcomes Bayesian multivariate models, a robust extension of multivariate linear mixed models (Wang & Fan, 2011), were fitted and computed using R

Statistical Software (v4.1.2; R Core Team 2024). To reduce dimensionality the quantitative image qualities were grouped into the five domains of Symmetry and Balance, Color, Contrast and Complexity, Fractal Features, Texture and Entropy, as suggested by Redies et al. (2025).

Table 6

Group	**Outcome**
Symmetry and Balance	Mirror Symmetry Balance DCM Distance DCM X and Y Position CNN Symmetry LR CNN Symmetry UP CNN Symmetry LRUD
Color	Mean L Channel Mean V Channel SD L Channel SD V Channel
Contrast and Complexity	RMS Contrast Lightness Entropy Complexity Edge Density
Fractal Features	PHOG based Self - Similarity CNN based Self - Similarity Fourier Slope Fourier Sigma 2D Fractal Dimension 3D Fractal Dimension
Texture Entropy	Homogeneity Anisotropy 1st order EOE Sparseness Variability

Note. Theoretical grouping of Quantitative Image Properties for Bayesian Multivariate lmm as suggested by Redies et al. (2025)

To analyze whether differences in perceptual processing and executive functioning were associated with different outcomes on the quantitative image properties the fragmentation scores in the copy condition of the ROCF test were used. The copy condition of the fragmentation score was chosen to avoid effects of memory load influencing the reproduction of the figure and thus confounding the measured effect of perceptual biases (Kuschner et al., 2009).

For each outcome Bayesian multivariate linear mixed models were fitted across all 28 outcomes, once using the organization scores as a fixed effect and once using fragmentation scores as a fixed effect. Random intercepts were modeled for participants, accounting for repeated measures across quantitative image property scores. The brms package (Bürkner, 2018) was used for analyses and independent residual variance across outcomes was assumed.

The resulting models were specified as either Outcome ~ ORG + (1 | ID) or Outcome ~ Frag + (1 | ID) and were run with 4 chains and 4000 iterations. The R – hat statistic was used to assess whether models had converged successfully. All models converged successfully except for the model group "Contrast and Complexity" for both the model using fragmentation and using organization as a predictor. Although the results are included in the overview the results for the image properties in this group will not be incorporated into further interpretations. Due to the large number of analyses being conducted False Discovery Rate was applied to all approximated *p* - values.

Results Predictor Fragmentation

Fragmentation scores significantly predicted the outcomes of quantitative image properties across multiple variables.

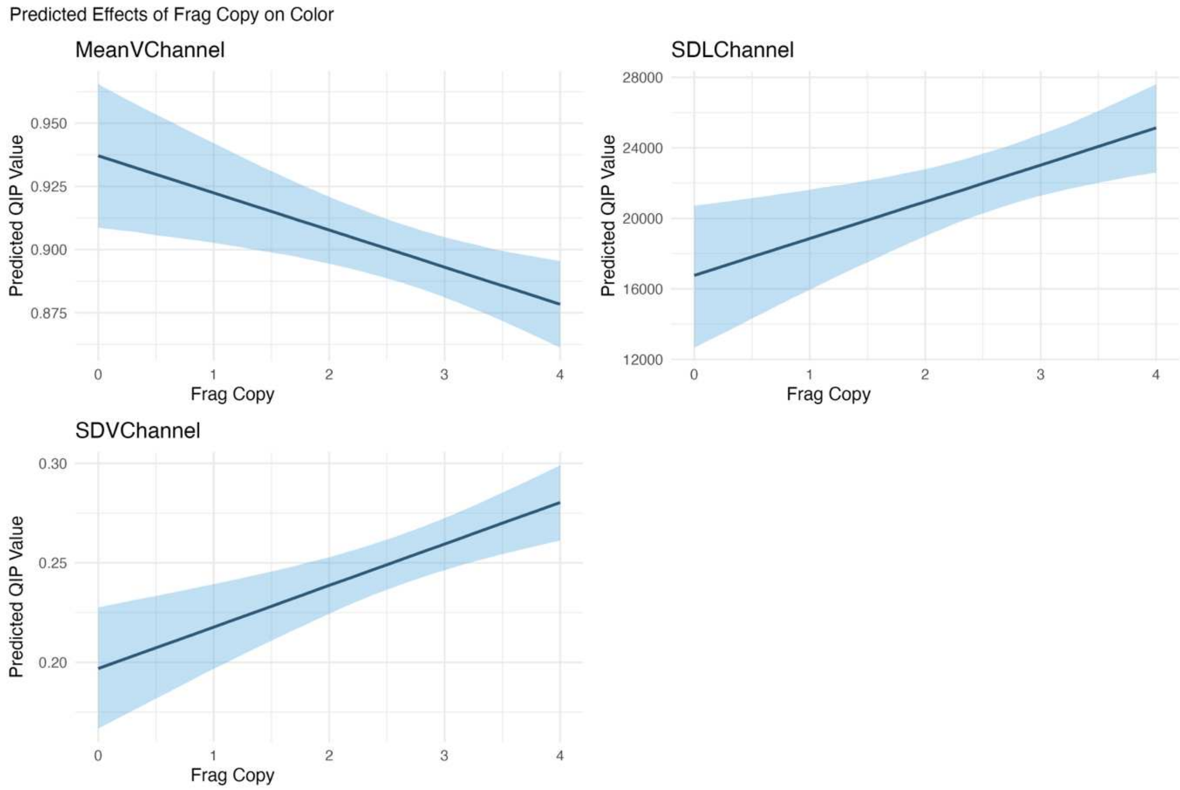
Table 7

Outcome	*B*	*SE*	95% *CI*	*p*
RMSContrast	2,106.87	730.51	[674.91; 3,518.89]	0.01**
Lightness Entropy	214.07	72.64	[72.91; 359.03]	0.01**
Complexity	722.98	202.38	[329.58; 1,127.29]	< 0.001***
Edge Density	19,564.02	5,752.99	[8,365.2; 30,752.35]	< 0.001***
Mean L Channel	-1,190.21	1,699.35	[-4,575.08; 2,130.46]	0.57
Mean V Channel	-0.03	0.01	[-0.03; -0.01]	0.01**
SD L Channel	2,095.2	707.42	[722.53; 3,459.21]	0.01**
SD V Channel	0.02	0.01	[0.01; 0.03]	< 0.001***
Balance	-2,693.4	1,286.35	[-5,192.12; -148.21]	0.07
Mirror Symmetry	544.97	333.28	[-104.98; 1,191.54]	0.17
DCM Distance	-900.64	1,218.26	[-3,305.03; 1,459.59]	0.56
DCM X Position	-0.01	0.00	[-0.02; 0.00]	0.14
DCM Y Position	-0.01	0.01	[-0.03; 0.01]	0.25
CNN Symmetry LR	0.02	0.01	[0.01; 0.04]	0.03*
CNN Symmetry UD	0.02	0.01	[0.00; 0.04]	0.03*
CNN Symmetry LRUD	0.02	0.01	[0.00; 0.04]	0.03*
Fourier Slope	19.56	38.33	[-55.46; 94.24]	0.68
Fourier Sigma	-0.00	0.00	[-0.01; 0.00]	0.24
2DFractalDimension	39.18	27.19	[-13.7; 92.89]	0.23
3DFractalDimension	-45.57	55.88	[-154.72; 62.63]	0.53
Self-Similarity PHOG	0.04	0.01	[0.02; 0.06]	< 0.001***
Self-Similarity CNN	0.06	0.02	[0.02; 0.09]	0.01**

Outcome	*B*	*SE*	95% *CI*	*p*
Homogeneity	92.36	1,751.07	[-3,418.14; 3,493.16]	0.96
Anisotropy	0.000	0.000	[0.000; 0.00]	0.01**
1storderEOE	-19.48	80.72	[-177.07; 138.43]	0.84
2ndorderEOE	19.58	82.24	[-143.11; 178.94]	0.84
Sparseness	0.00	0.00	[0.000; 0.00]	< 0.001***
Variability	0.00	0.00	[-0.002; 0.00]	0.53

Note. Results Bayesian Multivariate Linear Mixed Effects Model including posterior means (=*B*) posterior standard deviations (=*SE*) and 95% *CI*s. Pseudo *p*-values were computed from the posterior mean of the coefficient and the posterior standard deviation using p_val = 2 * pmin(pnorm(Estimate / Est.Error), 1 - pnorm(Estimate / Est.Error)) in R. All *p*-values listed here represent FDR corrected *p*-values. RMS contrast, lightness entropy, complexity and edge density were computed using a model that did not converge (contrast and complexity) and should not be considered for further interpretations. Sparseness values are very small due to the range of the outcomes provided by the toolbox being defined as 0 – 0.0014.

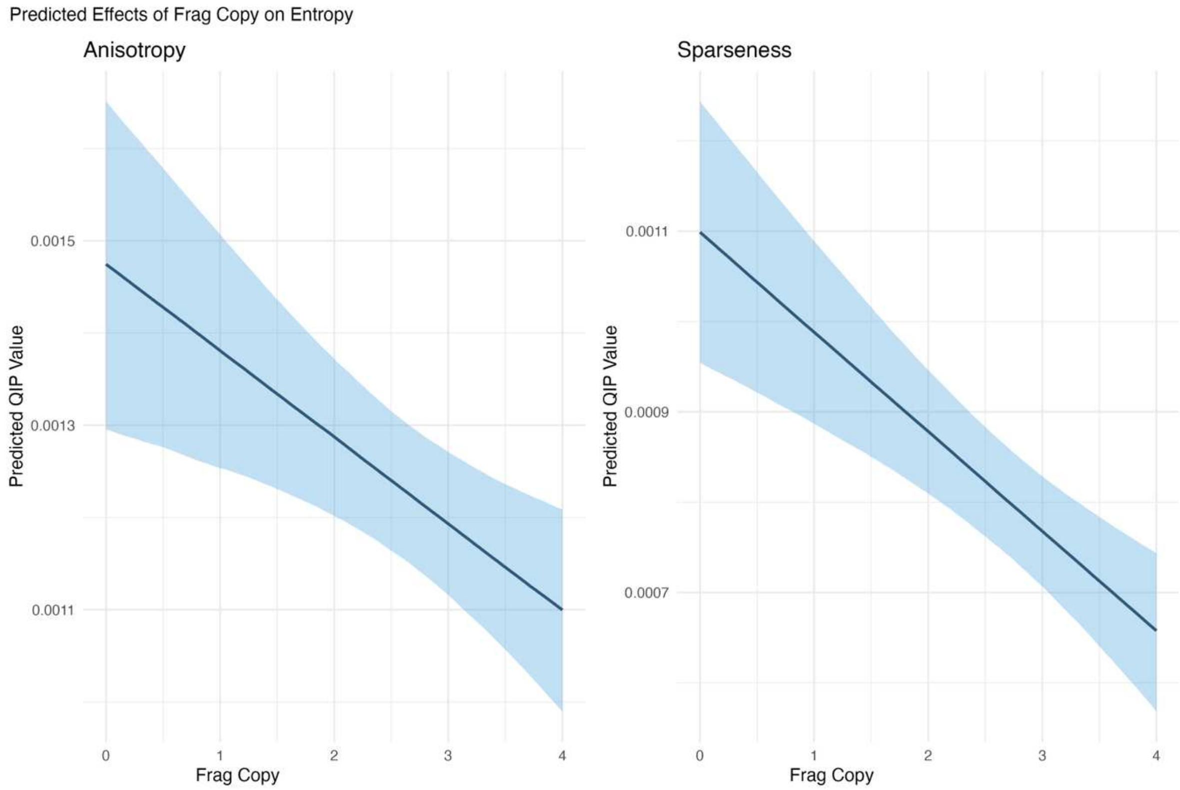
Figure 17



Note. Estimated effect of fragmentation scores on significant outcomes of color-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

Post hoc computations revealed that less fragmented drawings in the ROCF (signified by higher fragmentation scores) were associated with darker images, as demonstrated by the Mean V Channel and more complex, as seen in the increase in the SD values of both Value (V) and Lightness (L) channels.

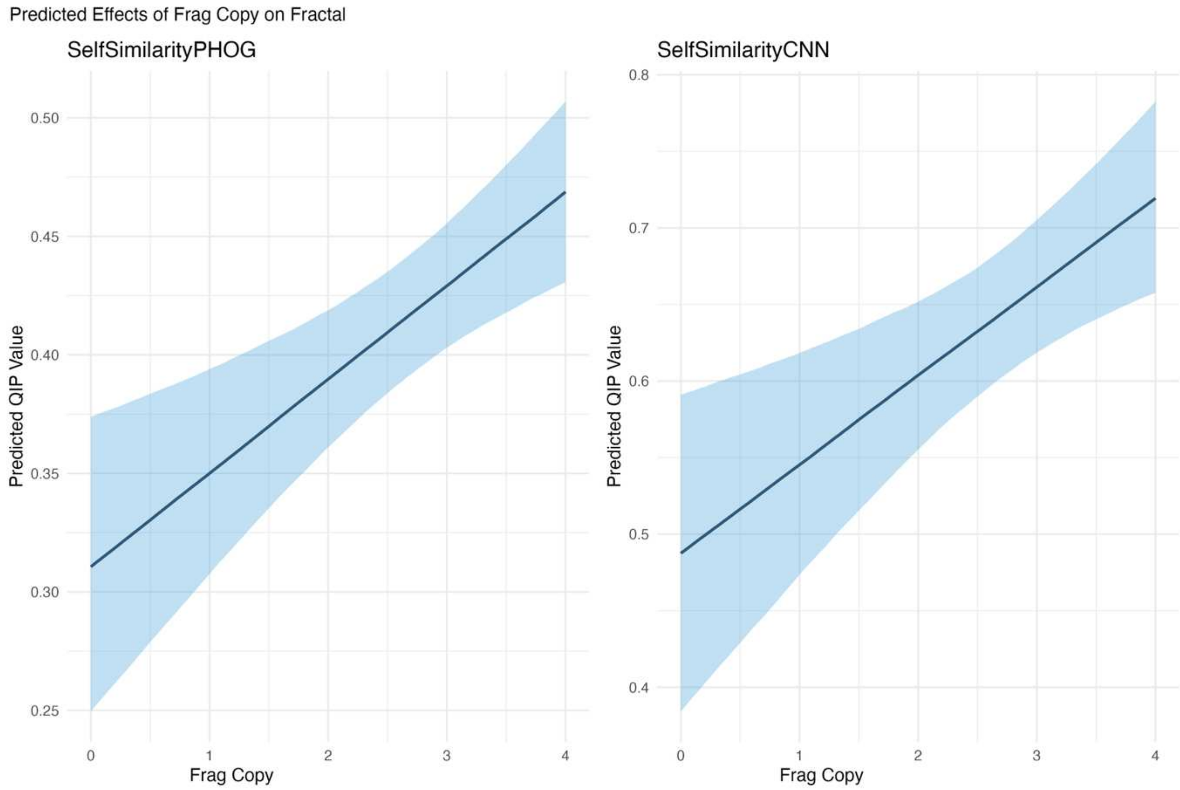
Figure 18



Note. Estimated effect of fragmentation scores on significant outcomes of entropy-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

The results of the group "Entropy" show that higher scores in fragmentation predicted lower outcomes in sparseness and anisotropy. Lower sparseness scores indicate that an image contains many structures and features with few empty spaces, whereas lower anisotropy scores indicate that directions and patterns appear random and isotropic with no strong directional patterns. Higher fragmentation scores predicted more complex images.

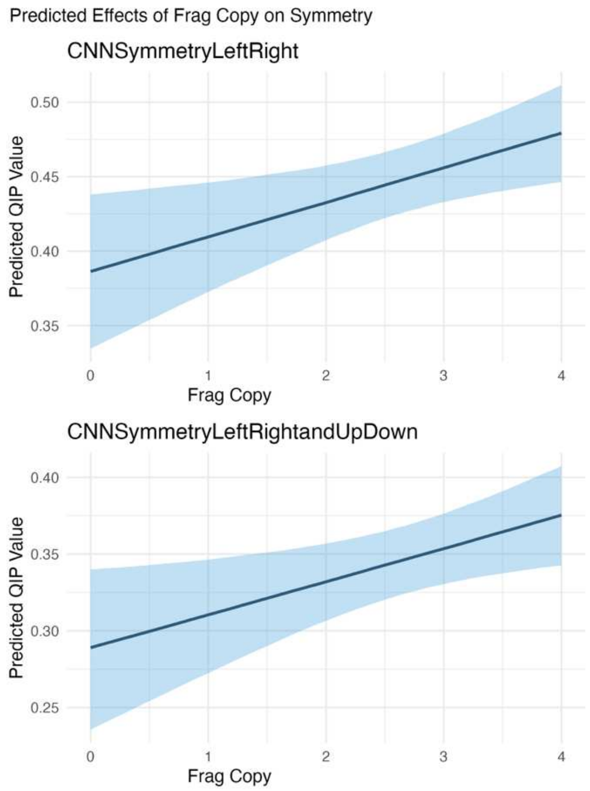
Figure 19



Note. Estimated effect of fragmentation scores on significant outcomes of fractality-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

Both PHOG and CNN based self-similarity assess how uniform and consistent features of the images are, with lower scores indicating more complex and diverse features and higher scores indicating specific directions and patterns. PHOG self-similarity assesses the spatial distribution of edge orientations in an image, with higher scores representing consistent edge orientations, as seen in wood, fabric or the buildings of a skyline, whereas lower scores indicate that the edge orientations are more complex and diverse. Similarly, CNN based self-similarity was used to quantify features such as edges and textures and how consistently they appear in an image, with higher scores suggesting the presence of dominant patterns and lower scores representing the presence of a multitude of objects and structures. Higher fragmentation scores predicted more uniform distributions of patterns and edge orientations.

Figure 20



Note. Estimated effect of fragmentation scores on significant outcomes of symmetry-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

Post hoc estimated marginal effects revealed that higher fragmentation scores predict images that are both vertically and horizontally more symmetrical, as well as across all orientations.

Results Predictor Organization

The organization score predicted image properties significantly across multiple outcomes.

Table 8

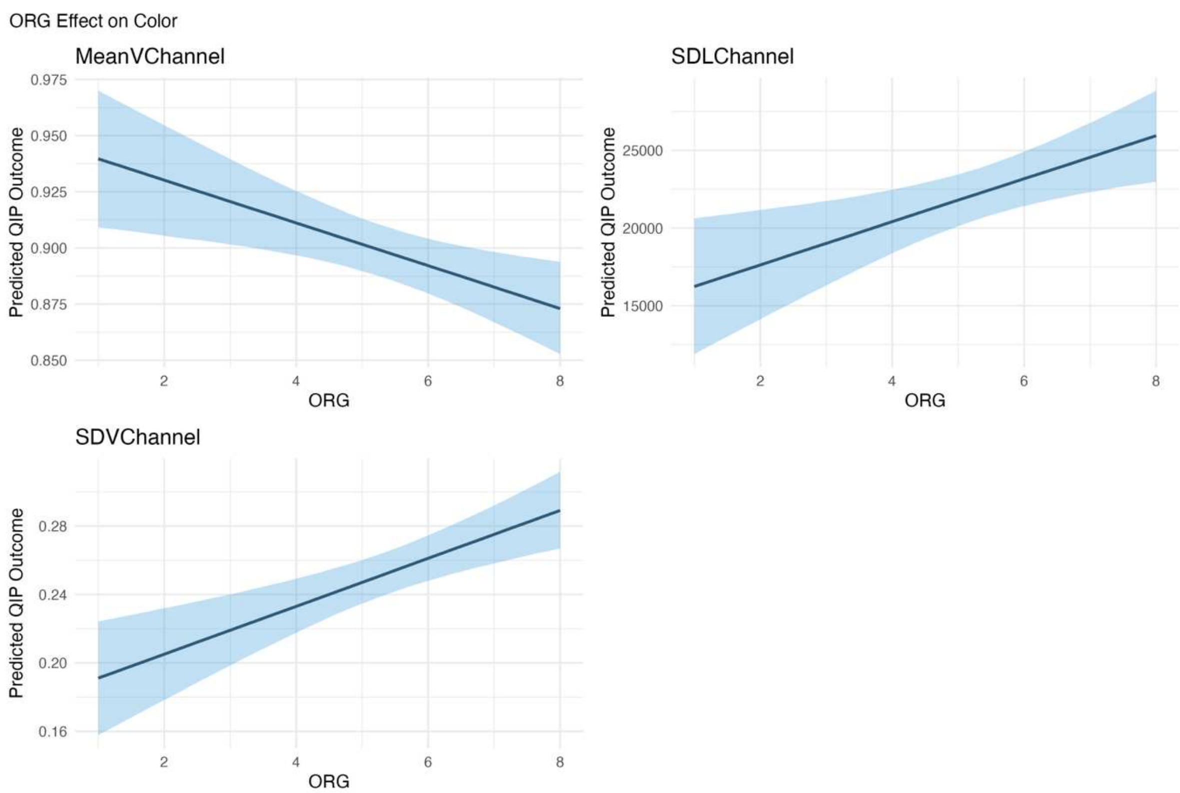
Outcome	*B*	*SE*	95% *CI*	*p*
Mean L Channel	-616.75	1,126.76	[-2817.12; 1591.34]	0.64

Outcome	*B*	*SE*	95% *CI*	*p*
Mean V Channel	-0.01	0.00	[-0.02; 0]	0.01**
SD L Channel	1,381.76	473.03	[447.56; 2310.86]	0.01**
SD V Channel	0.01	0.00	[0.01; 0.02]	< 0.001***
Balance	-2,023.55	864.04	[-3752.69; -355.81]	0.04*
Mirror Symmetry	347.05	226.05	[-87.9; 791.37]	0.23
DCM Distance	-1,169.63	824.77	[-2774.33; 466.92]	0.27
DCMX Position	0.00	0.00	[-0.01; 0]	0.36
DCMY Position	0.00	0.01	[-0.02; 0.01]	0.62
CNN Symmetry LR	0.02	0.01	[0; 0.03]	0.02**
CNN Symmetry UD	0.01	0.01	[0; 0.02]	0.07
CNN Symmetry LRUD	0.01	0.01	[0; 0.03]	0.04**
Fourier Slope	3.89	25.82	[-47.17; 54.21]	0.92
Fourier Sigma	0.00	0.00	[-0.01; 0]	0.37
2D Fractal Dimension	44.27	17.78	[9.07; 78.95]	0.03**
3D Fractal Dimension	-22.15	38.32	[-98.91; 51.95]	0.64
Self-Similarity PHOG	0.03	0.01	[0.01; 0.04]	< 0.001***
Self-Similarity CNN	0.05	0.01	[0.02; 0.07]	< 0.001***
Homogeneity	813.07	1,169.19	[-1457.63; 3108.38]	0.62
Anisotropy	0.00	0.00	[0; 0]	0.01**
1st order EOE	-51.25	55.37	[-161.57; 56.95]	0.50
2nd order EOE	32.74	54.97	[-75.42; 141.04]	0.64

Outcome	*B*	*SE*	95% *CI*	*p*
Sparseness	0.00	0.00	[0; 0]	< 0.001***
Variability	0.00	0.00	[0; 0]	0.94

Note. Results Bayesian Multivariate Linear Mixed Effects Model including posterior means (=*B*) posterior standard deviations (=*SE*) and 95% *CI*s. Pseudo *p*-values were computed from the posterior mean of the coefficient and the posterior standard deviation using p_val = 2 * pmin(pnorm(Estimate / Est.Error), 1 - pnorm(Estimate / Est.Error)) in R. All *p*-values listed here represent FDR corrected *p*-values. RMS contrast, lightness entropy, complexity and edge density were computed using a model that did not converge (contrast and complexity) and should not be considered for further interpretations.

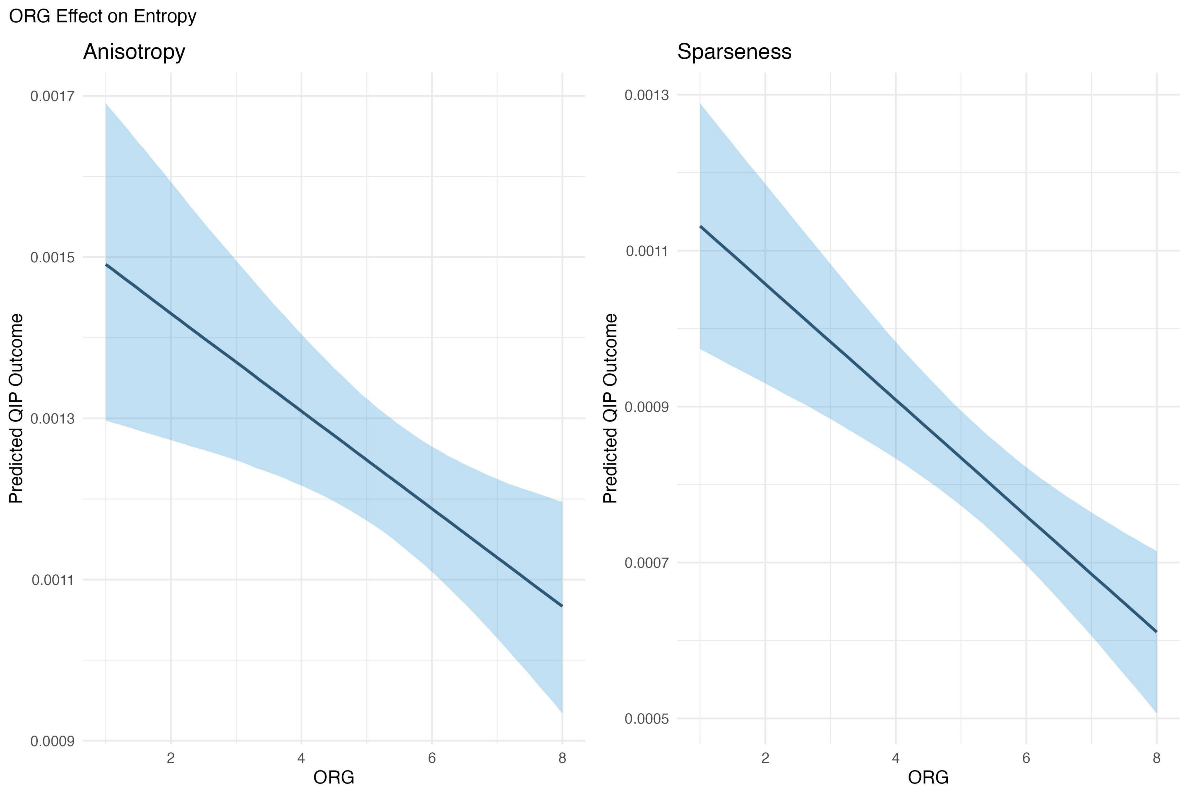
Figure 21



Note. Estimated effect of organization scores on significant outcomes of color - related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s

For the effect of organization scores on color-related image properties the same pattern emerged as it did for fragmentation scores. Higher organization scores were associated with darker images, as demonstrated by the lower mean V channel, and more complex images, as seen in the SD L and V channels outputs.

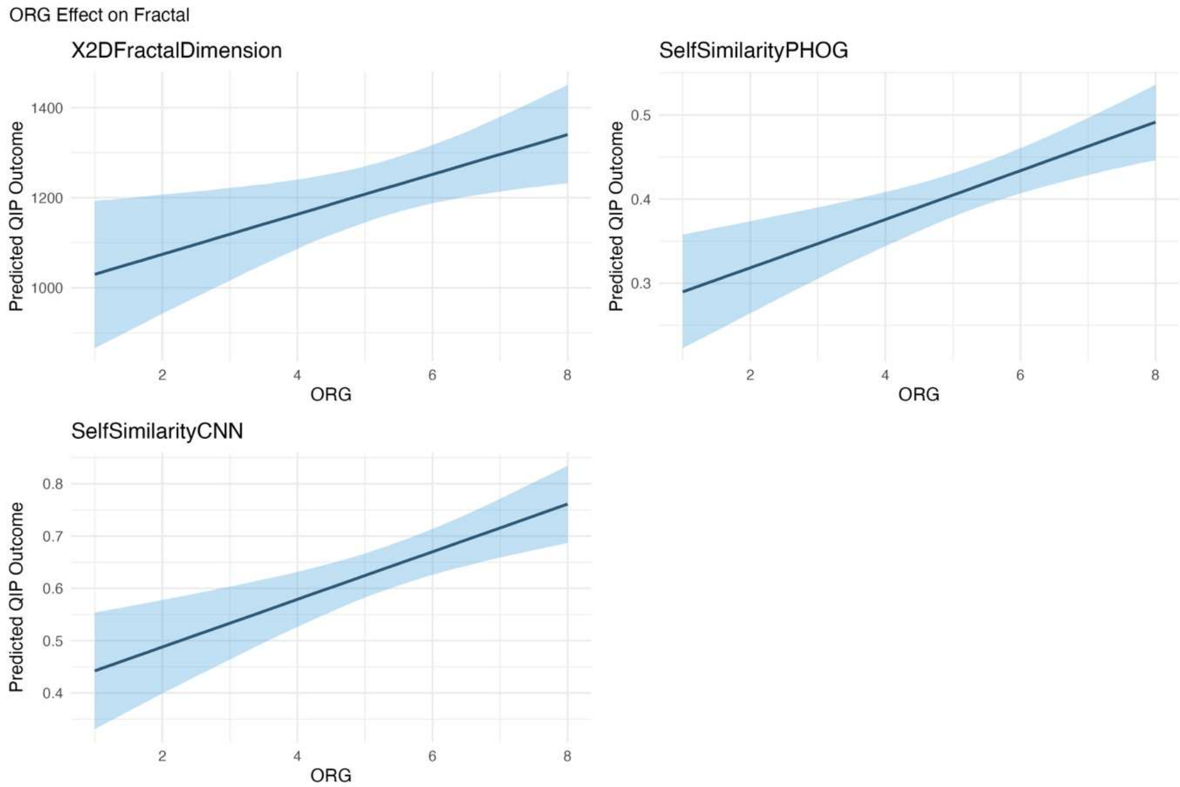
Figure 22



Note. Estimated effect of organization scores on significant outcomes of entropy-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

For entropy-related image properties, as for color-related image properties, the direction of effects of the predictor score were the same across both fragmentation and organization. Higher organization scores were associated with images including more structural elements with fewer blank spaces, as can be seen in the sparseness channel. Higher organization scores furthermore predicted weaker directional patterns in images, suggesting that no single direction of textures or features dominated in an image, making it more complex, which was measured by assessing anisotropy scores.

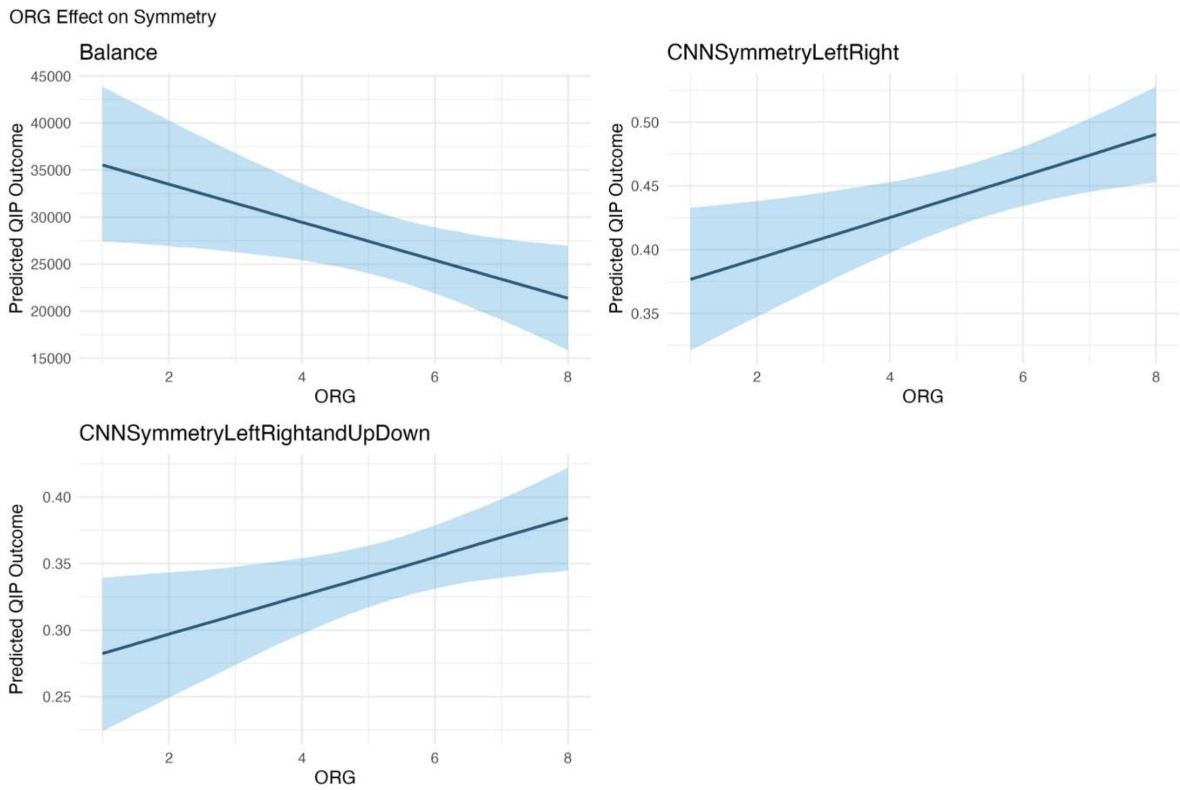
Figure 23



Note. Estimated effect of organization scores on significant outcomes of fractality-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

Organization scores and fragmentation scores were again associated with the same pattern in outcomes related to self-similarity. Higher PHOG and CNN based self-similarity both are indicative of images having smooth or repetitive structures and edges, whereas 2D fractality assesses how complex the self-similar textures are, with higher 2D fractality representing more intricate patterns. Higher organization scores were not only associated with more self-similar images, but also with more complex structures within the patterns of said images.

Figure 24



Note. Estimated effect of organization scores on significant outcomes of symmetry-related image properties from Bayesian multivariate models. Shaded ribbons represent 95% *CI*s.

Higher organization scores were associated with more symmetrical images. High LR CNN based symmetry, as well as LRUD CNN based symmetry both indicate more symmetrical images, as well as lower balance scores, which signify high balance and symmetry.

Discussion

The overall aim of this study was to explore art created by individuals diagnosed with autism spectrum disorder, one of the two modalities in autistic self-expression that have remained largely unexplored in adults. To do this, a between-participants experimental design was employed, for which autistic and non-autistic adults were separated into two groups and tasked with creating nonrepresentational, black and white drawings which were supposed to depict one of four emotions (fear, happiness, sadness, anger) in an abstract manner.

Furthermore, all participants also completed the Rey-Osterrieth Complex Figure Test (Rey & Osterrieth, 1941), which was intended to help assess executive functioning (Shin et al., 2006; Somerville et al., 2000) and perceptual processing styles (Kramer & Wells, 2004). As has been elaborated in the earlier chapters, research exploring art created by autistic individuals and its quantitative properties is quite limited and possible explorations which processes in cognition and perception might or might not contribute to differences in producing this art, even more so. Literature and research however suggest that there are differences. Based on previous findings, it was hypothesized that autistic individuals would not only differ from TD participants in their ROCF test scores, but also in the quantitative image properties of the drawings that they created. The findings however mainly do not support these hypotheses.

While group differences were found in the ROCF test, with the non-autistic group outperforming the autistic group across all scores, these differences were not significant. Scores pertaining to executive function (planning, neatness, organization, copy presence accuracy, immediate presence accuracy, delayed presence accuracy, immediate retention, delayed retention and organization) and those pertaining to local processing biases (organization, fragmentation) showed no significant group differences. These findings are consistent with previous research (Kramer & Wells, 2004; Kuschner et al., 2009; Savickaite et al., 2022) for which no differences in ROCF performance were found across autistic and non-autistic individuals if the assessed intelligence of the participants was average or above average. The results of the study at hand further support the idea that symptom severity diminishes with higher IQ scores, particularly higher verbal intelligence, in autistic populations (Black et al., 2009; Johnson et al., 2021).

To analyze the quantitative image properties of the abstract drawings created the "Aesthetics Toolbox" (Redies et al., 2025) was used. This ensured the highest level of objectivity in dissecting image properties and helped obtain scores for symmetry and balance, scale invariance and self-similarity, feature distribution and entropy, and lightness, complexity and contrast over a range of 46 outputs. After exclusion of all color-related quantitative image properties a total of 28 outcomes were left to analyze. Out of these 28 variables only one image property, fourier sigma, showed significant differences between the two groups. Fourier sigma quantifies how much an image composition resembles that of natural scenes or traditional artworks, with lower fourier sigma values indicating less deviation and higher values indicating more deviation. The higher the deviation the more unpleasant an image is typically rated as. The finding that autistic individuals create drawings more closely resembling traditional artworks or scenes in nature is one that, to the best of my knowledge, has not been examined in research so far. While studies exist, which analyze different properties such as page usage and repetitions (Bergmann et al., 2020) a measure which quantifies how much drawings resemble that of traditional, aesthetically appealing artworks has not been included in those. While some researchers theorize that autistic individuals experience sensory input on a deeper level, which then in turn might facilitate creating "rich" art (Peña, 2024) due to deeper engagement with surroundings and tasks, more research would have to be done on this topic to analyze whether on average the art created by autistic individuals more closely resembles traditional artworks or is rated as more aesthetically appealing.

For all other measures relating to symmetry, balance, complexity and lightness no significant group differences were found. None of the measures for self-similarity returned significant results. These results are largely inconsistent with research on drawings created by autistic adults. PHOG-based self-similarity, which assesses whether the structure and orientation of edges are consistent, or complex was higher for non-autistic individuals ($B = 0.05$, $SE = 0.03$, 95% CI [−0.02, 0.11], $p = .34$), though this difference was not statistically significant. This result can be read as autistic individuals incorporating less repetitions of edge orientations in their drawings. Even though this difference was not significant, it is interesting to note, that this image property is not included in any of the analyses of images summarized in this thesis. Conversely, for CNN based self-similarity, which assesses patterns and textures, rather than edge orientations, autistic individuals scored higher (B = -0.11, SE = 0.07, 95% CI [−0.25, 0.04], p = .34), indicating that they used more repetitions of patterns, as opposed to edge orientations in their drawings. While this finding is consistent with literature (Bergmann et al., 2020; Shi et al. 2021) it did not reach significance.

While differences in fragmentation scores between groups did not reach significance, thus failing to reproduce the claims that autistic people exhibit a preference for, or even superior local processing (Happé & Frith, 2006) the Bayesian multivariate linear mixed models used to assess whether ROCF scores could serve as predictors of different image properties did return multiple significant outcomes across models. It appears that a more global processing style as exhibited in the ROCF test manifests itself in the drawings created. Lower fragmentation found in ROCF scores predicted more symmetrical drawings, across all three measures of symmetry – CNN symmetry LR, UD and LRUD. This finding is consistent with the claim that fragmentation copy scores represent a local or global approach to creating drawings (Kuschner et al., 2009), seeing as creating symmetrical images would require comprehending an image as its whole, rather than producing disconnected aspects of a drawing. When analyzing image properties relating to self-similarity, fragmentation scores in the copy condition significantly predicted both PHOG based self-similarity, which assesses how uniform edge orientations are across an image and CNN-based self-similarity which quantifies how consistently the same visual features appear across an image. Here too, it seems that the approach to creating the drawing was a more global one, seeing as both edge orientations and visual features appeared more uniformly in drawings when fragmentation scores were high, meaning the ROCF copy drawing had been produced in a non-fragmented manner.

This same pattern also emerged when analyzing organization scores, which are commonly used to assess both perceptual processing styles and executive function (Kuschner et al., 2009, Shin et al., 2006, Somerville et al., 2000), for which higher organization scores were associated with more symmetrical, balanced and complex images. It seems that rather than diagnostic status having a namely influence on drawing styles and image properties, cognitive functions and perceptual processing styles influence artistic expression. This in turn offers an explanation as to why art as a modality of self-expression seems to not differ between autistic and non-autistic individuals in this study, since the structures which would produce these differences could not be solely attributed to either autistic or non-autistic individuals in this participant sample.

Limitations

Several limitations need to be considered while interpreting findings. First, although the ROCF test is often used to assess executive functioning and perceptual processing biases, when comparing the ROCF scores to the scores of other tests which aim to assess executive functioning, weak correlations were found (Ogino et al., 2008; Temple et al., 2006). Other cognitive tests, which measure executive functioning, such as Wisconsin Card Sorting Test (WCST, Grant & Berg, 1948) could have maybe provided better and clearer results. Secondly, pertaining to the ROCF, difficulties with scoring the drawings were encountered, due to ten of the participants being nonbinary, for which no standardized scores are provided in the BQSS manual. Due to this shortcoming raw scores had to be used, which range from zero to four for the scores planning, neatness and fragmentation and zero to eight for organization scores. Due to this very limited range of outcome scores data distribution was largely skewed. Furthermore, the scores analyzed do not account for gender and age differences, although men have been found to have overall better test performance, and younger people on average outperform older participants (Stern et al., 1994). Pertaining to the ROCF standardization, issues in regard to the time passing between the immediate retention and the delayed retention condition also need to be noted. Seeing as participants were tasked with filling out questionnaires between the immediate and the delayed retention condition and it didn't take all participants equally long to finish the questionnaires. For some participants the time that had passed between the immediate and the delayed retention condition was longer than for others. In addition, bearing in mind that all participants which were included in analyses were able to engage in reciprocal conversation and to partake in the study in its entirety, lasting almost 3 hours, most participants in the group of autistic participants at hand might not be the most representative sample of autistic individuals. Repeating this study with individuals whose autism symptoms are more pronounced might produce different results. Lastly, as mentioned before, the study lasted long and for most of the experiment participants had an fNIRS cap on their head. The effort exerted for self-regulation might have influenced how participants would have created their drawings in a more natural situation.

Strengths

Despite all methodological and statistical limitations discussed above this study also has notable strengths. For one, using art as a modality of self-expression has been neglected in most analyses of autistic self-expression. Most of the previous studies have examined drawings created by children. This makes accounting for which characteristics of said drawings might solely be due to the age of participants difficult. Secondly, the drawings in this study are highly standardized, with all of them being black and white and each participant receiving the same prompts. This makes comparing the drawings in regard to image properties much more straightforward, since systematic differences between groups that emerge in drawings are not due to broad and unspecific drawing prompts.

Another strength of this study is that it analyses ROCF performance in autistic adults, both in regard to executive functioning and perceptual processing biases. Most studies attend to these questions separately, although the ROCF offers measures for both. Finally, results in the field of perceptual processing are largely contradicting, with some studies finding no differences in perceptual biases (Smith et al., 2016), others finding superior local and average global processing (Koldewyn et al., 2013), others again finding superior local and inadequate global processing (Frith, 1989). This study sheds further light on inconclusive research.

Lastly, while studies analyzing image properties of drawings created by autistic individuals and studies analyzing aspects of cognition and perception that are characteristic of people on the autism spectrum exist, studies attempting to combine both domains, conceptualizing how one might shape the other are few and far between. Not only has this study taken on this task, furthermore it has shed light on which processes in perceptual processing and cognition shape what type of art individuals create.

Future Research

While this study analyzed how differences in cognition and perception might influence differences in visual art as a modality of self-expression, this project could not reproduce postulated systematic differences. As to analyze whether this is a general phenomenon, one that emerges with lower support needs autistic individuals, or simply a result of the participant pool of this study, projects aiming to shed light on this very question should be repeated with larger sample sizes and collect drawing data in isolation, rather than as one task in a long sequence of many. Furthermore, the implications of abstract drawings created by autistic individuals more closely resembling traditional artworks should be followed up by presenting either abstract drawings of this kind created by autistic individuals or the very drawings created in this experiment to a separate participant pool and collecting ratings along different scales such as how visually appealing or aesthetically pleasing they would be deemed.

References

Almeida, R. A., Dickinson, J. E., Maybery, M. T., Badcock, J. C., & Badcock, D. R. (2010). A new step towards understanding Embedded Figures Test performance in the autism spectrum: The radial frequency search task. *Neuropsychologia*, *48*(2), 374–381. https://doi.org/10.1016/j.neuropsychologia.2009.09.024

Atherton, G., & Cross, L. (2021). Reading the mind in cartoon eyes: Comparing human versus cartoon emotion recognition in those with high and low levels of autistic traits. *Psychological Reports*, *125*(3), 1380–1396. https://doi.org/10.1177/0033294 120988135

Atkinson, V. S., Danielson, E., & Rogers, O. (2024). Stereotypes on the small Screen: Applying a media rating tool to portrayals of autism in television series 2010 – 2019. *Disability Studies Quarterly, 43*(4). https://doi.org/10.18061/dsq.v43i4.8258

Asghari, S. Z., Farashi, S., Bashirian, S., & Jenabi, E. (2021). Distinctive prosodic features of people with autism spectrum disorder: a systematic review and meta-analysis study. *Scientific Reports, 11(*1). https://doi.org/10.1038/s41598-021-02487-6

Au-Yeung, S. K., Bradley, L., Robertson, A. E., Shaw, R., Baron-Cohen, S., & Cassidy, S. (2018). Experience of mental health diagnosis and perceived misdiagnosis in autistic, possibly autistic and non-autistic adults. *Autism, 23*(6), 1508–1518. https://doi.org/10.1177/1362361318818167

Bagby, R., Parker, J. D., & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia scale—I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research, 38*(1), 23–32. https://doi.org/10.1016/0022-3999(94)90005-1

Ball, K. K., Beard, B. L., Roenker, D. L., Miller, R. L., & Griggs, D. S. (1988). Age and visual search: expanding the useful field of view. *Journal of the Optical Society of America A, 5(*12), 2210. https://doi.org/10.1364/josaa.5.002210

Banganho, A., Santos, M., & Da Silva, H. P. (2022). Electrodermal activity: Fundamental principles, measurement, and application. *IEEE Potentials, 41*(5), 35–43. https://doi.org/10.1109/mpot.2020.2983381

Baron-Cohen, S. (2001). Autism-Spectrum Quotient--Adult [Dataset]. In PsycTESTS Dataset. https://doi.org/10.1037/t00350-000

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind? " *Cognition*, *21*(1), 37–46. https://doi.org/10.1016/0010-0277(85)90022-8

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects models usinglme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. F. (1996). Comparison of Beck Depression Inventories-IA and-II in Psychiatric outpatients. *Journal of Personality Assessment*, *67*(3), 588–597. https://doi.org/10.1207/s15327752jpa6703_13

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery Rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society Series B (Statistical Methodology)*, *57*(1), 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Bergmann, T., Camatta, R., Birkner, J., & Sappok, T. (2020). Vision, concretism, repetitism. Typical artistic design features in drawings of adults with autism and intellectual disability. *The Arts in Psychotherapy*, *72*, 101723. https://doi.org/10.1016/j.aip.2020.101723

Bernardino, I., Mouga, S., Almeida, J., Van Asselen, M., Oliveira, G., & Castelo-Branco, M. (2012). A Direct Comparison of Local-Global Integration in Autism and other Developmental Disorders: Implications for the Central Coherence Hypothesis. *PLoS ONE*, *7*(6), e39351. https://doi.org/10.1371/journal.pone.0039351

Bettcher, B. M., Libon, D. J., Kaplan, E., Swenson, R., & Penney, D. L. (2010b). Block design. In *Springer eBooks* (pp. 419–422). https://doi.org/10.1007/978-0-387-79948-3_1347

Bieberich, A. A., & Morgan, S. B. (2004). Self-regulation and affective expression during play in children with autism or Down syndrome: A short-term longitudinal study. *Journal of Autism and Developmental Disorders, 34*(4), 439–448.

Bilalić, M., McLeod, P., & Gobet, F. (2008). Why good thoughts block better ones: The mechanism of the pernicious Einstellung (set) effect. *Cognition, 108*(3), 652–661. https://doi.org/10.1016/j.cognition.2008.05.005

Bilker, W. B., Hansen, J. A., Brensinger, C. M., Richard, J., Gur, R. E., & Gur, R. C. (2012). Development of abbreviated Nine-Item forms of the Raven's Standard Progressive Matrices Test. *Assessment*, *19*(3), 354–369. https://doi.org/10.1177/107319111244 6655

Black, D. O., Wallace, G. L., Sokoloff, J. L., & Kenworthy, L. (2009). Brief Report: IQ Split Predicts Social Symptoms and Communication Abilities in High-Functioning Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, *39*(11), 1613–1619. https://doi.org/10.1007/s10803-009-0795-3

Braddock, B. A., Gabany, C., Shah, M., Armbrecht, E. S., & Twyman, K. A. (2016). Patterns of gesture use in adolescents with autism spectrum Disorder. *American Journal of*

Speech-Language Pathology, *25*(3), 408–415. https://doi.org/10.1044/2015_ajslp-14-0112

Brewer, R., Biotti, F., Catmur, C., Press, C., Happé, F., Cook, R., & Bird, G. (2015). Can neurotypical individuals read autistic facial expressions? Atypical production of emotional facial expressions in autism spectrum disorders. *Autism Research*, *9*(2), 262–271. https://doi.org/10.1002/aur.1508

Brown, H. M., & Klein, P. D. (2011). Writing, Asperger syndrome and Theory of mind. *Journal of Autism and Developmental Disorders, 41*(11), 1464--1474. https://doi.org/10.1007/s10803-010-1168-7

Bürkner, P. (2018). Advanced Bayesian Multilevel Modeling with the R Package brms. *The R Journal*, *10*(1), 395. https://doi.org/10.32614/rj-2018-017

Cakan, M. (2003). Psychometric Data on the Group Embedded Figures Test for Turkish Undergraduate Students. *Perceptual and Motor Skills, 96*(3), 993–1004. https://doi.org/10.2466/pms.2003.96.3.993

Cardillo, R., Lievore, R., & Mammarella, I. C. (2022). Do children with and without autism spectrum disorder use different visuospatial processing skills to perform the Rey–Osterrieth complex figure test? *Autism Research, 15*(7), 1311–1323. https://doi.org/10.1002/aur.2717

Cassidy, S. A., Bradley, L., Bowen, E., Wigham, S., & Rodgers, J. (2018). Measurement properties of tools used to assess depression in adults with and without autism spectrum conditions: A systematic review. *Autism Research*, *11*(5), 738–754. https://doi.org/10.1002/aur.1922

Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism*, *9*(4), 428–449. https://doi.org/10.1177/1362361305056082

Chen, Y., Norton, D., McBain, R., Gold, J., Frazier, J., & Coyle, J. (2012). Enhanced local processing of dynamic visual information in autism: Evidence from speed discrimination. *Neuropsychologia, 50*(5), 733–739. https://doi.org/10.1016/j.neuropsychologia.2012.01.007

Connor, K. M., Davidson, J. R. T., Churchill, L. E., Sherwood, A., Weisler, R. H., & Foa, E. (2000). Psychometric properties of the Social Phobia Inventory (SPIN). *The British Journal of Psychiatry*, *176*(4), 379–386. https://doi.org/10.1192/bjp.176.4.379

Connor, K. M., Kobak, K. A., Churchill, L. E., Katzelnick, D., & Davidson, J. R. T. (2001). Mini-SPIN: A brief screening assessment for generalized social anxiety disorder. *Depression and Anxiety, 14*(2), 137–140. https://doi.org/10.1002/da.1055

Craig, J., & Baron-Cohen, S. (1999). Creativity and imagination in autism and Asperger syndrome. *Journal of Autism and Developmental Disorders*, *29*(4), 319–326. https://doi.org/10.1023/a:1022163403479

Croen, L. A., Zerbo, O., Qian, Y., Massolo, M. L., Rich, S., Sidney, S., & Kripke, C. (2015). The health status of adults on the autism spectrum. *Autism, 19*(7), 814–823. https://doi.org/10.1177/1362361315577517

Czapinski, P., & Bryson, S. E. (2003). Reduced facial muscle movements in Autism: Evidence for dysfunction in the neuromuscular pathway? *Brain and Cognition, 51*, 177–179.

Davids, R. C., Groen, Y., Berg, I. J., Tucha, O., & Van Balkom, I. D. (2020). Local-global processing approaches in older autistic adults: A matched control study using RCFT and WAIS-IV. *Research in Autism Spectrum Disorders*, *78*, 101655. https://doi.org/10.1016/j.rasd.2020.101655

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. JSAS *Catalog of Selected Documents in Psychology*, 10, 85–104.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology, 44*(1), 113–126. https://doi.org/10.1037/0022-3514.44.1.113

Dawson, M., Soulières, I., Gernsbacher, M. A., & Mottron, L. (2007). The level and nature of autistic intelligence. *Psychological Science*, *18*(8), 657–662. https://doi.org/10.1111/j.1467-9280.2007.01954.x

De Marchena, A., Kim, E. S., Bagdasarov, A., Parish-Morris, J., Maddox, B. B., Brodkin, E. S., & Schultz, R. T. (2018). Atypicalities of gesture form and function in autistic adults. *Journal of Autism and Developmental Disorders*, *49*(4), 1438–1454. https://doi.org/10.1007/s10803-018-3829-x

Demetriou, E. A., Lampit, A., Quintana, D. S., Naismith, S. L., Song, Y. J. C., Pye, J. E., Hickie, I., & Guastella, A. J. (2017). Autism spectrum disorders: a meta-analysis of executive function. *Molecular Psychiatry*, *23*(5), 1198–1204. https://doi.org/10.1038/mp.2017.75

Diamond, A. (2012). Executive functions. *Annual Review of Psychology, 64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dragovic, M. (2004). Towards an improved measure of the Edinburgh Handedness Inventory: A one-factor congeneric measurement model using confirmatory factor analysis.

Laterality Asymmetries of Body Brain and Cognition, 9(4), 411–419. https://doi.org/10.1080/13576500342000248

Drake, J. E. (2014). Knowing how to look predicts the ability to draw realistically. *British Journal of Developmental Psychology*, *32*(4), 397–414. https://doi.org/10.1111/bjdp.12048

Drake, J. E., Redash, A., Coleman, K., Haimson, J., & Winner, E. (2010). 'Autistic'local processing bias also found in children gifted in realistic drawing. *Journal of autism and developmental disorders,* 40, 762-773.

D'Souza, D., Booth, R., Connolly, M., Happé, F., & Karmiloff-Smith, A. (2015). Rethinking the concepts of 'local or global processors': evidence from Williams syndrome, Down syndrome, and Autism Spectrum Disorders. *Developmental Science, 19*(3), 452–468. https://doi.org/10.1111/desc.12312

Eigsti, I. (2013). A review of Embodiment in autism Spectrum Disorders. *Frontiers in Psychology*, *4*. https://doi.org/10.3389/fpsyg.2013.00224

Elmose, M. (2019). Understanding loneliness and social relationships in autism: The reflections of autistic adults. *Nordic Psychology, 72*(1), 3–22. https://doi.org/10.1080/19012276.2019.1625068

English, M. C. W., Gignac, G. E., Visser, T. a. W., Whitehouse, A. J. O., Enns, J. T., & Maybery, M. T. (2021). The Comprehensive Autistic Trait Inventory (CATI): development and validation of a new measure of autistic traits in the general population. *Molecular Autism, 12*(1). https://doi.org/10.1186/s13229-021-00445-7

Eycke, K. D. T., & Müller, U. (2016). Drawing links between the autism cognitive profile and imagination: Executive function and processing bias in imaginative drawings by children with and without autism. *Autism, 22*(2), 149–160. https://doi.org/10.1177/1362361316668293

Faso, D.J., Sasson, N.J. & Pinkham, A.E. Evaluating Posed and Evoked Facial Expressions of Emotion from Adults with Autism Spectrum Disorder. *J Autism Dev Disord 45*, 75–89 (2015). https://doi.org/10.1007/s10803-014-2194-7

Finnegan, E., & Accardo, A. L. (2017). Written Expression in Individuals with Autism Spectrum Disorder: A Meta-Analysis. *Journal of Autism and Developmental Disorders, 48*(3), 868-882. https://doi.org/10.1007/s10803-017-3385-9

Finnegan, E. G., & Accardo, A. L. (2022). Written Expression in Individuals with Autism: A Meta-analysis. *Current Developmental Disorders Reports, 9*(4), 178--186. https://doi.org/10.1007/s40474-022-00262-4

Fitzpatrick, P., Romero, V., Amaral, J. L., Duncan, A., Barnard, H., Richardson, M. J., & Schmidt, R. C. (2017b). Social motor synchronization: Insights for understanding social behavior in autism. *Journal of Autism and Developmental Disorders*, *47*(7), 2092–2107. https://doi.org/10.1007/ s10803-017-3124-2

Fogliati, V. J., Terides, M. D., Gandy, M., Staples, L. G., L., Karin, E., Rapee, R. M., Titov, N., & Dear, B. F. (2016). Psychometric properties of the mini-social phobia inventory (Mini-SPIN) in a large online treatment-seeking sample. *Cognitive Behaviour Therapy, 45*(3), 236–257. https://doi.org/10.1080/16506073.2016.1158206

Fombonne, E., Snyder, L. G., Daniels, A., Feliciano, P., & Chung, W. (2020). Psychiatric and medical profiles of autistic adults in the SPARK cohort. *Journal of Autism and Developmental Disorders, 50*(10), 3679–3698. https://doi.org/10.1007/s10803-020-04414-6

Freitag, C. M., Retz-Junginger, P., Retz, W., Seitz, C., Palmason, H., Meyer, J., Rösler, M., & Von Gontard, A. (2007). Evaluation der deutschen Version des Autismus-Spektrum-Quotienten (AQ) - die Kurzversion AQ-k. *Zeitschrift Für Klinische Psychologie Und Psychotherapie*, *36*(4), 280–289. https://doi.org/10.1026/1616-3443.36.4.280

Frith, U. (2003). *Autism: Explaining the enigma* (2nd ed.). Blackwell Publishing.

Fusaroli, R., Lambrechts, A., Bang, D., Bowler, D. M., & Gaigg, S. B. (2017). Is voice a marker for Autism spectrum disorder? A systematic review and meta-analysis. *Autism Research, 10*(3), 384-407.

Gibson, M. T., Schmidt-Kassow, M., & Paulmann, S. (2023). How neurotypical listeners recognize emotions expressed through vocal cues by speakers with high-functioning autism. *Plos one, 18*(10), e0293233.

Gillespie-Lynch, K., Hotez, E., Zajic, M., Riccio, A., DeNigris, D., Kofner, B., Bublitz, D., Gaggi, N., & Luca, K. (2020). Comparing the writing skills of autistic and nonautistic university students: A collaboration with autistic university students. *Autism, 24*(7), 1898 -1912. https://doi.org/10.1177/1362361320929453

Gillott, A., & Standen, P. (2007). Levels of anxiety and sources of stress in adults with autism. *Journal of Intellectual Disabilities, 11*(4), 359–370. https://doi.org/10.1177/1744629507083585

Glass, D., & Yuill, N. (2023). Social motor synchrony in autism spectrum conditions: A systematic review. *Autism*, *28*(7), 1638–1653. https://doi.org/10.1177/13623613231213295

Grant, D. A., & Berg, E. A. (1948). Wisconsin card sorting Test [Dataset]. In *PsycTESTS Dataset*. https://doi.org/10.1037/t31298-000

Hall, J., O'Carroll, R. E., & Frith, C. D. (2010). Neuropsychology. *In Elsevier eBooks* (pp. 121–140). https://doi.org/10.1016/b978-0-7020-3137-3.00007-3

Harrison, T. B., & Stiles, J. (2008). Hierarchical forms processing in adults and children. *Journal of Experimental Child Psychology, 103*(2), 222–240. https://doi.org/10.1016/j.jecp.2008.09.004

Hayward, S. M., McVilly, K. R., & Stokes, M. A. (2016). Challenges for females with high functioning autism in the workplace: a systematic review. *Disability and Rehabilitation, 40*(3), 249–258. https://doi.org/10.1080/09638288.2016.1254284

Hechler, F. C., Tuomainen, O., Weber, N., Fahr, F., Karlek, B., Maroske, M., Misia, M., & Caruana, N. (2025). "What does 'often' even mean?" Revising and validating the Comprehensive Autistic Trait Inventory in partnership with autistic people. *Molecular Autism*, *16*(1). https://doi.org/10.1186/s13229-025-00643-7

Hickey, A., Crabtree, J., & Stott, J. (2017). 'Suddenly the first fifty years of my life made sense': Experiences of older people with autism. *Autism, 22*(3), 357–367. https://doi.org/10.1177/1362361316680914

Hill, E. L. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences*, *8*(1), 26–32. https://doi.org/10.1016/j.tics.2003.11.003

Hirvikoski, T., & Blomqvist, M. (2014). High self-perceived stress and poor coping in intellectually able adults with autism spectrum disorder. *Autism, 19*(6), 752–757. https://doi.org/10.1177/1362361314543530

Hoy, J. A., Hatton, C., & Hare, D. (2004). Weak central coherence: a Cross-Domain phenomenon specific to autism? *Autism*, *8*(3), 267–281. https://doi.org/10.1177/1362361304045218

Hubbard, D. J., Faso, D. J., Assmann, P. F., & Sasson, N. J. (2017). Production and perception of emotional prosody by adults with autism spectrum disorder. *Autism Research, 10*(12), 1991–2001. https://doi.org/10.1002/aur.1847

Hull, L., Petrides, K. V., Allison, C., Smith, P., Baron-Cohen, S., Lai, M., & Mandy, W. (2017). "Putting on My Best Normal": Social Camouflaging in Adults with Autism Spectrum Conditions. *Journal of Autism and Developmental Disorders, 47*(8), 2519–2534. https://doi.org/10.1007/s10803-017-3166-5

Hunt, E., Hogan, A., Will, E. A., & Roberts, J. E. (2022). ADHD and ASD symptoms in young males with fragile X syndrome: associations with early trajectories of inhibitory control. *Child Neuropsychology*, *29*(5), 760–786. https://doi.org/10.1080/09297049.2022.2120605

Janes, A., McClay, E., Gurm, M., Boucher, T. Q., Yeung, H. H., Iarocci, G., & Scheerer, N. E. (2024). Predicting Social Competence in Autistic and Non-Autistic Children: Effects of prosody and the amount of speech input. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-024-06363-w

Jolley, R. P., O'Kelly, R., Barlow, C. M., & Jarrold, C. (2013). Expressive drawing ability in children with autism. *British Journal of Developmental Psychology, 31*(1), 143–149. https://doi.org/10.1111/bjdp.12008

Johnston, K., Murray, K., Spain, D., Walker, I., & Russell, A. (2019). Executive Function: Cognition and Behaviour in Adults with Autism Spectrum Disorders (ASD). *Journal* *of Autism and Developmental Disorders*, *49*(10), 4181–4192. https://doi.org/10.1007/s10803-019-04133-7

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2,* 217–250.

Kessler, R. C., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E., Howes, M. J., Jin, R., Secnik, K., Spencer, T., Ustun, T. B., & Walters, E. E. (2005). The World Health Organization adult ADHD self-report scale (ASRS): a short screening scale for use in the general population. *Psychological Medicine, 35*(2), 245–256. https://doi.org/10.1017/s0033291704002892

Kim, J., Lee, E., & Joung, Y. (2013). The WHO Adult ADHD Self-Report Scale: Reliability and validity of the Korean version. *Psychiatry Investigation, 10*(1), 41. https://doi.org/10.4306/pi.2013.10.1.41

Kim, S. Y., Song, D., Kim, Y. A., Bong, G., Kim, J., Kim, J. H., & Yoo, H. J. (2020). How Do Children with Autism Spectrum Disorder Encode and Reproduce Visuospatial Stimuli?: Investigation into Visuospatial Processing Abilities and Styles. *Psychiatry Investigation*, *17*(11), 1105–1107. https://doi.org/10.30773/pi.2020.0189

Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. *Psychological Bulletin, 112*(1), 24–38. https://doi.org/10.1037/0033-2909.112.1.24

Kliem, S., Mößle, T., Zenger, M., & Brähler, E. (2013). Reliability and validity of the beck depression inventory-fast screen for medical patients in the general German population. *Journal of Affective Disorders*, *156*, 236–239. https://doi.org/10.1016 /j.jad.2013.11.024

Koldewyn, K., Jiang, Y. V., Weigelt, S., & Kanwisher, N. (2013). Global/Local processing in Autism: not a disability, but a disinclination. *Journal of Autism and Developmental Disorders*, *43*(10), 2329–2340. https://doi.org/10.1007/s10803-013-1777-z

Koller, M. (2016). robustlmm: An R Package for Robust Estimation of Linear Mixed-Effects Models. *Journal of Statistical Software, 75*(6). https://doi.org/10.18637/jss.v075.i06

Kramer, J. H., & Wells, A. M. (2004). The role of perceptual bias in complex figure recall. *Journal of Clinical and Experimental Neuropsychology, 26*(6), 838–845. https://doi.org/10.1080/13803390490509556

Kuschner, E. S., Bodner, K. E., & Minshew, N. J. (2009). Local vs. global approaches to reproducing the Rey Osterrieth complex figure by children, adolescents, and adults with high-functioning autism. *Autism Research*, *2*(6), 348–358. https://doi.org/10.1002/aur.101

Lage, C., Smith, E. S., & Lawson, R. P. (2023). A meta-analysis of cognitive flexibility in autism spectrum disorder. *Neuroscience & Biobehavioral Reviews*, *157*, 105511. https://doi.org/10.1016/j.neubiorev.2023.105511

Lai, M., Lombardo, M. V., Ruigrok, A. N., Chakrabarti, B., Auyeung, B., Szatmari, P., Happé, F., & Baron-Cohen, S. (2016). Quantifying and exploring camouflaging in men and women with autism. *Autism, 21*(6), 690–702. https://doi.org/10.1177/1362361316671012

Lebreton, K., Malvy, J., Bon, L., Hamel-Desbruères, A., Marcaggi, G., Clochon, P., Guénolé, F., Moussaoui, E., Bowler, D. M., Bonnet-Brilhault, F., Eustache, F., Baleyte, J., & Guillery-Girard, B. (2021). Local processing bias impacts implicit and explicit memory in autism. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.622462

Lehrl, S., Triebig, G., & Fischer, B. (1995). Multiple choice vocabulary test MWT as a valid and short test to estimate premorbid intelligence. *Acta Neurologica Scandinavica, 91*(5), 335–345. https://doi.org/10.1111/j.1600-0404.1995.tb07018.x

Lei, J., Leigh, E., Charman, T., Russell, A., & Hollocks, M. J. (2023). Understanding the relationship between social camouflaging in autism and safety behaviours in social anxiety in autistic and non-autistic adolescents. *Journal of Child Psychology and Psychiatry*. https://doi.org/10.1111/jcpp.13884

Lenth, R. V. (2017). *emmeans: Estimated Marginal Means, aka Least-Squares Means* [Dataset]. https://doi.org/10.32614/cran.package.emmeans

Livingston, L. A., Colvert, E., Bolton, P., & Happé, F. (2018). Good social skills despite poor theory of mind: exploring compensation in autism spectrum disorder. *Journal of Child Psychology and Psychiatry, 60*(1), 102–110. https://doi.org/10.1111/jcpp.12886

Mandy, W. (2019). Social camouflaging in autism: Is it time to lose the mask? *Autism, 23*(8), 1879–1881. https://doi.org/10.1177/1362361319878559

Maricle, D. E., & Johnson, W. L. B. (2016). Instructional Implications from the Woodcock–Johnson IV Tests of Cognitive Abilities. In *Elsevier eBooks* (pp. 123–150). https://doi.org/10.1016/b978-0-12-802076-0.00005-0

Martin, N. (2008). Assessing portrait drawings created by children and adolescents with autism spectrum disorder. *Art Therapy, 25*(1), 15–23. https://doi.org/10.1080/07421656.2008.10129348

McCann, J., & Peppé, S. (2003). Prosody in autism spectrum disorders: a critical review. *International Journal of Language & Communication Disorders, 38*(4), 325–350. https://doi.org/10.1080/1368282031000154204

Mejia, Y. L. M., Thompson, J. L., & Woods, S. P. (2023). A process analysis of Rey-Osterrieth complex figure test performance using the Boston Qualitative scoring system in HIV-Associated Neurocognitive Disorders. *Perceptual and Motor Skills, 130*(6), 2530–2546. https://doi.org/10.1177/00315125231212682

Menon, V., Adleman, N. E., White, C., Glover, G., & Reiss, A. (2001). Error-related brain activation during a Go/NoGo response inhibition task. *Human Brain Mapping, 12*(3), 131–143. https://doi.org/10.1002/1097-0193(200103)12:3

Mezzacappa, E. (2011). Executive function. In *Elsevier eBooks* (pp. 142–150). https://doi.org/10.1016/b978-0-12-373951-3.00016-8

Minshew, N. J., Goldstein, G., & Siegel, D. J. (1997). Neuropsychologic functioning in autism: Profile of a complex information processing disorder. *Journal of the International Neuropsychological Society*, *3*(4), 303–316. https://doi.org/10.1017/s1355617797003032

Morett, L. M., O'Hearn, K., Luna, B., & Ghuman, A. S. (2015). Altered Gesture and Speech Production in ASD Detract from In-Person Communicative Quality. *Journal of Autism and Developmental Disorders*, *46*(3), 998–1012. https://doi.org/10.1007/s10803-015-2645-9

Mottron, L., & Burack, J. (2001). Enhanced perceptual functioning in the development of autism. In: Burack, Charman, Yirmiya, & Zelazo (Eds.), *The development of autism: Perspectives from theory and research.* (pp. 131–148). Mahwah, NJ: Erlbaum

Mottron, L., Dawson, M., Soulières, I., Hubert, B., & Burack, J. (2006). Enhanced Perceptual Functioning in Autism: An Update, and Eight Principles of Autistic Perception. *Journal of Autism and Developmental Disorders, 36*(1), 27–43. https://doi.org/10.1007/s10803-005-0040-7

Moseley, R. L., Turner-Cobb, J. M., Spahr, C. M., Shields, G. S., & Slavich, G. M. (2021b). Lifetime and perceived stress, social support, loneliness, and health in autistic adults. *Health Psychology, 40*(8), 556–568. https://doi.org/10.1037/hea0001108

Müller, E., Schuler, A., & Yates, G. B. (2008). Social challenges and supports from the perspective of individuals with Asperger syndrome and other autism spectrum disabilities. *Autism, 12*(2), 173–190. https://doi.org/10.1177/1362361307086664

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, 9, 353–383.

Nayar, K., Voyles, A. C., Kiorpes, L., & Di Martino, A. (2017). Global and local visual processing in autism: An objective assessment approach. *Autism Research, 10*(8), 1392–1404. https://doi.org/10.1002/aur.1782

Oakley, B. F., Tillmann, J., Ahmad, J., Crawley, D., Cáceres, A. S. J., Holt, R., Charman, T., Banaschewski, T., Buitelaar, J., Simonoff, E., Murphy, D., & Loth, E. (2020). How do core autism traits and associated symptoms relate to quality of life? Findings from the Longitudinal European Autism Project. *Autism, 25*(2), 389–404. https://doi.org/10.1177/1362361320959959

Ogino, T., Watanabe, K., Nakano, K., Kado, Y., Morooka, T., Takeuchi, A., Oka, M., Sanada, S., & Ohtuska, Y. (2008). Predicting executive function task scores with the

Rey-Osterrieth Complex Figure. *Brain and Development, 31*(1), 52–57.https://doi.org/10.1016/j.braindev.2008.07.003

Oldfield, R. (1971). The assessment and analysis of handedness: *The Edinburgh inventory. Neuropsychologia, 9*(1), 97–113. https://doi.org/10.1016/0028-3932(71)90067-4

Pasarín-Lavín, T., Abín, A., García, T., & Rodríguez, C. (2023). Relationship between Executive Functions and Creativity in Children and Adolescents: A Systematic Review. *Children*, *10*(6), 1002. https://doi.org/10.3390/children10061002

Pasquini, C. (2018). Near infrared spectroscopy: A mature analytical technique with new perspectives – A review. *Analytica Chimica Acta, 1026*, 8–36. https://doi.org/10.1016/j.aca.2018.04.004

Paul, R., Augustyn, A., Klin, A., & Volkmar, F. R. (2005). Perception and Production of Prosody by Speakers with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 35*(2), 205–220. https://doi.org/10.1007/s10803-004-1999-1

Paulus, C. (2009). *DER SAARBRÜCKER PERSÖNLICHKEITSFRAGEBOGEN SPF(IRI) ZUR MESSUNG VON EMPATHIE: Psychometrische Evaluation der deutschen Version des Interpersonal Reactivity Index.* https://doi.org/10.23668/psycharchives.9249

Pelowski, M., Markey, P. S., Goller, J., Förster, E. L., & Leder, H. (2018). But, how can we make “art?” Artistic production versus realistic copying and perceptual advantages of artists. *Psychology of Aesthetics Creativity and the Arts*, *13*(4), 462–481. https://doi.org/10.1037/aca0000178

Peña, M. a. S. (2024). Sculpting Aesthetic Experiences through Autistic Indigenous Knowledge. *Ought the Journal of Autistic Culture*, *5*(2). https://doi.org/10.9707/2833-1508.1171

Pellicano, E., & Burr, D. (2012). When the world becomes ‘too real’: a Bayesian explanation of autistic perception. *Trends in Cognitive Sciences, 16*(10), 504–510. https://doi.org/10.1016/j.tics.2012.08.009

Pennisi, P., Giallongo, L., Milintenda, G., & Cannarozzo, M. (2020). Autism, autistic traits and creativity: A systematic review and meta-analysis. *Cognitive Processing, 22*(1), 1–36. https://doi.org/10.1007/s10339-020-00992-6

Philippsen, A., Tsuji, S., & Nagai, Y. (2022). Quantifying developmental and individual differences in spontaneous drawing completion among children. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.783446

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R Core Team. (2021*). nlme: Linear and Nonlinear Mixed Effects Models*. https://CRAN.R-project.org/package=nlme

Pirinen, V., Loukusa, S., Dindar, K., Mäkinen, L., Hurtig, T., Jussila, K., Mattila, M., & Eggers, K. (2023). A Comprehensive analysis of speech disfluencies in Autistic Young Adults and Control Young Adults: group differences in Typical, Stuttering-Like, and Atypical disfluencies. *Journal of Speech Language and Hearing Research*, 1–17. https://doi.org/10.1044/2022_jslhr-22-00265

Pirinen, V., Loukusa, S., Eggers, K., Sivonen, J., Mäkinen, L., Mämmelä, L., Ebeling, H., Mattila, M., & Hurtig, T. (2024). Could linguistic and cognitive factors, degree of autistic traits and sex predict speech disfluencies in autistic young adults and controls? *Clinical Linguistics & Phonetics*, 1–18. https://doi.org/10.1080/02699206.2024.2357158

Plaisted, K., Saksida, L., Alcántara, J., & Weisblatt, E. (2003). Towards an understanding of the mechanisms of weak central coherence effects: experiments in visual configural learning and auditory perception. *Philosophical Transactions of the Royal Society B Biological Sciences*, *358*(1430), 375–386. https://doi.org/10.1098/rstb.2002.1211

Plaisted, K., Swettenham, J., & Rees, L. (1999). Children with Autism Show Local Precedence in a Divided Attention Task and Global Precedence in a Selective Attention Task. *Journal of Child Psychology and Psychiatry, 40*(5), 733–742. https://doi.org/10.1111/1469-7610.00489

Poreh, A., & Shye, S. (1998). Examination of the global and local features of the Rey Osterrieth Complex figure using faceted smallest space analysis. *The Clinical Neuropsychologist, 12*(4), 453–467. https://doi.org/10.1076/clin.12.4.453.7240

Preece, D. A., Parry, C. L., Allan, M. M., & Allan, A. (2020). Assessing alexithymia in forensic settings: Psychometric properties of the 20-item Toronto Alexithymia Scale among incarcerated adult offenders. *Criminal Behaviour and Mental Health, 31*(1), 31–43. https://doi.org/10.1002/cbm.2176

Price, J. R., Martin, G. E., Chen, K., & Jones, J. R. (2019). A Preliminary Study of Writing Skills in Adolescents with Autism Across Persuasive, Expository, and Narrative Genres. *Journal of Autism and Developmental Disorders, 50*(1), 319--332. https://doi.org/10.1007/s10803-019-04254-z

Ramirez-Melendez, R., Matamoros, E., Hernandez, D., Mirabel, J., Sanchez, E., & Escude, N. (2022). Music-enhanced emotion identification of facial emotions in autistic Spectrum disorder children: A pilot EEG study. *Brain Sciences, 12*(6), 704.

Raven, J. C. (1938) Raven's progressive matrices (1938): sets A, B, C, D, E. *Melbourne: Australian Council for Educational Research; 1938* .

Raven, J. C. (2000). The Raven's Progressive Matrices: Change and Stability over Culture and Time. *Cognitive Psychology, 41*(1), 1–48. https://doi.org/10.1006/cogp.1999.0735

Rey, A., & Osterrieth, P. A. (1941b). Rey-Osterrieth Complex Figure Copying Test [Dataset]. In *PsycTESTS Dataset*. https://doi.org/10.1037/t07717-000

Rong, Y., Yang, C., Jin, Y., & Wang, Y. (2021). Prevalence of attention-deficit/hyperactivity disorder in individuals with autism spectrum disorder: A meta-analysis. *Research in Autism Spectrum Disorders*, *83*, 101759. https://doi.org/10.1016/j.rasd.2021.101759

Rönnegård, L., Felleki, M., Fikse, F., Mulder, H. A., & Strandberg, E. (2010). Genetic heterogeneity of residual variance - estimation of variance components using double hierarchical generalized linear models. *Genetics Selection Evolution*, *42*(1). https://doi.org/10.1186/1297-9686-42-8

Rubiales, J., Russo, D., González, R., & Bakker, L. (2018). Estrategias de organización en la Figura Compleja de Rey en niños con TDAH. *European Journal of Investigation in Health Psychology and Education*, *7*(2), 99. https://doi.org/10.30552/ejihpe.v7i2.199

Rueda, P., Fernández-Berrocal, P., & Baron-Cohen, S. (2014). Dissociation between cognitive and affective empathy in youth with Asperger Syndrome. *European Journal of Developmental Psychology*, *12*(1), 85–98. https://doi.org/10.1080/17405629.2014.950221

Savickaite, S., Morrison, C., Lux, E., Delafield-Butt, J., & Simmons, D. R. (2022). The use of a tablet-based app for investigating the influence of autistic and ADHD traits on performance in a complex drawing task. *Behavior Research Methods, 54*(5), 2479-2501.

Scarpina, F., Ambiel, E., Albani, G., Pradotto, L. G., & Mauro, A. (2016). Utility of Boston Qualitative Scoring System for Rey-Osterrieth Complex Figure: evidence from a

Parkinson's Diseases sample. *Neurological Sciences*, *37*(10), 1603–1611. https://doi.org/10.1007/s10072-016-2631-9

Scheerer, N. E., Jones, J. A., & Iarocci, G. (2020). Exploring the Relationship between Prosodic Control and Social Competence in Children with and without Autism Spectrum Disorder. *Autism Research*, *13*(11), 1880–1892. https://doi.org/10.1002/aur.2405

Schlotz, W., Wallot, S., Omigie, D., Masucci, M. D., Hoelzmann, S. C., & Vessel, E. A. (2021). The Aesthetic Responsiveness Assessment (AReA): A Screening Tool to Assess Individual Differences in Responsiveness to Art in English and German. *Psychology of Aesthetics, Creativity, and the Arts, 15*(4), 682–696. https://doi.org/10.1037/aca0000348

Schreiber, H. E., Javorsky, D. J., Robinson, J. E., & Stern, R. A. (1999). Rey-Osterrieth Complex Figure Performance in Adults with Attention Deficit Hyperactivity Disorder: A Validation Study of the Boston Qualitative Scoring System. *The Clinical Neuropsychologist*, *13*(4), 509–520. https://doi.org/10.1076/1385-4046(199911)13:04;1-y;ft509

Schmitt, L. M., White, S. P., Cook, E. H., Sweeney, J. A., & Mosconi, M. W. (2017). Cognitive mechanisms of inhibitory control deficits in autism spectrum disorder. *Journal of Child Psychology and Psychiatry*, *59*(5), 586–595. https://doi.org/10.1111/jcpp.12837

Schweizer, C., Knorth, E. J., & Spreen, M. (2014). Art therapy with children with Autism Spectrum Disorders: A review of clinical case descriptions on 'what works.' *The Arts in Psychotherapy*, *41*(5), 577–593. https://doi.org/10.1016/j.aip.2014.10.009

Senju, A., & Johnson, M. H. (2009). Atypical eye contact in autism: Models, mechanisms and development. *Neuroscience & Biobehavioral Reviews*, *33*(8), 1204–1214. https://doi.org/10.1016/j.neubiorev.2009.06.001

Shallice, T. (1982). Specific impairments of planning. Philosophical Transactions of the Royal Society of London. *Series B, Biological Sciences, 298*(1089), 199–209. https://doi.org/10.1098/rstb.1982.0082

Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, *27*(3), 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Shevchuk-Hill, S., Szczupakiewicz, S., Kofner, B., & Gillespie-Lynch, K. (2023). Comparing narrative writing of autistic and non-autistic College students. *Journal of Autism and Developmental Disorders, 53*(10), 3901-3915.

Shi, F., Sun, W., Duan, H., Liu, X., Hu, M., Wang, W., & Zhai, G. (2021). Drawing reveals hallmarks of children with autism. *Displays, 67,* 102000. https://doi.org/10.1016/j.displa.2021.102000

Shin, M., Park, S., Park, S., Seol, S., & Kwon, J. S. (2006). Clinical and empirical applications of the Rey–Osterrieth Complex Figure Test. *Nature Protocols, 1*(2), 892–899. https://doi.org/10.1038/nprot.2006.115

Shriberg, L. D., Paul, R., McSweeny, J. L., Klin, A., Cohen, D. J., & Volkmar, F. R. (2001). Speech and prosody characteristics of adolescents and adults with High-Functioning Autism and Asperger Syndrome. *Journal of Speech Language and Hearing Research, 44*(5), 1097–1115. https://doi.org/10.1044/1092-4388(2001/087

Siegfried Lehrl: *Mehrfachwahl-Wortschatz-Intelligenztest MWT-B. 5.* unveränderte Auflage. Spitta Verlag, Balingen 2005, ISBN 3-934211-04-6.

Skotalczyk, M. A., Dąbrowska, K. A., Smorońska-Rypel, J., Wilczyński, K. M., & Janas-Kozik, M. (2024). Alexithymia as a Risk Factor for an Internet Addiction in Adolescents and Young Adults with Autism Spectrum Disorder. *European Journal of*

Investigation in Health Psychology and Education, *14*(3), 669–684. https://doi.org/10.3390/ejihpe14030044

Smith, A. (2009). The Empathy Imbalance Hypothesis of Autism: A theoretical approach to cognitive and Emotional empathy in autistic development. *The Psychological Record*, *59*(3), 489–510. https://doi.org/10.1007/bf03395675

Smith, A. D., Kenny, L., Rudnicka, A., Briscoe, J., & Pellicano, E. (2016). Drawing firmer conclusions: autistic children show no evidence of a local processing bias in a controlled copying task. *Journal of Autism and Developmental Disorders*, *46*(11), 3481–3492. https://doi.org/10.1007/s10803-016-2889-z

Somerville, J., Tremont, G., & Stern, R. A. (2000). The Boston Qualitative scoring System as a measure of executive functioning in Rey-Osterrieth complex figure performance. *Journal of Clinical and Experimental Neuropsychology, 22*(5), 613–621. https://doi.org/10.1076/1380-3395(200010)22:5;1-9;ft613

Song, Y., Hakoda, Y., Sanefuji, W., & Cheng, C. (2015). Can They See It? The Functional Field of View Is Narrower in Individuals with Autism Spectrum Disorder. *PLoS ONE*, *10*(7), e0133237. https://doi.org/10.1371/journal.pone.0133237

Song, Y., & Hakoda, Y. (2017). Selective Impairment of Basic Emotion Recognition in People with Autism: Discrimination Thresholds for Recognition of Facial Expressions of Varying Intensities. *Journal of Autism and Developmental Disorders*, *48*(6), 1886–1894. https://doi.org/10.1007/s10803-017-3428-2

Spain, D., Sin, J., Linder, K. B., McMahon, J., & Happé, F. (2018). Social anxiety in autism spectrum disorder: A systematic review. *Research in Autism Spectrum Disorders*, *52*, 51–68. https://doi.org/10.1016/j.rasd.2018.04.007

Spek, A., Schatorjé, T., Scholte, E., & Van Berckelaer-Onnes, I. (2008). Verbal fluency in adults with high functioning autism or Asperger syndrome. *Neuropsychologia, 47*(3), 652–656. https://doi.org/10.1016/j.neuropsychologia.2008.11.015

Sperry, L. A., & Mesibov, G. B. (2005). Perceptions of social challenges of adults with autism spectrum disorder. *Autism, 9*(4), 362–376. https://doi.org/10.1177/1362361305056077

Stagg, S. D., Slavny, R., Hand, C., Cardoso, A., & Smith, P. (2013). Does facial expressivity count? How typically developing children respond initially to children with autism. *Autism*, *18*(6), 704–711. https://doi.org/10.1177/1362361313492392

Stebbins, G. T. (2007). Neuropsychological testing. In *Elsevier eBooks* (pp. 539–557). https://doi.org/10.1016/b978-141603618-0.10027-x

Sterling-Turner, H. E., & Jordan, S. S. (2007). Interventions addressing transition difficulties for individuals with autism. *Psychology in the Schools*, *44*(7), 681–690. https://doi.org/10.1002/pits.20257

Stern, R. A. (1999). *BQSS: The Boston Qualitative Scoring System for the Rey-Osterrieth Complex Figure*. Psychological Assessment Resources.

Szechy, K. A., Turk, P. D., & O’Donnell, L. A. (2023). Autism and Employment Challenges: The double empathy problem and perceptions of an autistic employee in the workplace. *Autism in Adulthood, 6*(2), 205–217. https://doi.org/10.1089/aut.2023.0046

Tassinary, L. G., Cacioppo, J. T., & Vanman, E. J. (2009). The skeletomotor system: surface electromyography. In *Cambridge University Press eBooks* (pp. 267–300). https://doi.org/10.1017/cbo9780511546396.012

Temple, R. O., Davis, J. D., Silverman, I., & Tremont, G. (2006). Differential impact of executive function on visual memory tasks. *The Clinical Neuropsychologist, 20*(3), 480–490. https://doi.org/10.1080/13854040590967540

Trevisan, D. A., Hoskyn, M., & Birmingham, E. (2018). Facial expression production in autism: A meta-analysis. *Autism Research, 11*(12), 1586-1601.

Trujillo, J. P., Özyürek, A., Kan, C. C., Sheftel-Simanova, I., & Bekkering, H. (2021). Differences in the production and perception of communicative kinematics in autism. *Autism Research*, *14*(12), 2640–2653. https://doi.org/10.1002/aur.2611

Turan, B., Algedik Demirayak, P., Yildirim Demirdogen, E., Gulsen, M., Cubukcu, H. C., Guler, M., ... & Dursun, O. B. (2023). Toward the detection of reduced emotion expression intensity: an autism sibling study. *Journal of Clinical and Experimental Neuropsychology, 45*(3), 219-229.

Umagami, K., Remington, A., Lloyd-Evans, B., Davies, J., & Crane, L. (2022). Loneliness in autistic adults: A systematic review. *Autism, 26*(8), 2117–2135.https://doi.org/10.1177/13623613221077721

Van Der Hallen, R., Evers, K., Brewaeys, K., Van Den Noortgate, W., & Wagemans, J. (2014). Global processing takes time: A meta-analysis on local–global visual processing in ASD. *Psychological Bulletin, 141*(3), 549–573.https://doi.org/10.1037/bul0000004

Vogindroukas, I., Stankova, M., Chelas, E., & Proedrou, A. (2022). Language and speech characteristics in autism. *Neuropsychiatric Disease and Treatment, Volume 18*, 2367–2377. https://doi.org/10.2147/ndt.s331987

Vuillier, L., Carter, Z., Teixeira, A. R., & Moseley, R. L. (2020). Alexithymia may explain the relationship between autistic traits and eating disorder psychopathology. *Molecular Autism*, *11*(1). https://doi.org/10.1186/s13229-020-00364-z

Wang, W., & Fan, T. (2011). Bayesian analysis of multivariate t linear mixed models using a combination of IBF and Gibbs samplers. *Journal of Multivariate Analysis*, *105*(1), 300–310. https://doi.org/10.1016/j.jmva.2011.10.006

Wang, L., Mottron, L., Peng, D., Berthiaume, C., & Dawson, M. (2007). Local bias and local-to-global interference without global deficit: A robust finding in autism under various conditions of attention, exposure time, and visual angle. *Cognitive Neuropsychology, 24*(5), 550–574. https://doi.org/10.1080/13546800701417096

Wilcox, T., & Biondi, M. (2015). fNIRS in the developmental sciences. Wiley Interdisciplinary Reviews *Cognitive Science, 6*(3), 263–283.https://doi.org/10.1002/wcs.1343

Witkin, H. A. (1971). A Manual for the embedded figures tests. In *Consulting Psychologists Press eBooks*. http://ci.nii.ac.jp/ncid/BA02732546

Webster, P. J., Wang, S., & Li, X. (2021). Review: Posed vs. Genuine Facial Emotion Recognition and Expression in Autism and Implications for Intervention. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.653112

Weiss, M. J., Moran, M. F., Parker, M. E., & Foley, J. T. (2013). Gait analysis of teenagers and young adults diagnosed with autism and severe verbal communication disorders. *Frontiers in Integrative Neuroscience*, *7*. https://doi.org/10.3389/fnint.2013.00033

Xie, R., Sun, X., Yang, L., & Guo, Y. (2020). Characteristic executive dysfunction for High-Functioning Autism sustained to adulthood. *Autism Research*, *13*(12), 2102–2121. https://doi.org/10.1002/aur.2304

Zajic, M. C., & Brown, H. M. (2022). Measuring Autistic Writing Skills: Combining Perspectives from Neurodiversity Advocates, Autism Researchers, and Writing Theories. *Human Development, 66*(2), 128-148. https://doi.org/10.1159/000524015

Zhang, X., Lv, L., Min, G., Wang, Q., Zhao, Y., & Li, Y. (2021). Overview of the complex figure test and its clinical application in neuropsychiatric disorders, including copying and recall. *Frontiers in Neurology, 12.* https://doi.org/10.3389/fneur.2021.680474

Zuur, A. F., Ieno, E. N., & Elphick, C. S. (2009). A protocol for data exploration to avoid common statistical problems. *Methods in Ecology and Evolution*, *1*(1), 3–14. https://doi.org/10.1111/j.2041-210x.2009.00001.x

List of Figures

List of Tables

List of Abbreviations

AQ – k	Autismus-Spektrum-Quotienten Kurzversion
AReA	Aesthetic Responsiveness Assessment
ASD	Autism Spectrum Disorder
ASRS	Adult ADHD Self-Report Scale
BDI-FS	Beck Depression Inventory-Fast Screen
BDT	Block Design Test
BTPJ	bilateral temporoparietal junctions
BQSS	Boston Qualitative Scoring System
CATI	Comprehensive Autism Trait Inventory
CNN	Convolutional Neural Network
CPA	Copy Presence and Accuracy
DCM	Deviation of the Center of Mass
DPA	Delayed Presence and Accuracy
DR	Delayed Retention
EDA	Electrodermal Activity
EF	Executive Functioning
EFT	Embedded Figures Task
EHI	Edinburgh Handedness Inventory
EPF	Enhanced Perceptual Functioning
EOE	Edge-Orientation Entropy
FDR	False Discovery Rate
fEMG	Facial Electromyography
fNIRS	functional Near-Infrared Spectroscopy
GEFT	Group Embedded Figures Test

HOG	Histogram of Oriented Gradients
IPA	Immediate Presence and Accuracy
IR	Immediate Retention
LMM	Linear Mixed-Effects Model
LR	Left-Right
LRUD	Left – Right – Up – Down
Mini-SPIN	Mini-Social Phobia Inventory
mPFC	Medial Prefrontal Cortex
MWT-B	Mehrfachwahl-Wortschatz-Intelligenztest-B
ORG	Organization
PHOG	Pyramid Histogram of Oriented Gradients
RSPM	Raven´s Standard Progressive Matrices
rdlPFC	Right Dorsolateral Prefrontal Cortex
rIFG	Right Inferior Frontal Gyrus
ROCF	Rey – Osterrieth Complex Figure
RMS	Root Mean Square
SMS	Social Motor Synchrony
SPF-IRI	Saarbrücken Personality Questionnaire - Interpersonal Reactivity Index
TAS-20	Toronto Alexithymia Scale-20
TD	Typically Developed
TMT	Trail Making Test
TOL	Tower of London
UD	Up – Down
WCST	Wisconsin Card Sorting Test

Appendix

Model Actions

Variable	Shapiro p	Outlier Count	Levene_ Group	Levene - Emotion	Breusch	model
RMS_Contrast	0.00000585	0	0.7072	0.0022	0.0345	varIdent(~1 | emotion)
Lightness_Entropy	0.00000013	0	0.1616	0.0025	0.0066	varIdent(~1 | emotion)
Complexity	0.00000003	1	0.2067	0.0092	0.0000	varIdent(~1 | emotion)
Edge_Density	0.00157360	0	0.4010	0.0005	0.0022	varIdent(~1 | emotion)
Mean_L_Channel	0.00000000	0	0.0470	0.2490	0.6123	varIdent(~1 | group)
Mean_V_Channel	0.00000001	2	0.5025	0.0000	0.0014	varIdent(~1 | emotion)
SD_L_Channel	0.00000585	0	0.7072	0.0022	0.0345	varIdent(~1 | emotion)
SD_V_Channel	0.68831551	0	0.5291	0.0311	0.6573	varIdent(~1 | emotion)

Variable	Shapiro p	Outlier Count	Levene_ Group	Levene - Emotion	Breusch	model
Mirror__Symmetry	0.00000000	4	0.0927	0.0000	0.0097	varIdent(~1 | emotion)
Balance	0.00081126	1	0.4674	0.0004	0.0000	varIdent(~1 | emotion)
DCM_Distance	0.00000000	4	0.5114	0.0028	0.0002	varIdent(~1 | emotion)
DCM_X_Position	0.00000000	6	0.5524	0.2189	0.9121	rlmer (robust LMM)
DCM_Y_Position	0.00002108	4	0.9297	0.0007	0.0433	varIdent(~1 | emotion)
CNN_Symmetry_Left_Right	0.38452423	2	0.1099	0.0174	0.3800	varIdent(~1 | emotion)
CNN_Symmetry_Up_Down	0.61851159	1	0.5140	0.0346	0.3914	varIdent(~1 | emotion)
CNN_Symmetry_Left_Right_and_Up_Down	0.60839266	0	0.3317	0.0035	0.0854	varIdent(~1 | emotion)
Fourier_Slope	0.00000000	0	0.9571	0.8902	0.0492	rlmer (robust LMM)

Variable	Shapiro p	Outlier Count	Levene_ Group	Levene - Emotion	Breusch	model
Fourier_Sigma	0.00000000	6	0.6220	0.0006	0.0002	varIdent(~1 | emotion)
2_D_Fractal_Dimension	0.00000000	4	0.7500	0.2287	0.4037	rlmer (robust LMM)
3_D_Fractal_Dimension	0.00000000	0	0.3558	0.3943	0.0487	rlmer (robust LMM)
Self_Similarity_PHOG	0.37364377	0	0.5318	0.2292	0.5112	No adjustment needed
Self_Similarity_CNN	0.00000000	0	0.1678	0.0049	0.0008	varIdent(~1 | emotion)
Homogeneity	0.00000000	0	0.6120	0.9041	0.7045	rlmer (robust LMM)
Anisotropy	0.00000000	3	0.3226	0.5766	0.0004	rlmer (robust LMM)
1st_order_EOE	0.00000000	2	0.9752	0.0890	0.8247	rlmer (robust LMM)
2nd_order_EOE	0.00000000	0	0.8154	0.7151	0.7550	rlmer (robust LMM)

Variable	Shapiro p	Outlier Count	Levene_ Group	Levene - Emotion	Breusch	model
Sparseness	0.00715595	0	0.7996	0.0320	0.3804	varIdent(~1 | emotion)
Variability	0.01247139	2	0.2561	0.2229	0.5083	rlmer (robust LMM)

Abstract (English)

ASD is a pervasive disability, affecting almost all aspects of an individual's lived experience, including perception, cognition and self-expression. Existing research aiming to quantify differences in perception, cognition and self-expression have yielded inconsistent results regarding systematic differences between autistic and typically developed individuals. This study examined whether drawings created by autistic and non-autistic individuals differ significantly from each other and whether differences in test batteries assessing perceptual processing and executive functioning could predict drawing properties. All 59 participants in this study completed the ROCF, which offers a tool to measure both perceptual processing and executive functioning, and created abstract drawings, which were analyzed across 28 objective, quantitative image properties. Both the ROCF and the image properties analyses revealed no significant differences between both groups, except for the image property fourier sigma (B = 0.30, SE = 0.09, t= 3.30, 95% CI [0.12 , 0.47], p = 0.03), which was significantly lower in the autistic group, suggesting that images created by autistic individuals more closely resemble natural scenes or traditional artworks. Further regression analyses revealed that higher fragmentation scores on the ROCF (quantifying local or global perceptual processing biases) and higher organization scores on the ROCF (indicative of better executive functioning) predicted more symmetrical, complex and balanced drawings.

Abstract (German)

ASD ist eine tiefgreifende Behinderung, die viele Aspekte eines Lebens maßgeblich beeinflussen kann, darunter Wahrnehmung, Kognition und wie man sich selbst mitteilt und ausdrückt. Die bestehende Forschung, welche Unterschiede in der Wahrnehmung, Kognition und Selbstdarstellung zu quantifizieren versucht, liefert weitgehend inkonsistente Ergebnisse hinsichtlich systematischer Unterschiede zwischen autistischen und nicht-autistischen Personen. Diese Studie untersucht, ob sich Zeichnungen von autistischen und nicht-autistischen Personen signifikant voneinander unterscheiden und ob Unterschiede in der Wahrnehmungsverarbeitung und der exekutiven Funktionen, bestimmte Bildeigenschaften vorhersagen können. Im Rahmen dieser Studie wurde mit 59 Teilnehmer: Innen der ROCF durchgeführt, ein Test zur Messung sowohl der Wahrnehmungsverarbeitung als auch der exekutiven Funktionen. Des Weiteren kreierten Teilnehmer: Innen abstrakte Zeichnungen, die anhand von 28 objektiven, quantitativen Bildeigenschaften analysiert wurden. Sowohl der ROCF als auch die Bildeigenschaften zeigten keine signifikanten Unterschiede zwischen den beiden Gruppen, mit Ausnahme des Bildmerkmals fourier sigma ($B = 0.30$, $SE = 0.09$, $t= 3.30$, 95 % CI [0.12 , 0.47], $p = 0.03$), welches in der autistischen Gruppe signifikant niedriger ausfiel. Dies deutet darauf hin, dass die von autistischen Personen erstellten Zeichnungen eher natürlichen Szenen oder traditionellen Kunstwerken ähneln. Weitere Regressionsanalysen ergaben, dass höhere Fragmentierungswerte beim ROCF, welche die lokale oder globale Wahrnehmungsverarbeitungsneigungen quantifizieren, und höhere Organisationswerte auf dem ROCF, welche auf eine bessere exekutive Funktion hinweisen, symmetrischere, komplexere Zeichnungen vorhersagten.

Erklärung zur Verwendung von Künstlicher Intelligenz (KI)

Hiermit erkläre ich, dass ich die folgenden KI-Hilfsmittel zur Erstellung meiner Masterarbeit mit dem Titel „Self-Expression in Autistic Adults: Differences in Art and Cognition“verwendet habe. Ich versichere, dass die Kennzeichnung der verwendeten KI-Hilfsmittel vollständig ist, inkl. Verwendungszweck, Produktname, als auch ggfs. Prompts und Outputs des KI-Hilfsmittels. Ich verantworte die Auswahl und die Übernahme sämtlicher Ergebnisse der von mir verwendeten KI-Hilfsmittel vollumfänglich selbst.

Verwendungszweck*	**Produktname des KI-Hilfsmittels**
Statistische Analyse (Schreiben, Verbessern und Anpassen von R Skripten)	StatsBot (https://statsbot.univie.ac.at/)

* Hilfsmittel zur Überprüfung von Grammatik und Rechtschreibung oder der automatisierten Erstellung des Literaturverzeichnisses sind von dieser Erklärung ausgenommen.