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Understanding cognitive anomalies in adolescents with anorexia nervosa

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Understanding cognitive anomalies in adolescents with anorexia nervosa

Clinical presentation and consequences of anorexia nervosa

Anorexia nervosa (AN) is a severe mental disorder that typically occurs in adolescent girls and young women. According to the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association, 2013), three necessary criteria have to be fulfilled to justify a diagnosis of AN. Patients with AN often restrict their energy intake in drastic ways, resulting in low body weight (Criterion A). Another strategy that is often employed for weight loss is excessive exercise. Significantly low body weight is typically defined by considering the Body-Mass-Index (BMI). For adults, a BMI of 18.5 kg/m^2 or less is considered an indicator of AN. For children and adolescents, it is an age-adjusted BMI below the fifth percentile. Despite their already low body weight, patients experience continuous fear of gaining weight and keep restricting energy intake (Criterion B). Contributing to these maladaptive behaviors is their distorted body image and the large impact of body weight and shape on their self-worth (Criterion C). Even though their weight might already be dangerously low, affected individuals remain unable to recognize it as such and to consider the serious consequences their eating behavior has on their health. The DSM-5 describes four stages of illness severity: mild AN if the BMI is above 17, moderate with a BMI between 16 and 16.99, severe with a BMI between 15 and 15.99, and extreme with a BMI below 15 (American Psychiatric Association, 2013). By determining the symptom development, the stage of the illness can be categorized as follows: acutely ill patients meet all of the above-mentioned criteria. Patients in partial remission have restored and maintained their weight for a period of time and no longer restrict their food intake, but either criterion B or C is still present. Fully remitted individuals do not fulfill any of the diagnostic criteria and have maintained that state for some time after all criteria were previously met before.

As a secondary result, malnutrition often leads to endocrinologic or metabolic disturbances and other physical dysfunctions. They might include loss of menstruation in women (amenorrhea), cold intolerance, fatigue, dizziness, fainting, chest pain, cardiovascular instabilities, and many more (Neale & Hudson, 2020). In contrast to numerous other mental disorders, distress, and functional impairment are not necessary criteria for a diagnosis of AN. Nevertheless, research consistently shows significant impairment in quality of life in patients with AN. Bamford et al. (2015) were able to show that changes in BMI and eating disorder symptomatology lead to improvements in quality of life. Conversely, eating disorder symptomatology has been shown to lead to short-term improvements in quality of life which

might be explained by a subjectively positive evaluation of the low weight and associated symptoms due to the illness (Mitchison et al., 2015).

Diagnostic differentiation

Besides the restrictive type, characterizing patients who achieve their low body weight primarily through dieting, fasting, and/or excessive exercise, there is a binge-purge subtype. Patients with binge-purge AN experience recurrent episodes of binge eating, meaning that they consume large amounts of food within a short period of time. They usually try to compensate for those episodes by more restriction, vomiting, or misuse of medications. Some patients with binge-purge AN do not binge eat but still purge after consuming food. Individuals with the binge-purge subtype tend to score higher in impulsivity and alcohol or drug abuse is seen more frequently (American Psychiatric Association, 2013).

Even though significant underweight represents a crucial criterion for AN diagnosis, there is a subgroup of patients who meet all criteria except their weight never drops below the threshold of the normal range. These patients receive the diagnosis of atypical AN. This diagnosis is often administered to individuals coming from a very high weight who therefore have not dropped below the threshold of underweight (American Psychiatric Association, 2013). Since the diagnosis of AN is still so closely linked to body weight, atypical AN runs the risk of remaining undetected. Research shows that patients with this phenotype are admitted to inpatient treatment less often (Harrop et al., 2021).

AN is to be differentiated from other eating disorders, the main ones being bulimia nervosa (BN) and binge eating disorder (BED). Patients with BN experience frequent binge eating episodes in which they consume very large amounts of food accompanied by a feeling of loss of control over food. These binge eating episodes are often followed by compensatory behavior such as vomiting, fasting, excessive exercise, or misuse of medications. Just as in patients with AN, body weight and shape have a large impact on one's self-worth. In contrast to patients with binge-purge AN, BN patients experience episodes of binge eating more frequently and usually have a BMI within or even above the normal range (American Psychiatric Association, 2013).

BED is characterized by reoccurring episodes of binge eating with a perceived loss of control over food. These episodes are accompanied by increased speed of eating, eating until physical discomfort, eating without hunger, eating alone or in secret as well as feelings of

guilt or disgust over one's eating behavior. Binge eating is not followed by compensatory behavior as seen in BN (American Psychiatric Association, 2013).

Epidemiology

AN typically develops early in life with the peak age of onset ranging from 15 to 19 years (Micali et al., 2013). However, it does occur much earlier as well with patients as young as 8 years (Petkova et al., 2019). Onset later in adulthood is reported too, although much less frequently. While adolescent-onset of the disorder generally leads to better outcomes than adult-onset (Andrés-Pepiñá et al., 2020), earlier onset in adolescence or childhood predicts worse outcomes in eating pathology and worse chances of full recovery (Dobrescu et al., 2020). Regarding the pathogenesis, it proves difficult to pinpoint singular causes that lead to the development of AN. It is assumed that genetic, biological, neuropsychological, socio-emotional, and sociocultural factors play together (Treasure & Schmidt, 2013).

Although not highly prevalent compared to other mental disorders, AN is thought to be the most common eating disorder in adolecents. Stice et al. (2013) report a lifetime prevalence of 3.6%. A recent review estimates the lifetime prevalence at 4% for females and 0.3% for males (Van Eeden et al., 2021). Since women are more often affected than men, the vast majority of studies on AN focus on female participants, which states a problem regarding the seeking of treatment and treatment outcomes in male patients. According to the DSM-5, AN is especially prevalent in postindustrialized, high-income countries including the U.S., European countries, Australia, New Zealand, and Japan (American Psychiatric Association, 2013). A recent study examining incidence rates within the past 40 years found a stable overall incidence of AN, but a significant increase in incidence among 10-14 year-olds within the past decade, which is especially worrying (Van Eeden et al., 2023). The reasons for this increase are mostly unclear. One possible explanation might be the age of onset of puberty, which has gone down significantly during the past century. Since an earlier onset of puberty is associated with a higher risk for AN, it might partially explain increasingly younger patients (Van Eeden et al., 2023). Another factor the authors discussed is the rise of social media within the latest decade. Adolescent girls are much more susceptible to external influences which is why the constant confrontation with thin, athletic individuals on social media use might drive a negative and distorted body image (Saul et al., 2022). It is further discussed whether an elevated awareness of parents and clinicians simply leads to more reliable detection of the illness and therefore to changes in reported incidence (Van Eeden et al., 2023).

Outcomes of anorexia nervosa

Despite extensive research on potential epidemiological factors contributing to the development of AN, treatments are still insufficiently successful (Dobrescu et al., 2020). Still, illness duration before seeking treatment is associated with worse outcomes over time which calls for more extensive treatment concepts and opportunities (Andrés-Pepiñá et al., 2020). If treatment has not been provided within three years after onset, recovery prospects diminish drastically (Treasure & Russell, 2011). While weight is often restored within a relatively short period of time, psychological symptoms usually persist for much longer and hold the risk of relapse (Neale & Hudson, 2020).

A longitudinal study examining the outcomes of AN over the course of 30 years reported full recovery in 64% of patients with adolescent-onset and a current eating disorder in 19% of patients (Dobrescu et al., 2020). Another long-term study showed a very similar recovery rate of 65.8% after 22 years, and a mortality of 2% (Andrés-Pepiñá et al., 2020). In the often-cited review of Steinhausen (2002) 46.9% of all patients fully recovered while in 20.8% of the cases the illness took a chronic course and 5% died. Fichter & Quadflieg (2016) report a five times higher risk of mortality in AN patients than in the general population and a significantly higher risk of death for AN than for other eating disorders. Despite studies reporting varying numbers regarding mortality, AN is thought to be the most lethal mental disorder (Arcelus et al., 2011). The most common causes of death are medical complications such as circulatory collapse, cachexia, and organ failure or suicide (Fichter & Quadflieg, 2016). Regarding the mean illness duration, a recent review reports a variation between 6.5 to 14 years. Also, transitioning from AN to other eating disorders, especially BN, is very common (Miskovic-Wheatley et al., 2023). In the AN sample of Dobrescu et al. (2020), half of the patients were diagnosed with BN at some point within 10 years after the first assessment. Relapse rates are highest in AN compared to other eating disorders (Miskovic-Wheatley et al., 2023).

Prognostic factors

Clinical factors contributing to a worse prognosis are symptom severity, comorbidities, younger age of onset, lower BMI at first presentation, longer illness duration, binge-purge behaviors, duration of treatment, and inpatient treatment (Miskovic-Wheatley et al., 2023). Beyond that, there are disadvantageous sociocultural factors such as being male, belonging to the LGBTQIA+ community, a non-white ethnic background, having a lower level of

education and socioeconomic status, living in a more rural area, or having a family member with an eating disorder (Miskovic-Wheatley et al., 2023).

Comorbidities and associated characteristics

AN frequently goes along with other forms of psychopathology. Wentz et al. (2009) reported comorbid disorders in 39% of AN patients with specifically obsessive-compulsive disorder (OCD) and autistic spectrum disorder predicting worse outcomes. In a more recent longitudinal study, 47.4% of the patients demonstrated a comorbidity at the time of first treatment, the most common ones being anxiety disorder, depression, and OCD. At 22-year follow-up, of those who still showed a current eating disorder, the number had risen to 70% of patients suffering from at least one comorbid disorder (Andrés-Pepiñá et al., 2020). Other studies confirmed that comorbid disorders usually become more frequent with prolonged illness duration (Plana-Ripoll et al., 2019). Ulfvebrand et al. (2015) found comorbid axis 1 diagnoses in 71% of patients. In the following paragraphs, the most common comorbidities will be addressed in more detail.

Between 4.5% and 62% of AN patients have a lifetime comorbid diagnosis of OCD (Cederlöf et al., 2015). A recent meta-analysis reported a lifetime comorbidity rate of OCD of 18% (Mandelli et al., 2020). In another meta-analysis, AN patients had a 12.9 higher risk for lifetime OCD than participants without AN (Drakes et al., 2021). Notably, certain forms of obsessions and compulsions seen in individuals with AN can be seen as part of the eating disorder. Typical symptoms would include hoarding recipes or ruminative thoughts about food. If obsessive thoughts and behaviors are purely related to food, a diagnosis of OCD might not be justified (American Psychiatric Association, 2013).

A recent review reported a comorbid diagnosis of depression ranging from 36% to 80% due to studies being very heterogeneous (Calvo-Rivera et al., 2022). Both disorders might possibly be linked through the severely impaired self-image in depression which could represent a risk factor for developing an eating disorder. In line with this, the level of body image distortion seems to predict the additional development of depressive symptoms over the course of the eating disorder. AN patients with depression usually display more severe symptoms, commit more suicide attempts, and are hospitalized more often. The same review suggested that comorbid depression could explain the high prevalence of alexithymia in AN patients (Calvo-Rivera et al., 2022). Just as in comorbid OCD, it is important to note that certain symptoms that are typical for depressive disorder can be caused by starvation. Depressive mood, social withdrawal, irritability, insomnia, and diminished sex drive are seen

in individuals without AN who are malnourished. Hence, certain depressive symptoms can be viewed as purely secondary consequences of starvation due to the eating disorder (American Psychiatric Association, 2013).

Another group of common comorbidities are anxiety disorders. In the sample of Ulfvebrand et al. (2015), 54.5% of female and 37.8% of male patients with restrictive AN had a comorbid anxiety disorder. The most common one was generalized anxiety disorder with 27.9% in women and 24.3% in men.

However, especially regarding anxiety and mood disorders the effect seems to be bidirectional. The direction and time relation of these different symptoms are usually difficult to disentangle and are the subject of scientific debate. Research provides evidence for effects in both directions. Studies demonstrate preceding anxiety before the onset of AN and beyond AN recovery. A recent study compared patients with either major depression or any anxiety disorder with healthy controls. The researchers found a lifetime diagnosis of AN in 2.3% of patients versus only 0.5% of healthy controls (Garcia et al., 2020). Simultaneously, the presence of anxiety negatively affected the outcome of the eating disorder. Other studies showed pre-existing anxious temperament and negative emotionality in AN patients. Research investigating the genetic foundations of psychopathology gives some insight into this association. Both genetic and environmental influences were shown to underly the development of comorbid anxiety and disordered eating with earlier onset of anxiety (Fairweather-Schmidt & Wade, 2020).

Besides any psychopathology, research repeatedly shows common personality characteristics in women with AN that are associated with the disorder and usually fall into a similar cluster of personality traits. They comprise higher anxiety, perfectionism, lower novelty-seeking, harm avoidance, and punishment sensitivity (Danner et al., 2012; Johnston et al., 2018). Studies found that anxious temperament and negative emotionality were risk factors for AN. In a recent study, Longo et al. (2024) demonstrated associations between perfectionism and core dimensions of AN like drive for thinness, and eating pathology. The data further revealed correlations between perfectionism and anxious temperament. Another study reported clinical perfectionism as a reliable predictor of AN (Miles et al., 2022). Other findings suggest higher sensitivity for punishment and reward in AN patients compared to healthy controls (Jappe et al., 2011). Further, higher punishment sensitivity, meaning a higher sensitivity for criticism and negative stimuli in general, has been associated with worse AN prognosis (Jonker et al., 2022). The DSM-5 further describes feelings of ineffectiveness, a

strong desire to control one's environment, inflexible thinking, limited social spontaneity, and overly restrained emotional expression as common features associated with AN (American Psychiatric Association, 2013). These traits are often found in acutely ill patients as well as recovered patients (Danner et al., 2012). Accordingly, they are not only thought to contribute to the onset and maintenance of the disorder. Evidence indicates a genetic predisposition to these characteristics since they are observed in unaffected family members as well (Jacobs et al., 2009). Milder distinctions in perfectionism, anxiety, novelty-seeking, and harm avoidance in mothers of AN patients were linked to less severe symptomatology in their daughters which does support a familiar component in the pathogenesis of AN (Jacobs et al., 2009).

Neurocognitive Anomalies in AN

Besides common personality traits and comorbidities that can act as risk factors for developing AN, extensive research explores numerous other factors contributing to the onset of the disorder. In this context, the idea of endophenotypes is repeatedly discussed. Endophenotypes are heritable, stable characteristics associated with the illness and are thought to be present before the onset of the disorder and to persist beyond recovery (Gottesman & Gould, 2003). Endophenotypes that are widely discussed in connection with AN are anomalies in neurocognitive functioning, particularly the domains of *set-shifting* and *central coherence* (Gottesmann & Gould, 2003). These concepts are further described in the following paragraphs.

Set-shifting

Set-shifting is an operationalization of cognitive flexibility and refers to the ability to switch between tasks, thoughts, or strategies depending on situational changes (Smith et al., 2018). Research consistently finds impaired set-shifting in adult AN patients (Danner et al., 2012; Keegan et al., 2021; Stedal et al., 2021; Wu et al., 2014). This impairment is assumed to clinically present itself in the form of rigid rule-bound thinking patterns and fixation on routines related to food and body weight that are hard to deviate from (McAnarney et al., 2011; Roberts et al., 2007). Furthermore, it is thought to make recovery more difficult since the willingness and ability to change one's behavior are impaired. Poor set-shifting has also been found in unaffected mothers and sisters of AN patients (Holliday et al., 2005; Kanakam et al., 2013; Roberts et al., 2010). Difficulties in set-shifting seem to be relatively stable beyond recovery from the disorder. Numerous studies found no differences in set-shifting ability between acutely ill and recovered patients (Bohon et al., 2020; Fuglset, 2019; Roberts et al., 2010; Treasure et al., 2007). Impairments in set-shifting and other domains of executive

functioning were also found in patients with other eating disorders, suggesting it to be a transdiagnostic factor (Diaz-Marsa et al., 2023).

Central coherence

Central coherence describes the tendency of healthy individuals to process information within the context in which it is embedded, which is also referred to as global processing. According to Gestalt theory, a whole unit is comprised of interacting global and local structures. While both are necessary for perception and information processing, more global elements are usually prioritized over local elements (Navon, 1977). Accumulating evidence indicates that AN patients show weak central coherence. Simply put, they show a cognitive bias toward a local, more detailed information processing style that fails to consider the context, in other words, to see the bigger picture (Happé & Frith, 2006; Keegan et al., 2021; Stedal et al., 2021; Wu et al., 2014). This bias is thought to be associated with the strong fixation on body characteristics, food components, numbers on the scale, etc., without being able to consider the serious consequences these behaviors have on overall health. This cognitive style was also found in unaffected family members of AN patients which points to a familial predisposition (Galimberti et al., 2013; Lang et al., 2016). Weight-restored patients usually demonstrate better global processing which suggests that part of it is accounted for by rapid weight loss and malnutrition (Lopez et al., 2009).

Cognitive Remediation Therapy (CRT)

Considering these findings, neurocognitive anomalies like poor set-shifting and weak central coherence have recently become subject to new treatment approaches. Due to the severe psychological stress and high risk of medical complications through AN, there is a pressing need for a larger variety of treatment options for affected patients. Emerging from research on cognitive anomalies is a relatively new therapy concept called Cognitive Remediation Therapy (CRT). It specifically targets neurocognitive functions such as cognitive flexibility and global processing by trying to modify cognitive processes (Giombini et al., 2022). This is achieved through training of metacognition, hence reflecting on cognitive strategies in order to change maladaptive thinking and behavior. CRT can be provided in an individual setting in ten weekly or twice weekly sessions as well as in a more abbreviated form in a group setting. Research shows promising results regarding the feasibility, acceptance, and effectiveness of CRT in patients with AN (Tchanturia et al., 2014). Effects on younger patients are less well examined and more inconsistent, reflecting the lack of sufficient high-quality research. However, one meta-analysis provided evidence for significant

improvements in central coherence in young patients through CRT (Tchanturia et al., 2017). In a recent study testing a group-setting CRT program on young patients, significant changes were found in set-shifting and central coherence (Rhind et al., 2022). Due to the need for more effective therapeutic options, CRT might be a promising additional approach to improve symptoms and engage patients in treatment early on. Still, randomized controlled trials are needed to confirm previous results. Furthermore, treatment approaches that include, but are not limited to the improvement of cognitive skills have proven to successfully influence central coherence and set-shiftin (Wittek et al., 2024).

In sum, research on cognitive functioning and treatment options targeting this topic specifically, is a field of which the potential has not been exhausted yet. Given that established forms of therapy do not always provide the improvement that is hoped for, research needs to spread further in different directions. In this regard, achieving a better understanding of neurocognitive functioning in AN patients can contribute to a better adaptation of CRT and hence better chances of recovery.

The state or trait debate

Although studies suggest that cognitive anomalies might be relevant for the pathogenesis of AN, an extensive examination of the body of research reveals unanswered questions. Despite the large body of evidence demonstrating neurocognitive anomalies in acutely ill adults, findings are inconsistent. Some studies failed to demonstrate similar results in adolescents and therefore suggest that cognitive deficits might only establish themselves beginning at a certain age (Lang et al., 2014; Miles et al., 2020; Rößner et al., 2017; Van Noort et al., 2016). A recent meta-analysis reported overall impaired cognitive functioning across domains with a moderating effect of age (Stedal et al., 2021). Furthermore, the authors found that participants with a lower BMI tend to perform worse in cognitive tasks which would indicate that cognitive anomalies are merely a state caused by malnutrition and dependent on age. However, in the same study, neither age of onset nor illness duration affected cognitive performance, speaking against ongoing malnutrition as the underlying cause. Other studies found no impairments in set-shifting or central coherence in remitted patients (Bohon et al., 2020; Castro-Fornieles et al., 2019). These findings challenge the hypothesis of neurocognitive anomalies being endophenotypes since they might as well just be results of the disorder that diminish after recovery.

Nevertheless, other studies draw a different picture. Danner et al. (2012) were able to show more perseverative errors in acutely ill and recovered patients than in healthy controls.

Perseverative errors are an indicator of cognitive inflexibility or weak set-shifting as they show a lacking ability to mentally switch between concepts. In line with these findings, Lopez et al. (2009) found weak central coherence and superior local processing in remitted AN patients. Furthermore, Lang et al. (2015) found more perseverative errors and more global processing in children and adolescents with AN. Similar results were found in a study by McAnarney et al. (2011). A synthesis of studies using the Rey-Osterrieth Complex Figure Test (ROCFT) found consistently poorer central coherence in AN patients and unaffected family members across studies (Lang, Roberts, et al., 2016). All of these research results are inconsistent with some other findings and suggest neurocognitive anomalies in AN as stable characteristics. However, the fact that the effects in acutely ill adults are much more consistent than in acutely ill adolescents and recovered patients calls for exploration of the underlying causes.

As a possible explanation, research suggests large interindividual differences in the performance in cognitive tasks among currently ill and recovered patients. This raises the possibility that cognitive anomalies might not be general traits in AN, but rather traits of a subgroup of patients. Since remitted patients show these characteristics less often, it would be plausible that this subgroup tends to have a more severe and chronic form of the illness with a worse chance of recovery (Danner et al., 2012; Merwin et al., 2010; Roberts et al., 2010; Talbot et al., 2015). According to this assumption, weak central coherence and poor set-shifting would in fact be stable characteristics, but only in a subpopulation of patients. This is in line with research finding that patients with stronger local processing often have more severe symptoms (Harrison et al., 2012; Roberts et al., 2010; Weinbach et al., 2017). Also, impaired set-shifting has been demonstrated to go along with longer illness duration and more severe symptoms (Roberts et al., 2010; Tchanturia et al., 2011).

These results might also provide an explanation for the more consistent findings in adult patients. Since the disorder typically establishes itself in adolescence, patients with especially severe symptoms and therefore a worse chance of recovery might be more likely to still be ill in adulthood (Zerwas et al., 2015). Findings, demonstrating a longer duration of illness in patients with poor set-shifting compared to patients with intermediate set-shifting skills, back this assumption (Danner et al., 2012; Roberts et al., 2010). Accordingly, adult AN samples in studies investigating neurocognitive functioning, often display an overall longer illness duration. In a review of studies on central coherence, adult participants in all studies had an illness duration of nine years or longer (Lang et al., 2016).

All of the findings mentioned above might provide an explanation for the inconsistency in previous research. The overall conclusion would be that an inflexible, detail-oriented thinking style exacerbates the symptoms and worsens the prognosis of AN. Danner et al. (2012) found impaired set-shifting in acutely ill patients and recovered patients compared to healthy controls. But, they could not detect any group differences in central coherence. Remarkably, they showed that patients with poorer set-shifting usually displayed weak central coherence too. This suggests that rigid, inflexible traits accumulate into a pattern of interrelated characteristics that varies in distinctness between individuals. It is therefore reasonable to identify other factors that fit into this cognitive and behavioral pattern. One possible factor might be comorbid disorders. As established earlier, there is a considerable clinical resemblance between AN and OCD. Therefore, it might be reasonable to take into account additional symptoms of OCD to make sense of the mixed results regarding cognitive anomalies.

Obsessive-compulsive symptoms

It has been proposed that OCD is one of the most common comorbid disorders of AN. Obsessions are intrusive and unwelcome obsessional thoughts. Compulsions are repetitive behaviors or rituals to prevent perceived harm that is established through obsessions (American Psychiatric Association, 2013). AN is often accompanied by a comorbid diagnosis of OCD. In addition, OCD and obsessive-compulsive personality disorder have been suggested as risk factors for the development of eating disorders (Jacobi et al., 2004). Especially individuals who show obsessional traits in childhood are more likely to develop AN later in life (American Psychiatric Association, 2013). In addition, OCD as well as other comorbidities demonstrate associations with a worse prognosis and a more severe course of AN. Drakes et al. (2021) reported a higher prevalence of a lifetime comorbidity of OCD in patients requiring more extensive treatment, suggesting a more common comorbidity in more severe AN cases.

It is assumed that AN and OCD share certain etiological factors that can contribute to the development of both disorders and provide explanations for their conceptual proximity (Micali et al., 2011; Steinhausen et al., 2015). Research shows that weak set-shifting is associated with perfectionism, just as OCD is (Bühren et al., 2012). Additionally, the large overlap in clinical presentation might be partially explained by increased compulsivity in both disorders in the form of maladaptive behavior that persists despite negative consequences (Godier & Park, 2015). Other personality characteristics that are thought of as risk factors for

AN and OCD are neuroticism, harm avoidance, conscientiousness, concern over mistakes, and perfectionism (Benatti et al., 2014; Ettelt et al., 2008; Fassino et al., 2002). Some authors even suggest that AN could be classified under some broader conceptualization of OCD (Hollander et al., 2007). Research shows associations between the core dimensions of AN and compulsions as well as between core dimensions of both disorders and concern over mistakes (Levinson et al., 2019).

Compulsive behaviors as seen in AN and OCD might also be interpreted as a form of cognitive inflexibility. Additional symptoms of OCD could hence amplify cognitively rigid tendencies, further reinforcing maladaptive behavioral and cognitive patterns associated with AN. This could, in turn, impair recovery chances. Inconsistent findings on cognitive functioning might therefore partially depend on the presence or absence of OCD symptoms (Bohon et al., 2020). This is supported by study results demonstrating greater impairment in set-shifting in patients with OCD than in weight-restored AN patients and more symptoms of OCD in adults with AN than in adolescents (Bohon et al., 2020; Steinhausen, 2002). Nevertheless, research on neurocognitive functioning in AN usually fails to report on and control for comorbid disorders. Moreover, weak central coherence in acutely ill patients has been shown to be particularly present in patients with a comorbid OCD diagnosis (Lopez et al., 2008).

Research gap

In summary, anomalies in cognitive functioning are consistently shown in research on currently ill AN patients. Less clear findings in studies examining adolescents suggest that these anomalies are not as pronounced and/or as common as in adult patients. Inconsistent results in recovered patients further demand a more extensive examination of this association. These inconsistencies challenge the theory that neurocognitive anomalies are stable characteristics. Other study results do suggest stability over time by demonstrating the same anomalies in adolescent and recovered patients as well as in unaffected family members. Therefore, it is yet to be resolved whether neurocognitive anomalies are a predisposing factor for the illness or a result of AN, diminishing after recovery, or possibly leading to a scarring effect.

One possible explanation would be that cognitive anomalies are more common in patients with additional symptoms that amplify rigid thinking patterns and detail fixation in the form of obsessions and compulsions. Previous research points to symptoms of OCD possibly being a part of the puzzle. It seems reasonable that symptoms of OCD and

neurocognitive anomalies are interconnected and in combination add up to a general pattern of mental rigidity that is associated with more severe symptoms and harder recovery. This could explain the mixed findings regarding central coherence and set-shifting in adolescents since patients in this age group might be more heterogeneous in symptom severity.

Inconsistent findings in recovered patients might be explained similarly since they might not have had as severe symptoms in the first place and were therefore able to recover relatively quickly. As research suggests, neurocognitive anomalies are thought to be exacerbated during the acute phase of the illness and diminish with recovery, but still be present after remission.

Furthermore, cognitive anomalies in combination with OCD symptoms might add to a more severe symptomatology and impair chances of recovery. In this case, cognitive anomalies would not be a predisposing factor for AN in general, but instead a predisposing factor for a more severe course and worse prognosis of the illness.

Based on the previous body of research, it is hypothesized that there will be differences between AN patients and healthy controls in central coherence and set-shifting. These differences should be especially pronounced in acutely ill patients, meaning they are expected to display weaker central coherence and set-shifting than remitted patients. Since research still partially indicates a predisposition for such cognitive weaknesses, it is hypothesized that remitted patients will display weaker central coherence and set-shifting than healthy controls. Weaker central coherence and set-shifting are further expected to be associated with symptoms of OCD. Specifically, it is expected that OCD symptoms will influence the group differences in the cognitive measures. Worse performance in cognitive functioning as well as more symptoms of OCD are hypothesized to predict more severe AN symptoms in acutely ill patients and a longer illness duration.

Research questions and hypotheses

The overall goal of this study was to analyze differences in neurocognitive functioning between AN patients in different stages of the illness and healthy controls. Moreover, it was aimed to explore the underlying causes of these differences and explain interindividual variation by taking into account other influencing factors like OCD symptoms, illness duration, and symptom severity.

RQ 1: Do AN patients and healthy controls differ in central coherence and set-shifting?

H1: Acutely ill patients display more weak central coherence than healthy controls, and patients in partial or full remission.

H2: Acutely ill patients display worse set-shifting than healthy controls, and patients in partial or full remission.

H3: Patients in partial or full remission display more weak central coherence than healthy controls.

H4: Patients in partial or full remission display worse set-shifting than healthy controls.

RQ 2: Do OCD symptoms partly account for worse central coherence and set-shifting?

H1: Participants with more OCD symptoms display worse central coherence.

H2: Participants with more OCD symptoms display worse set-shifting.

H3: The influence of group affiliation on central coherence is moderated by OCD symptoms.

H4: The influence of group affiliation on set-shifting is moderated by OCD symptoms.

RQ 3: Are worse central coherence and set-shifting and OCD symptoms associated with more severe AN symptoms and longer duration of the illness in acutely ill patients?

H1: Acutely ill patients with weak central coherence display more severe AN symptoms.

H2: Patients with weak central coherence display a longer illness duration.

H3: Acutely ill patients with weak set-shifting display more severe AN symptoms.

H4: Patients with weak set-shifting display a longer illness duration.

H5: Acutely ill patients with more OCD symptoms display more severe AN symptoms.

H6: Patients with more OCD symptoms display a longer illness duration.

Methods

Study design

The study followed a cross-sectional design with three patient groups and a control group. The patients were divided into acutely ill, partially remitted, and fully remitted patients. Data were collected in the context of the ANBEL study, a cooperative project of the Medical University of Vienna and the University of Vienna. The main focus of the project a reward processing in AN which included extensive psychological assessments and an MRI scan. This work however will focus on clinical and neurocognitive data that were collected in the course of the project. Ethical approval was provided by the Ethics commission of the Medical University of Vienna (EK 1670/2021).

Participants

Participants were recruited mainly through practitioners of the Department of Child and Adolescent Psychiatry of the Medical University of Vienna. Additionally, social media advertisements and personal contacts of the researchers were consulted for the recruitment of healthy control and fully remitted patients. Participants were female adolescents and young adults between the ages of 12 and 30. After the clinical assessments, AN patients were assigned to three different groups based on the current state of the illness. Healthy controls were matched to the patient group regarding age. The aimed sample was planned to consist of 90 patients, of which 30 are in partial remission, 30 are in full remission, and 60 are healthy controls. To be eligible, participants needed sufficient German language skills and had to provide written consent. Inclusion criteria were a present or past diagnosis of AN according to DSM-5 criteria for patients, and no neurological or psychiatric illnesses for healthy controls. Further, exclusion criteria comprised intellectual disabilities, organic psychosyndrome, psychotic or bipolar disorder, pregnancy, cardiovascular disease or illness of the lungs, metabolic disease. Since the participants also underwent an MRI scan in the second part of the study, they had to fulfil several conditions for MRI compatibility such as claustrophobia, or metal parts in the body.

Procedure

After first contact with the study team, an online questionnaire via SosciSurvey was sent to the participants to screen for eligibility criteria and collect first pieces of general information like age, contact details, etc. If eligibility was given, an appointment for the on-site assessment was set. One week prior to the assessment, a second online questionnaire was sent to the participants via LimeSurvey software, including the *Obsessive-Compulsive*

Inventory Revised (OCI-R) to assess obsessive-compulsive symptoms. They were further provided written consent and detailed information on the testing process via mail which they had to sign and bring with them on the day of testing. The next step was an appointment at the Department of Child and Adolescent Psychiatry of the Medical University of Vienna. Here, the neurological tests were conducted. In addition to the tests described in the following paragraph, a structural clinical interview (Diagnostisches Interview bei psychischen Störungen; DIPS) was conducted with all participants to assess any comorbid disorders of the AN patients and to make sure that the controls were all psychologically healthy. After finishing all tests, participants received a 70€ voucher of their choice.

Measures

Eating disorder symptomatology

Eating disorder symptoms were assessed using the *Eating Disorder Examination* (EDE; Hilbert & Tuschen-Caffier, 2016) in order to assess symptom severity and the current state of the illness for group administration. The EDE is a diagnostic interview measuring AN symptomatology on the subscales of Restraint, Eating Concern, Weight Concern, and Shape Concern. The Restraint scale captures the attempt to limit the amount of food consumed or to follow specific dietary rules. The Eating Concern scale describes ruminating thoughts about food and related topics. The Weight Concern scale comprises the preoccupation with body weight and its effect on self-worth. The Shape Concern scale captures similar thoughts and emotions centering around the shape of the body. The interview comprises 36 items, of which 22 are included in score calculations. Every item measures either the frequency or intensity of one symptom from zero to six, with six meaning extreme symptom severity or the symptom was present every single day during the past four weeks. For each subscale, a mean can be calculated by dividing the sum of the item scores by the number of items. Additionally, a total mean score can be determined by calculating the sum of the subscale means and dividing it by four. The reliability of the total score is reported to be high with a Cronbach's α of .93 (Hilbert & Tuschen-Caffier, 2016). For the group assignment, specific criteria needed to be checked to determine whether a participant was still in the acute phase of the illness, partially remitted, or fully remitted.

Participants were classified as acutely ill patients if they fulfilled all of the three main criteria according to DSM-5 that were elaborated earlier. Participants were considered partially remitted if they had reached a BMI above 18.5 and did not restrict food intake anymore, but still experienced symptoms of weight or shape concern, had a total mean EDE

score within two standard deviations of the normal score and had maintained that state for at least three months. They were administered to the group of fully remitted patients if their BMI was above 19, they did not restrict food intake, had no symptoms of weight or shape concern, their total mean EDE score was within 1.5 standard deviations of the normal score, and they had maintained that state for at least twelve months.

To check the weight criteria, height and weight were measured at the on-site appointment. Following that, the BMI was calculated. Since a good part of the participants were under 18 years old, the BMI alone was not a suitable measure. In addition, the BMI standard deviation score (BMI-SDS) was calculated to enable comparison of participants all across the age range. It is a standardized measure that is based on the BMI but also consideres age and sex (Kromeyer-Hauschild et al., 2001).

Set-shifting

Set-shifting was assessed using a modified version of the *Computergestütztes Kartensortierverfahren* (CKV; Drühe-Wienholt & Wienholt, 2013) which is the German version of the Wisconsin Card Sorting Task (Nelson, 1976). The test is conducted on a computer where four decks of cards are shown with an additional deck from which new cards are drawn. The cards show geometric figures differing in number, shape, and color. Participants have to sort a newly drawn card to one of the four decks using one of the mentioned criteria. The rule, by which the card has to be sorted, also referred to as *concept*, is decided by the program and is not communicated to the participant. Via feedback from the program, they learn which rule to follow. After ten correct sortings, the concept changes without warning. The test ends after finishing six concepts or after using all the 96 cards from the drawing deck. The CKV has several outcome parameters, the most relevant for set-shifting being the number of perseverative errors. This number is indicative of how long participants hold onto a concept after receiving negative feedback. For the sake of this study, two different measures were consulted for the analyses: the perseverative score, which is the percentage of perseverative errors of all concepts, and the percentage of total response errors, which is the percentage of perseverative errors of all errors. A cut-off of 25% perseverative errors of the total errors indicates impairments in concept switching. For this study, the absolute percentages of perseverative errors were used as metric measures.

Central coherence

Central coherence in the visuospatial domain was measured by the *Rey-Osterrieth Complex Figure Test* (ROCFT; Meyers & Meyers, 1995). It includes a complex figure which

can be broken down into 18 smaller objects. Participants are first asked to copy the figure as accurately as possible. For this purpose, they are given a box of colored pencils. Every time they finish one object or switch to another object, they have to change pencils. After 30 minutes, participants are asked to draw the figure again from memory without warning. The resulting scores are Accuracy, Recall, Organizational Strategy, Order of Construction Index, and Style Index. Both accuracy of the copy and recall are thought to benefit from a more global approach to drawing the figure. The measure of interest for this study is the Central Coherence Index which can be calculated from the latter two using Booth's (2006) scoring system. The Order of Construction Index rates the types of elements that are drawn first. The elements of which the figure is comprised can be divided into global external structure, global internal structure, local perimeter elements, and local internal elements. Higher scores in Order of Construction are achieved by drawing rather global elements first. The first six elements drawn are rated on a scale ranging from 0 to 4 depending on the category they belong to. The second index relevant to central coherence is the Style Index. It rates the main six elements of the drawing in terms of the degree of continuity. A maximum of 2 points is achieved if an object is clearly drawn consecutively. 1 point is administered if it was drawn partially fragmented, and 0 points if it was clearly drawn in several steps. To calculate the central coherence index, means are determined for both indices. The mean of the Order of Construction Index is divided by 3.3, and the mean of the style index by 2. Those values are then added resulting in a central coherence score between 0 and 2 with a higher score indicating better central coherence.

Obsessive-compulsive symptoms

Obsessive-compulsive symptomatology was measured via the *Obsessive-Compulsive Inventory Revised* (OCI-R; Gönner et al., 2007). It comprises 18 items which are rated on a 5-point Likert scale from 0 (*not at all*) to 4 (*very much*) resulting in a total score ranging from 0 to 72. It includes six subscales, namely Washing, Checking, Obsessing, Mental Neutralizing, Ordering, and Hoarding, which are measured by three items each. The authors of the questionnaire report a high reliability (Cronbach's $\alpha = .86$) (Gönner et al., 2007). The factor structure of the original version has been empirically replicated for the German version. The total score as well as most subscales demonstrate excellent internal consistency and selectivity, only the subscale mental neutralizing demonstrates lower internal consistency and selectivity. Convergent and divergent validity have been shown to be high as well (Gönner et al., 2007).

Data analysis

Statistical analyses were conducted via Statistical Package for the Social Sciences (SPSS) version 29. Sociodemographic characteristics were analyzed for group differences using t-tests. Group differences in central coherence and set-shifting between healthy controls and the whole patient group were tested using analysis of covariance (ANCOVA). Following that, group differences were examined between healthy controls and the three subgroups of the patient sample. In addition, BMI and age were included as covariates in all analyses. Possible associations between BMI or age with the neurocognitive measures were tested via Pearson correlations. Bonferroni corrected pairwise comparisons were used to examine individual differences between the subgroups. Notably, some patients had taken part in a previous study where the CKV and the ROCFT had been administered as well. This is important to bear in mind since possible practice effects need to be considered. All group comparisons were rerun by excluding those patients who had taken part in the previous study to control for learning effects in this subgroup. Pearson correlations were used to analyze the relationship between OCD symptoms and cognitive functioning. The OCI-R total score was then included in the ANCOVA model as an additional covariate to see whether it would have a significant impact on the group differences. To examine OCD symptoms, central coherence, and set-shifting as possible predictors of the total EDE score and duration of the illness in acutely ill patients, Pearson correlation analyses were conducted. A significance level of α = .05 was set for all analyses.

For the ANCOVA analyses, homogeneity of regression slopes was given. There was no significant interaction between group and age (p = .450) or between group and BMI-SDS (p = .238). The Shapiro-Wilk-Test (p = .769) and the Kolmogorov-Smirnov-Test (p = .200) were both not significant for central coherence and the OCI-R total score. For both set-shifting measures, the normal distribution of the residuals was not fulfilled. Since the ANCOVA model is generally relatively robust for this assumption, analyses were still conducted. Homogeneity of variances was also fulfilled for central coherence, OCI-R score, and perseverative score, but not for the percentage of total response errors. Four outliers in the perseverative score seemed to affect the results. Therefore, they were removed from the analysis.

Results

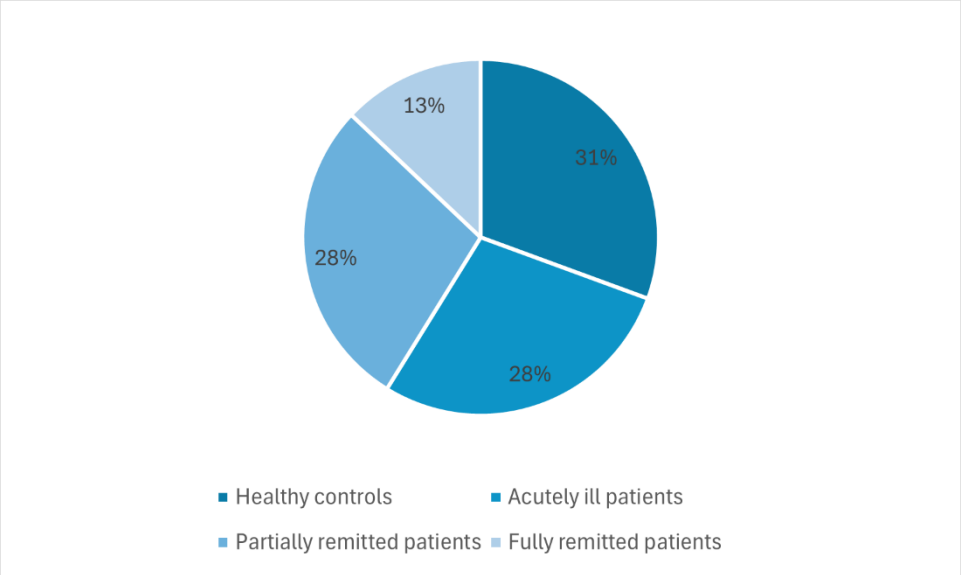
Sample characteristics

A total of 90 participants were tested. One participant was diagnosed with binge eating disorder, another patient had a purging disorder. Two participants turned out to have BN.

Hence, these four participants were excluded. One participant was supposed to be a control, but reported symptoms of disordered eating during the interview and was therefore excluded. The final sample consisted of 85 participants. 26 of them were healthy controls, 24 were acutely ill patients, 24 were partially remitted patients, and 11 were fully remitted patients. Since there were missing data in different measures, the number of cases varied between analyses. The distribution of participants over the groups is illustrated in Figure 1.

Figure 1

Number of participants in the different groups



An overview of sociodemographic characteristics and results in the variables of interest is provided in Table 1. For these regarding all participants, the three patient groups were summarized into one group. T-test group comparisons revealed significantly lower BMI ($t = 4.099$, $p < 001$) and BMI-SDS ($t = 4.578$, $p < 001$) values in the patient group which was to be expected. Further, total OCI-R scores were significantly higher in the patient group than in the control group ($t = -2.519$, $p = .014$). There were no significant group differences in age ($t = .855$, $p = .395$), central coherence index ($t = -.771$, $p = .443$), style index ($t = -.142$, $p = .888$), order of construction index ($t = -1.299$, $p = .197$), perseverative score ($t = .096$, $p = .924$), and the percentage of total response errors ($t = -.574$, $p = .568$). The mean age was approximately 18 years in both groups. The sample was overall very educated. Around half of all participants were still in school and of the remaining half, most were studying at a university.

Table 1

Sociodemographic characteristics and variables of interest

Variable	Mean (SD)	
	Patients	*Healthy controls*
Age (in years)	18.19 (3.102)	18.72 (2.208)
BMI	18.932 (3.187)	21.354 (2.536)
BMI-SDS	-0.975 (1.382)	0.072 (0.858)
Central coherence index	1.353 (0.382)	1.337 (0.333)
Order of construction index	0.680 (0.201)	0.626 (0.174)
Style index	0.671 (0.226)	0.676 (0.207)
Percentage of total response errors	3.322 (4.674)	2.638 (2.022)
Perseverative score	13.096 (12.458)	14.100 (9.129)
OCI-R total score	20.127 (13.405)	14.840 (9.035)
	N (%)	
Occupation		
School	31 (52.5%)	14 (53.8%)
Vocational training	2 (3.4%)	0 (0%)
University	22 (37.3%)	11 (42.3%)
Working	8 (13.6%)	1 (3.8%)
N total	**59**	**26**

Note. Perseverative score = Percentage of all concepts; Percentage of total response errors = Percentage of all errors

The clinical characteristics of the three patient groups are presented in Table 2. The comorbid diagnoses displayed in the table were selected since they were the most common ones in this sample. Other, less common comorbid disorders that were assessed in the clinical interview were separation anxiety, specific phobia, selective mutism, panic disorder, agoraphobia, body dysmorphia, posttraumatic stress disorder, acute stress disorder, dysthymia, disruptive affect regulation disorder, suicidalness, alcohol abuse, cannabis abuse, tobacco abuse, and non-suicidal self-harming behavior. Acutely ill patients scored significantly higher in the EDE than partially ($p < .001$) and fully remitted patients ($p < .001$). Partially and fully remitted patients did not differ significantly from each other ($p = .008$). The acute patients also displayed a significantly lower BMI-SDS than the other two patient groups

($p < .001$). Partially and fully remitted patients did not display significantly different BMI-SDS scores ($p = 1.000$). There were no statistically significant differences in age of onset ($p = 1.000$) and illness duration ($p = .208$) between the three patient groups. There tended to be fewer patients in full remission who had received inpatient treatment than acutely ill or partially remitted patients. But, these differences in frequency were not significant ($p = .662$). The prevalence of typical and atypical AN did not differ significantly between the groups ($p = .616$). Only three patients in total had been diagnosed with atypical AN. Age of onset was around fourteen years in all three groups. Most patients displayed the restrictive subtype. Only six patients had binge-purge AN. The distribution of the two AN subtypes did not differ significantly between the three patient groups ($p = .360$). No patients in full remission showed any of the most common comorbidities. Notably, there were much fewer patients in this group compared with the other two groups.

Table 2

Clinical characteristics of the patients

Variable	Mean (SD)		
	Acutely ill	*Partial remission*	*Full remission*
EDE total mean	3.096 (1.011)	1.836 (1.154)	0.661 (0.623)
Illness duration	30.857 (31.2)	45.294 (30.649)	26.917 (23.346)
Age of onset	14.175 (1.567)	14.262 (1.972)	14.250 (1.586)
BMI-SDS	-2.099 (1.147)	-.417 (1.067)	-.047 (.955)
		N (%)	
Participation in earlier study			
Yes	5 (20.8%)	10 (41.7%)	4 (36.4%)
No	19 (79.2%)	14 (58.3%)	7 (63.6%)
Inpatient treatment			
Yes	11 (40.7%)	13 (54.2%)	5 (45.5%)
No	14 (51.9%)	10 (41.7%)	6 (54.5%)
Typical AN	22 (91.7%)	23 (95.8%)	11 (100%)
Atypical AN	2 (8.3%)	1 (4.2%)	0 (0%)
AN subtype			
Restrictive type	20 (83.3%)	22 (91.7%)	11 (100%)
Binge-purge type	4 (16.7%)	2 (8.3%)	0 (0%)
Any current comorbid disorder			
Yes	13 (14.8%)	4 (4.5%)	0 (0%)
No	6 (6.8%)	10 (11.4%)	8 (9.1%)
Obsessive-compulsive disorder	6 (23.1%)	1 (4.5%)	0 (0%)
Major depression	9 (34.6%)	3 (13.5%)	0 (0%)
Social anxiety disorder	4 (15.4%)	3 (13.6%)	0 (0%)
Generalized anxiety disorder	4 (15.4%)	1 (4.5%)	0 (0%)
N total	**24**	**24**	**11**

Note. Illness duration is reported in months

Group differences regarding cognitive functioning

The first question to be addressed was potential group differences regarding central coherence and set-shifting. First, differences were assessed between all patients and healthy controls. Following that, all the subgroups were compared to each other. To avoid underlying learning effects, analyses were rerun by excluding those patients who had already taken part in the previous study. Additionally, age and BMI-SDS were included in all analyses as covariates to see, if they would have an impact. The results of these analyses are outlined in the following sections.

Set-shifting

The main results of the analyses of variance are portrayed in Table 3. There was no significant correlation between perseverative score (p = .508) or percentage of total response errors (p = .794) and age. BMI-SDS was also unrelated to perseverative score (p = .713) and percentage of total response errors (p = .616). Comparing the whole patient group with the control group revealed no significant differences in the perseverative score (p = .864) and no differences in the percentage of total response errors (p = .334). Age did not have a significant impact on perseverative score (p =.235) or on the percentage of total response errors (p = .443) when included in the model. BMI-SDS also did not significantly influence the model regarding perseverative score (p = .531) and percentage of total response errors (p = .312).

Excluding the participants who had taken part in the previous study, did not lead to significant group differences in perseverative scores (p = .607) or in percentage of total response errors (p = .165).

The results of analyses of covariance comparing all four subgroups are portrayed in Table 4. Further examination of the patient subgroups did not show any differences in perseverative scores (p = .092) and percentage of total response errors (p = .065) either. Hence, all participants performed approximately similarly in set-shifting, regardless of group affiliation, although there was a trend towards significance for the percentage of total response errors. However, looking at the effect sizes, the differences were much smaller than those between healthy controls and patients. Still, the group factor demonstrated medium effect sizes for perseverative score (partial η^2 = .086) and the percentage of total response errors (η^2 = .096). Looking at the group means, partially remitted patients had the highest percentage of total response errors. Age (perseverative score: p = .057; percentage of total response errors: p = .137) and BMI-SDS (perseverative score: p = .974; percentage of total response errors: p = .686) again did not significantly affect the model.

Notably, excluding patients who had already participated in the earlier study, did reveal significant group differences (perseverative score: $p = .013$, partial $\eta^2 = .187$; percentage of total response errors: $p = .009$, partial $\eta^2 = .199$). Here, age significantly influenced the model when consulting perseverative score ($p = .035$, partial $\eta^2 = .083$), but not in regard of the percentage of total response errors ($p = .087$). BMI-SDS did not have a significant impact (perseverative score: $p = .532$; percentage of total repone error: $p = .863$). Post-hoc pairwise comparisons showed that acutely ill patients (M = 8.012) made significantly fewer perseverative errors than partially remitted patients (M = 24.670, $p = .009$). The other pairwise comparisons were not significant. Similarly, the percentage of total response errors was significantly higher for partially remitted patients (M = 3.113) than for acutely ill patients (M = 1.669, $p = .018$). By comparing the means with those in the analysis with the full sample, it became clear that especially in the partially remitted patient, the patients who had taken the test before made fewer errors than the others. Hence, there seemed to be a practice effect in this group.

Central coherence

The analysis of group differences concerning central coherence did not indicate any significant differences between patients and healthy controls ($p = .752$). Therefore, it can be assumed that the patients did not approach the task in a more detail-focused way. Interestingly, the mean central coherence index of patients was slightly higher than the mean score of the control group. Age ($p = .069$) showed a non-significant correlation with the central coherence index. BMI-SDS ($p = .898$) was not associated with the central coherence index or with the style index or order of construction index. When including both variables as covariates in the model, age demonstrated a significant influence on the group difference ($p = .019$, partial $\eta^2 = .072$). BMI-SDS had no significant effect on the model ($p = .523$). When excluding the more experienced group, there was no effect of group affiliation either ($p = .650$). Age ($p = .029$) still had a significant impact, but BMI-SDS ($p = .750$) did not.

When all four groups were compared to each other, there were no significant differences in central coherence between any of the groups ($p = .243$). Age still had a significant impact ($p = .005$). BMI-SDS did not make a difference ($p = .822$). Excluding the participants from the previous study did not reveal significant group differences in central coherence either ($p = .270$).

Table 3

Group comparisons between patients and healthy controls regarding cognitive functioning

Outcome	**Mean (SD)**		**Factor**	***F* (df)**	***p***	**Partial η^2**
	Healthy controls	*Patients*				
Central coherence	1.337 (0.333)	1.353 (0.382)	Group	0.013 (1)	.910	.000
	18.72 (2.208)	18.19 (3.102)	Age	5.750 (1)	**.019**	.072
	0.072 (0.858)	-0.975 (1.382)	BMI-SDS	0.413 (1)	.523	.006
Perseverative score	14.100 (9.129)	13.096 (12.458)	Group	0.030 (1)	.864	.000
	18.72 (2.208)	18.19 (3.102)	Age	1.433 (1)	.235	.019
	0.072 (0.858)	-0.975 (1.382)	BMI-SDS	0.396 (1)	.531	.005
Percentage of total response errors	2.638 (2.022)	3.322 (4.674)	Group	0.947 (1)	.334	.013
	18.72 (2.208)	18.19 (3.102)	Age	0.594 (1)	.443	.008
	0.072 (0.858)	-0.975 (1.382)	BMI-SDS	1.038 (1)	.312	.014

Table 4

Group comparisons between the four subgroups regarding cognitive functioning

Outcome	Factor	Mean (SD)				F (df)	*p*	Partial η^2
		Healthy controls	*Acutely ill*	*Partially remitted*	*Fully remitted*			
Central coherence	Group	1.337 (0.333)	1.385 (0.378)	1.277 (0.399)	1.443 (0.361)	1.424 (3)	.243	.056
	Age	18.72 (2.208)	16.77 (2.759)	19.63 (3.241)	17.91 (2.071)	8.210 (1)	**.005**	.102
	BMI-SDS	0.072 (0.858)	-2.099 (1.147)	-0.417 (1.067)	-0.047 (0.955)	0.051 (1)	.822	.001
Perseverative score	Group	14.100 (9.129)	10.590 (9.831)	16.927 (14.028)	9.991 (12.437)	2.232 (3)	.092	.086
	Age	18.72 (2.208)	16.77 (2.759)	19.63 (3.241)	17.91 (2.071)	3.729 (1)	.057	.050
	BMI-SDS	0.072 (0.858)	-2.099 (1.147)	-0.417 (1.067)	-0.047 (0.955)	0.001 (1)	.974	.000
Percentage of total response errors	Group	2.638 (2.022)	2.196 (2.814)	4.847 (6.011)	2.318 (3.731)	2.520 (3)	.065	.096
	Age	18.72 (2.208)	16.77 (2.759)	19.63 (3.241)	17.91 (2.071)	2.257 (1)	.137	.031
	BMI-SDS	0.072 (0.858)	-2.099 (1.147)	-0.417 (1.067)	-0.047 (0.955)	0.165 (1)	.686	.002

Obsessive-compulsive symptoms

Further analyses tried to detect the possible influence of obsessive-compulsive symptoms on the neurocognitive measures. No significant correlation was found between the OCI-R and perseverative scores ($p = .888$, $r = -.035$) as well as the percentage of total response errors ($p = .846$, $r = -.048$). Correlation analysis of the OCI-R and the central coherence index did not reveal any significant results either ($p = .782$, $r = -.066$). This

indicates that the extent of cognitive inflexibility and local processing is independent of the presence of OCD symptoms.

Figure 2

Correlation between the OCI-R and the Central coherence index

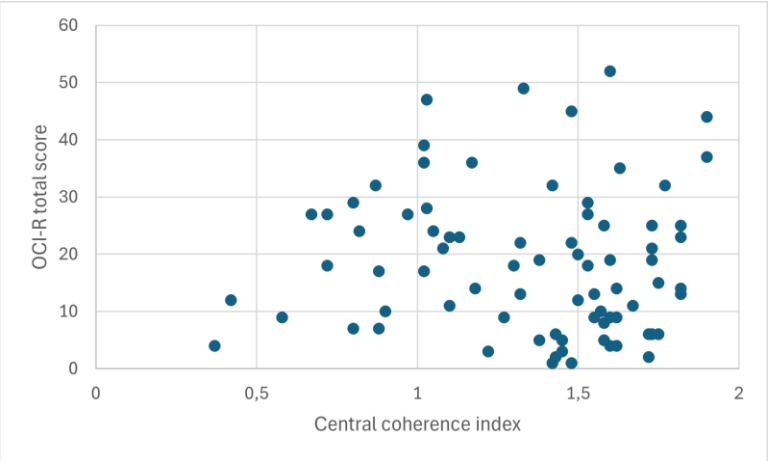


Figure 3

Correlation between the OCI-R and the perseverative score

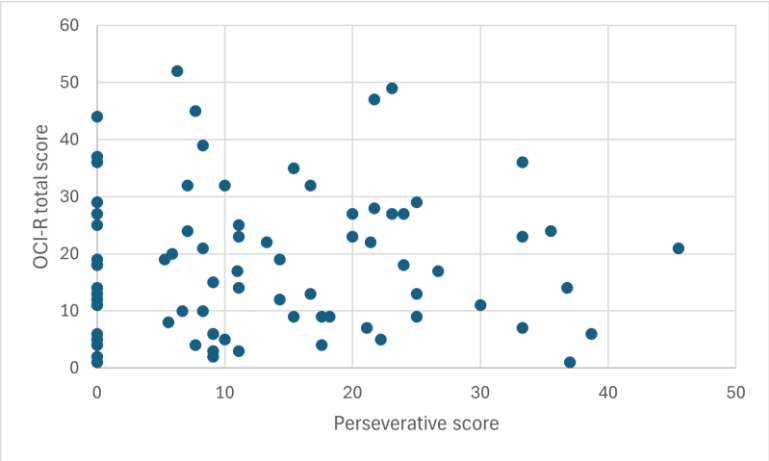
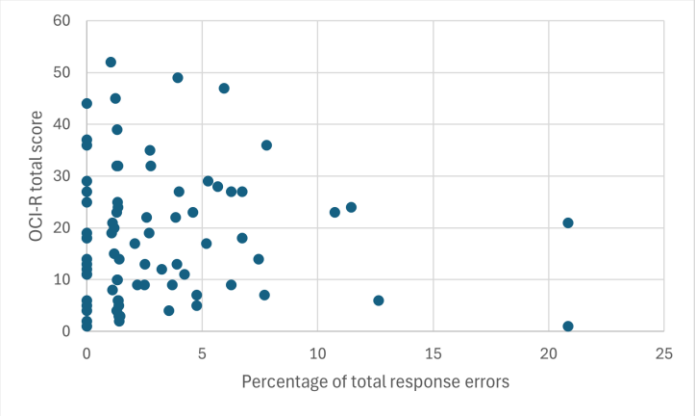


Figure 4

Correlation between the OCI-R and the percentage of total response errors



When included in the ANCOVA model, there was no significant effect of the OCI-R score on any of the cognitive measures. Also, it did not significantly affect the model when the patient group who had conducted the tests twice was excluded. Explorative group comparison revealed significant group differences in the total OCI-R score ($p < .001$, partial $\eta^2 = .200$). Post-hoc tests with a Bonferroni adjustment revealed that acutely ill patients (M = 27.100) demonstrated significantly more symptoms of OCD than healthy controls (M = 14.840, $p = .003$) and fully remitted patients (M = 11.000, $p = .002$). Acutely ill patients and partially remitted patients (M = 18.500) did not differ significantly from each other ($p = .085$). There were no significant differences between the remaining groups.

Associations with symptom severity and illness duration

Finally, multiple correlation analyses were conducted to explore the possible influence of central coherence, set-shifting, and OCD symptoms on illness duration and the total EDE score in the acute phase. There was a significant positive correlation between central coherence and illness duration ($p = 022$, $r = .439$). Central coherence and the EDE total score were unrelated ($p = .283$, $r = -.246$). There was also no correlation between the perseverative score and the EDE total score ($p = .061$, $r = .426$) and illness duration ($p = .256$, $r = -.179$). Similarly, the percentage of total response errors was not significantly correlated with the EDE total score ($p = .246$, $r = . 272$) or with illness duration ($p = .247$, $r = -.183$). The OCI-R score was not significantly related with the total EDE score ($p = .222$, $r = .302$), and illness duration ($p = .233$, $r = -.190$).

Table 5

Correlation of cognitive measures and OCD symptoms with AN symptom severity and illness duration

		Pearson correlation	*p*
OCI-R total score	*EDE total score*	.302	**.**222
	Illness duration	-.190	.233
Central coherence	*EDE total score*	-.246	.283
index	*Illness duration*	.439	**.022**
Perseverative score	*EDE total score*	.426	.061
	Illness duration	-.179	.256
Percentage of total	*EDE total score*	.272	.246
response errors	*Illness duration*	-.183	.247

Note. Only acutely ill patients were included in correlation analyses with EDE total score. Correlations with illness duration were conducted including the whole sample.

Discussion

The aim of this study was to explore neurocognitive abilities in patients with AN compared to healthy controls. To resolve some remaining questions that previous literature was not able to answer, additional factors like OCD symptoms, AN symptom severity, and illness duration were taken into account. The results described above will be discussed and put into context using previous research in the following paragraphs.

Clinical characteristics

The vast majority of patients included in the present sample displayed typical anorexia nervosa with the restrictive type. Only 5% of patients were diagnosed with atypical AN. In a systematic review, prevalence numbers of atypical AN were reported to be just as high or sometimes even higher than those of typical AN (Harrop et al., 2021). As pointed out earlier, due to the expectation for AN patients to be thin, this subtype might be correctly identified less frequently. The same meta-analysis pointed out that atypical AN might be more common in older patients, which could also partly explain the small number in this very young sample. Also, as mentioned earlier, most of the patients were acquired through the practitioners in the hospital. Patients with atypical AN are generally hospitalized less often and will therefore be less common in this ample.

The clinical characteristics of the AN patients in our sample were largely congruent with those described in the literature. Age of onset was around 14 in all three groups which roughly matches the numbers in previous studies. In the longitudinal study of Dobrescu et al. (2020) the mean age of onset was 14.3 years. A large register-based study reported the peak age of onset to be between 15 and 19 (Micali et al., 2013). Zerwas et al. (2015) reported the highest risk of developing AN at the age of 15. The average illness duration in the present sample ranged between 26 months in fully remitted patients and 45 months in partially remitted patients. It is noteworthy that the fully remitted patients displayed the shortest illness duration. They did not seem to finally have reached the status of remission after a long period of illness, but rather completely recovered relatively quickly. Meanwhile, another group of patients remained in a state of partial remission for quite long. On the other hand, these categories are not fixed, but only a snapshot of the current status. The illness duration as reported in this study was assessed beginning with the first AN episode until the present moment for partially remitted and acutely ill patients. For the fully remitted patients, it was the period of time beginning with the first AN episode until the point where they considered themselves recovered. Those in the fully remitted group may experience more episodes of acute AN in the future which would hence prolong the illness duration. Miskovic-Wheatley et al. (2023) report a risk of relapse of 41% at 1-year follow-up. Considering these numbers, more AN episodes would not be surprising in an adolescent sample. Especially in this young age group, there should not be any rash conclusions about the illness prognosis.

The most common comorbid disorders in this sample were major depression, OCD, social anxiety disorder, and generalized anxiety disorder. This is largely congruent with previous research. Andrés-Pepiñá et al. (2020) reported anxiety disorder, depression, and OCD as the most frequent comorbidities in their study. Acutely ill patients generally displayed comorbidities more often, which has also been shown in previous literature (Talbot et al., 2015).

Main results

Group differences in cognitive functioning

The first research question centered around group differences in central coherence and set-shifting. It was hypothesized that the patient group would generally perform worse regarding set-shifting and central coherence than participants in the control group. Specifically, it was expected that acutely ill AN patients would display worse set-shifting and central coherence than healthy controls and patients in partial or full remission. Further,

patients in partial or full remission were expected to demonstrate worse set-shifting and central coherence than healthy controls. The result revealed no significant group differences in central coherence. A closer look showed that partially remitted patients displayed the lowest scores in central coherence, although these differences were not significant.

A significant difference was found for set-shifting, but only when the patients who had taken part in the previous study, were excluded. The results support previous findings in the sense that group differences in set-shifting tend to be a bit more consistent than those in central coherence (Danner et al., 2012). Still, the effect was different than expected. The acutely ill patients made significantly fewer perseverative errors than partially remitted patients. This difference arose since the average number of perseverative errors was higher in partially remitted patients after excluding the ones who were experienced in the tests. Hence, there seemed to be a practice effect since they made fewer perseverative errors in the second assessment than in the first one. If they had a tendency to hold onto a rule for longer, it would have been compensated by their expectation that the rule would change, since they had performed the task before. An earlier study that examined practice effects on the CKV, demonstrated that the number of perseverative errors and the percentage of total response errors improved significantly over a period of 12 months (Basso et al., 2001). This demonstrates again the potential usefulness of treatment approaches targeting the improvement of cognitive skills in AN patients. It is questionable, why this effect was present only in the partially remitted group. Notably, there were 10 patients from the earlier study in the partially remitted group, but only five in the acute group and four in the fully recovered group. Excluding such a small number of participants might not have the potential to have such a big impact on the results.

Considering these findings, the first four hypotheses could not be confirmed. This is in line with a considerable part of the previous literature that also failed to detect poorer global processing and set-shifting in AN patients than in healthy controls (Bohon et al., 2020; Castro-Fornieles et al., 2019). As established earlier in the introduction, many studies on adolescent patients and remitted patients do not find such effects. This is in contrast to a large number of articles reporting poorer central coherence and set-shifting in acutely ill adult patients (Danner et al., 2012; Happé & Frith, 2006; Keegan et al., 2021; Stedal et al., 2021; Wu et al., 2014). The general assumption that AN is associated with a certain predisposition for mental rigidity that is further expressed in the form of neurocognitive anomalies is hence

challenged. The results of the present study further contribute to the collection of findings that question the endophenotype assumption.

Visual inspection suggested that partially remitted patients displayed the worst set-shifting and central coherence, even though these differences were usually not significant. Notably, one study reported similar, although not significant, results with the most perseverative errors in the CKV in partially remitted patients (Talbot et al., 2015). Since the patient groups did not significantly differ from each other in that study, the authors aggregated them into one group and did not discuss these results any further. A closer look at the data in the present study shows that there was the largest variability in all cognitive measures in the partially remitted group. In this context, it is important to note that there was also a large variability in AN symptoms in the partially remitted group due to the criteria based on which remission status was assessed. Some partially remitted patients showed overall very little symptoms but simply had not been weight-restored for long enough to be fully remitted. Other patients had held a healthy weight for quite a long time but still scored high in crucial aspects like weight or shape concern, or had a strong intention to restrict food intake even though they did not give in to it anymore. This way, there might be a large number of patients who were able to recover their weight relatively quickly but remained in a state with considerable psychological impairment for a very long time. This observation can be supported by looking at the illness duration. Partially remitted patients displayed a longer illness duration compared to acutely ill and fully recovered patients. It is possible that many patients in the partially remitted group had been ill for a long time and cognitive rigidity had already developed further. The acutely ill patients, who were also quite young, might have had a relatively short course of the illness, and a tendency towards cognitive inflexibility might not be visible yet. On the other hand, cognitive rigidity may contribute to the maintenance of AN symptoms. Regaining weight is a process often brought about by external control – especially in adolescent patients. But, psychological symptoms are much harder and take longer to overcome. This is important to consider when comparing the groups. Still, these explanations are purely speculative. Since such group differences have not been found in the majority of previous studies, no rash conclusions should be drawn.

In the present study, there was no effect of BMI-SDS in any of the group comparing analyses. This finding contradicts the assumption of many authors that cognitive anomalies in AN arise through ongoing malnutrition. In a large meta-analysis, BMI consistently demonstrated a moderating effect on malfunctions in adult AN patients in different cognitive

domains (Stedal et al., 2021). Still, there are other individual studies that do not find an effect of BMI (McAnarney et al., 2011; Roberts et al., 2010).

Age did seem to have an effect on the group differences although it was not always significant. Looking at the direction of the association, younger patients demonstrated a more local processing style, respectively made more perseverative errors. Other studies have also found a moderating influence of age (Stedal et al., 2021). Some authors argue that, regarding the fact that executive functions such as central coherence and set-shifting are still developing until early adulthood, possible anomalies in these domains might establish themselves later in life (Lang et al., 2014; Miles et al., 2020; Rößner et al., 2017; Van Noort et al., 2016). In that case, AN patients might have a general tendency towards poorer global processing and set-shifting, but it might not show until the mid-twenties. Possibly, younger adolescents generally tend towards a more local, inflexible information processing style that naturally develops towards a more flexible and global style as they get older. An AN diagnosis might interfere with this cognitive development, leaving former patients with weaker central coherence and set-shifting. In line with this, Talbot et al. (2015) found a negative correlation between the number of perseverative errors and age in the entire sample and a positive correlation with central coherence in the control group. In other studies, age affected cognitive performance in a different way. One meta-analysis reported consistently lower cognitive performance in older participants. Contrarily to our results, these findings would indicate that cognitive rigidity develops with prolonged illness duration which naturally correlates with age. This again would rather indicate the formation of cognitive inflexibility as a result of the illness and not a predisposing factor for it. Similarly, in the study of Rößner et al. (2017) age was found to be the only predictor of set-shifting in acutely ill AN patients and healthy controls. They found that younger patients tended towards better set-shifting performance than older patients while age was unrelated to set-shifting in the control group. To see whether there is an age-related difference in central coherence in AN patients, a more age-diverse sample would be necessary, including patients from a very young age until well into adulthood.

Symptoms of obsessions and compulsions

The second research question centered around the potential influence of OCD symptoms on cognitive functioning in the different groups. It was hypothesized that OCD symptoms would be negatively associated with central coherence and set-shifting. Further, OCD symptoms were expected to influence the group differences regarding central coherence and set-shifting. In the present study, OCD symptoms were unrelated to the levels of both

measures. There are previous studies that reported similar results. In the article of Rößner et al. (2017), OCD symptoms did not predict the level of cognitive flexibility. Accordingly, Lang et al. (2015) did not detect associations between the number of perseverative errors in the CKV and obsessive-compulsive traits. This stands in contrast to some other previous findings. Bohon et al. (2020) demonstrated worse performance of OCD patients in the CKV than in weight-restored AN patients and healthy controls.

The finding that OCD symptoms were more common in the patient group than in the control group confirmed our expectations and is in line with the literature. Accordingly, Danner et al. (2012) reported higher scores of OCD in acute and recovered patients. It has been established that AN patients run a higher risk of an additional OCD diagnosis since obsessive-compulsive behaviors are commonly part of AN symptoms (Drakes et al., 2021; Micali et al., 2011). However, it is important to note that all participants in the control group had to be psychologically healthy, meaning they were excluded if they fulfilled the criteria for any psychiatric diagnosis. Therefore, chances are high that a participant who would have scored higher in the OCI-R, would have been excluded by the clinical interview anyway.

Associations with AN symptom severity and illness duration

The third research question postulated that poor set-shifting, weak central coherence, and more symptoms of OCD would predict more severe AN symptoms in acutely ill patients and a longer illness duration. Unexpectedly, the results revealed a positive relationship between central coherence and illness duration, meaning that participants with longer persisting AN approached the ROCFT in a more global way. This finding seems rather surprising since the expectation was that better global processing should be associated with a better chance of recovery and therefore with a shorter illness duration. What is worth mentioning here is that illness duration is likely correlated with age. Therefore, the effect of age on cognitive functioning might outweigh the association between a detail-focused thinking style and illness duration. Regarding the fact that partially remitted patients were the ones with the longest illness duration and the poorest cognitive performance, it is unclear how this result came about. The other parameters were unrelated to symptom severity and illness duration. Previous literature did not find a correlation between poor set-shifting or weak central coherence and longer illness duration in adolescents either (Lang et al., 2015; Lang, Roberts, et al., 2016; Talbot et al., 2015). Similarly, Talbot et al. (2015) did not report more severe AN symptoms in individuals with poor cognitive performance. Contrarily, Roberts et al. (2010) demonstrated a longer illness duration and more severe ED rituals in individuals

with poor set-shifting. OCD symptoms have been reported to be associated with a worse AN prognosis (Steinhausen, 2002), hence it seems rather surprising that higher OCI-R scores did not predict stronger EDE scores or a longer illness duration. However, the result demonstrated a medium effect size for the correlation between the OCI-R and the total EDE core. Possibly, the rather mall ample size prevented the finding of a significant association.

This present study contributes to the body of research that does not find a more detail-focused processing style or poorer set-shifting in adolescent AN patients. Since the difference between AN patients and healthy controls in cognitive functioning is relatively well-researched in adults, there remains the question of why this is not the case in younger patients. By including additional parameters like OCD symptoms and illness severity, the present study attempted to contribute to the resolution of this question. Unexpectedly, there were no significant associations between cognitive functioning and OCD symptoms, and none of these factors were found to negatively affect AN prognosis. The data showed that patients in the acute phase of the illness experienced more symptoms of OCD. This is in line with the expectation of more rigid thinking in acutely ill patients. Against our expectations, there was no connection between OCD symptoms, central coherence or set-shifting, and AN symptom severity. The hypothesis for this study was that poorer central coherence and set-shifting, and stronger obsessions and compulsions might be associated with more severe symptoms and longer illness duration because they should add up to a generally more rigid cognitive profile which should be more pronounced in more severe AN cases. The data did not support this hypothesis. Instead, it is possible that obsessive-compulsive tendencies are exacerbated during the acute phase of the illness and later diminish along with AN symptoms. It is still surprising that there were no differences in OCD symptoms between healthy controls and partially or fully remitted patients. It is important to note that in this study, analyses were conducted using the total OCI-R score as a metric measure. Possibly, there is an effect of OCD symptoms, but only with a full-threshold pathology.

Methodological difficulties

It has been proposed that anomalies in cognitive functioning might be related to a generally rigid, inflexible trait pattern leading to a preoccupation with food and body weight and resulting behavior (Merwin et al., 2010). Notably, evidence linking neurocognitive function to the everyday function of AN patients usually finds only limited effects on quite specific domains (Dann et al., 2021). However, studies based on self-report measures of set-shifting do find quite prominent differences between AN patients and healthy controls, in

particular regarding behavioral shifting. Furthermore, one study that used a complex inventory more similar to real-life tasks, found consistent differences between AN patients and healthy controls, especially regarding the speed of task solution (Spitoni et al., 2018). In the common tests that are applied in research, concepts such as central coherence and set-shifting are usually researched in the specific test conditions and rarely in association with the behavior typical for AN patients. Hence, the assumption that a certain approach to the tests assessing these abilities translates to a preoccupation with details and rules in everyday life, is, to date not sufficiently empirically validated. Both domains are usually assessed with one of a small selection of tests that examine a very narrow aspect of the concept. However, the way mental rigidity is clinically characterized in AN patients is much more practical and complex. This practical presentation of cognitive inflexibility and detail-focused information processing might withdraw itself from a simple one-dimensional task. This might be part of the explanation why previous research has failed to draw consistent conclusions. These findings indicate that common measures assessing isolated domains of neurocognitive function might have a limited ability to represent the skills that are applied in everyday situations. Stedal et al. (2021) further point out that most neurocognitive measures that are applied in this field were initially developed to detect brain lesions or trauma. Therefore, they might not be suitable or sensitive enough to differentiate between healthy and psychiatric populations. This is especially relevant for this present sample since most of the participants were very well educated and the average IQ might be higher than in other populations. However, IQ was not assessed.

There are additional obstacles that make the empirical examination of neurocognitive function difficult and impair the interpretation of study results. One point to consider is the heterogeneity of the samples in studies on adolescents. The studies on adolescents usually differ largely in the age distribution of their samples and the age range is usually relatively large. One meta-analysis found that frontal lobe maturation, which plays a central role in the development of executive functions, extends well into adolescence and early adulthood with large individual differences (Romine & Reynolds, 2005). Therefore, the development of executive functioning, including central coherence and set-shifting, will vary largely between individuals of similar ages. This makes it difficult to examine adolescents as a homogenous group since participants might be on quite different developmental levels. This reduces the comparability of different study results. The usefulness of cross-sectional studies in this age group is therefore questionable. Hence, there remain open questions, that this study was not able to answer. Further, it needs to be mentioned that studies differ in the groups of

participants that they test and compare. Usually, only acutely ill patients and healthy controls are compared. Others examine recovered patients and healthy controls, or acute and remitted patients. A classification into four groups that differentiates between partially and fully remitted patients is rarely reported. This further impairs the comparability of study results.

Additionally, different measures are used across studies to assess cognitive functioning in AN, presumably leading to variation to some degree between studies due to differences between tests (Stedal et al., 2021). These difficulties could further lead to inconsistent findings.

Prospects for future research

To date, there is still very little research on men with AN. Studies that examine cognitive functioning in AN, rarely include male patients. For example, a large meta-analysis, comprising 50 different studies, only included two studies with 5% and 4,2% of male participants, meaning the results do not apply to all patients (Stedal et al., 2021). Even though the much stronger tabu of AN in men does diminish slowly, future research needs to take into account all individuals who can potentially be endangered by this disorder.

It has been pointed out by different authors before that cognitive anomalies might be a phenomenon regarding only a subgroup of AN patients. By including additional factors like OCD symptoms and illness prognosis, this study tried to detect underlying causes for interindividual differences in cognitive functioning between patients. By including more additional factors, like other comorbid disorders for example, it might be possible for future research to explain how this variability comes about.

As previously emphasized, there is a lack of studies that investigate the development of central coherence and set-shifting over a longer period of time. To really understand if the course of the illness has an impact on cognitive functions, and in what form, it would be necessary to accompany patients from the age of onset early in adolescence until later in adulthood and to compare this process with healthy controls. To date, there are no longitudinal studies of this extent. One recent longitudinal study found that young children with poor set-shifting displayed a lower BMI and more restrictive eating patterns (Steegers et al., 2021). Notably, they did not examine AN patients, but only core markers of AN that may or may not be linked to a later eating disorder. Still, a similar approach might be helpful in gaining a deeper understanding of the long-term development of cognitive functions in correspondence with AN features.

Strengths and limitations

One strength of this study was that the sample was differentiated into partially and fully remitted patients. This is often not the case and allows for a more specific integration of the observed characteristics. Moreover, the control group and the patient group were age-matched, providing better comparability. The healthy controls were thoughtfully examined regarding psychopathology to ensure that they were actually healthy. Group differences were further controlled for age and BMI and comorbid disorders were considered which is often not the case.

The present study has several limitations. First of all, the sample size was rather small and the groups unequal in size. Due to this fact, it was also not possible to distinguish between AN subtypes, since there were only few individuals who displayed atypical AN or the binge-purge subtype.

Considering the sample of the present study, it is worth noting that it consisted mainly of highly educated individuals. This might play a role in neurocognitive functioning since the sample in our study might be especially skilled in neurocognitive tasks and hence not represent the general population. Still, studies that assess IQ or years of education usually do not report an interference effect (Danner et al., 2012; Keegan et al., 2021; Lopez et al., 2008; Weinbach et al., 2017).

In addition, the associations with age, BMI-SDS, OCD symptoms, AN severity, and illness duration were only analyzed for the whole sample and not separately for the different groups. Separate analyses for all groups might have provided more insight into the data. To finally resolve the role OCD symptoms might play in cognitive functioning, Rößner et al. (2017) suggest studying a sample of AN patients by splitting it into patients with and patients without a comorbid OCD diagnosis.

Conclusion

The findings of the present study do not support a general predisposition for mental rigidity in patients with AN. Possible explanations for these results include methodological challenges as well as hypotheses about the course of the illness. Looking at the body of research, it is noticeable that study results are very inconsistent in all aspects that were examined in the present one. It becomes more and more clear that punctual cross-sectional results fail to reflect the multilayered processes that conjoin this severe illness. The discoveries made in the present study again stress the complexity of the subject. They further

indicate that more complex, longitudinal studies are indispensable in order to fully understand the dynamics of neurocognitive functioning in correspondence with AN symptomatology.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Andrés-Pepiñá, S., Plana, M. T., Flamarique, I., Romero, S., Borràs, R., Julià, L., Gárriz, M., & Castro-Fornieles, J. (2020). Long-term outcome and psychiatric comorbidity of adolescent-onset anorexia nervosa. *Clinical Child Psychology and Psychiatry*, *25*(1), 33–44. https://doi.org/10.1177/1359104519827629

Arcelus, J., Mitchell, A. J., Wales, J., & Nielsen, S. (2011). Mortality Rates in Patients With Anorexia Nervosa and Other Eating Disorders: A Meta-analysis of 36 Studies. *Archives of General Psychiatry*, *68*(7), 724. https://doi.org/10.1001/archgenpsychiatry.2011.74

Bamford, B., Barras, C., Sly, R., Stiles-Shields, C., Touyz, S., Le Grange, D., Hay, P., Crosby, R., & Lacey, H. (2015). Eating disorder symptoms and quality of life: Where should clinicians place their focus in severe and enduring anorexia nervosa? *International Journal of Eating Disorders*, *48*(1), 133–138. https://doi.org/10.1002/eat.22327

Basso, M. R., Lowery, N., Ghormley, C., & Bornstein, R. A. (2001). Practice Effects on the Wisconsin Card Sorting Test–64 Card Version Across 12 Months. *The Clinical Neuropsychologist*, *15*(4), 471–478. https://doi.org/10.1076/clin.15.4.471.1883

Benatti, B., Dell'Osso, B., Arici, C., Hollander, E., & Altamura, A. C. (2014). Characterizing impulsivity profile in patients with obsessive–compulsive disorder. *International Journal of Psychiatry in Clinical Practice*, *18*(3), 156–160. https://doi.org/10.3109/13651501.2013.855792

Bohon, C., Weinbach, N., & Lock, J. (2020). Performance and brain activity during the Wisconsin Card Sorting Test in adolescents with obsessive–compulsive disorder and adolescents with weight-restored anorexia nervosa. *European Child & Adolescent Psychiatry*, *29*(2), 217–226. https://doi.org/10.1007/s00787-019-01350-4

Booth, R. D. L. (2006). *Local-global processing and cognitive style in autism spectrum disorders and typical development* [Ph.D., University of London]. https://kclpure.kcl.ac.uk/portal/en/theses/localglobal-processing-and-cognitive-style-in-autism-spectrum-disorders-and-typical-development(99cff8ab-25d8-4530-8e66-dc089e8db9fd).html

Bühren, K., Mainz, V., Herpertz-Dahlmann, B., Schäfer, K., Kahraman-Lanzerath, B., Lente, C., & Konrad, K. (2012). Cognitive flexibility in juvenile anorexia nervosa patients

before and after weight recovery. *Journal of Neural Transmission*, *119*(9), 1047–1057. https://doi.org/10.1007/s00702-012-0821-z

Calvo-Rivera, M. P., Navarrete-Páez, M. I., Bodoano, I., & Gutiérrez-Rojas, L. (2022). Comorbidity Between Anorexia Nervosa and Depressive Disorder: A Narrative Review. *Psychiatry Investigation*, *19*(3), 155–163. https://doi.org/10.30773/pi.2021.0188

Castro-Fornieles, J., Serna, E. D. L., Calvo, A., Blázquez, A., Moya, J., Lázaro, L., Andrés-Perpiñá, S., Plana, M. T., Gil, L., Flamarique, I., Martínez, E., Pariente, J., Moreno, E., & Bargallo, N. (2019). Functional MRI with a set-shifting task in adolescent anorexia nervosa: A cross-sectional and follow-up study. *Neuropsychologia*, *131*, 1–8. https://doi.org/10.1016/j.neuropsychologia.2019.05.019

Cederlöf, M., Thornton, L. M., Baker, J., Lichtenstein, P., Larsson, H., Rück, C., Bulik, C. M., & Mataix-Cols, D. (2015). Etiological overlap between obsessive-compulsive disorder and anorexia nervosa: A longitudinal cohort, multigenerational family and twin study. *World Psychiatry*, *14*(3), 333–338. https://doi.org/10.1002/wps.20251

Dann, K. M., Hay, P., & Touyz, S. (2021). Are poor set-shifting and central coherence associated with everyday function in anorexia nervosa? A systematic review. *Journal of Eating Disorders*, *9*(1), 40. https://doi.org/10.1186/s40337-021-00392-x

Danner, U. N., Sanders, N., Smeets, P. A. M., Van Meer, F., Adan, R. A. H., Hoek, H. W., & Van Elburg, A. A. (2012). Neuropsychological weaknesses in anorexia nervosa: Set-shifting, central coherence, and decision making in currently ill and recovered women. *International Journal of Eating Disorders*, *45*(5), 685–694. https://doi.org/10.1002/eat.22007

Diaz-Marsa, M., Pemau, A., De La Torre-Luque, A., Vaz-Leal, F., Rojo-Moreno, L., Beato-Fernandez, L., Graell, M., Carrasco-Diaz, A., & Carrasco, J. L. (2023). Executive dysfunction in eating disorders: Relationship with clinical features. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *120*, 110649. https://doi.org/10.1016/j.pnpbp.2022.110649

Dobrescu, S. R., Dinkler, L., Gillberg, C., Råstam, M., Gillberg, C., & Wentz, E. (2020). Anorexia nervosa: 30-year outcome. *The British Journal of Psychiatry*, *216*(2), 97–104. https://doi.org/10.1192/bjp.2019.113

Drakes, D. H., Fawcett, E. J., Rose, J. P., Carter-Major, J. C., & Fawcett, J. M. (2021). Comorbid obsessive-compulsive disorder in individuals with eating disorders: An

epidemiological meta-analysis. *Journal of Psychiatric Research*, *141*, 176–191. https://doi.org/10.1016/j.jpsychires.2021.06.035

Drühe-Wienholt, C.-M., & Wienholt, W. (2013). *Computergestütztes Kartensortierverfahren (CKV). Modifizierte Version des Wisconsin Kartensortiertests*. Pearson.

Ettelt, S., Grabe, H. J., Ruhrmann, S., Buhtz, F., Hochrein, A., Kraft, S., Pukrop, R., Klosterkötter, J., Falkai, P., Maier, W., John, U., Freyberger, H. J., & Wagner, M. (2008). Harm avoidance in subjects with obsessive-compulsive disorder and their families. *Journal of Affective Disorders*, *107*(1–3), 265–269. https://doi.org/10.1016/j.jad.2007.08.017

Fairweather-Schmidt, A. K., & Wade, T. D. (2020). Common genetic architecture and environmental risk factors underpin the anxiety-disordered eating relationship: Findings from an adolescent twin cohort. *International Journal of Eating Disorders*, *53*(1), 52–60. https://doi.org/10.1002/eat.23155

Fassino, S., Abbate-Daga, G., Amianto, F., Leombruni, P., Boggio, S., & Rovera, G. G. (2002). Temperament and character profile of eating disorders: A controlled study with the Temperament and Character Inventory. *International Journal of Eating Disorders*, *32*(4), 412–425. https://doi.org/10.1002/eat.10099

Fichter, M. M., & Quadflieg, N. (2016). Mortality in eating disorders - results of a large prospective clinical longitudinal study. *International Journal of Eating Disorders*, *49*(4), 391–401. https://doi.org/10.1002/eat.22501

Fuglset, T. S. (2019). Set-shifting, central coherence and decision-making in individuals recovered from anorexia nervosa: A systematic review. *Journal of Eating Disorders*, *7*(1), 22. https://doi.org/10.1186/s40337-019-0251-5

Galimberti, E., Fadda, E., Cavallini, M. C., Martoni, R. M., Erzegovesi, S., & Bellodi, L. (2013). Executive functioning in anorexia nervosa patients and their unaffected relatives. *Psychiatry Research*, *208*(3), 238–244. https://doi.org/10.1016/j.psychres.2012.10.001

Garcia, S. C., Mikhail, M. E., Keel, P. K., Burt, S. A., Neale, M. C., Boker, S., & Klump, K. L. (2020). Increased rates of eating disorders and their symptoms in women with major depressive disorder and anxiety disorders. *International Journal of Eating Disorders*, *53*(11), 1844–1854. https://doi.org/10.1002/eat.23366

Giombini, L., Nesbitt, S., Kusosa, R., Fabian, C., Sharia, T., Easter, A., & Tchanturia, K. (2022). Neuropsychological and clinical findings of Cognitive Remediation Therapy

feasibility randomised controlled trial in young people with anorexia nervosa. *European Eating Disorders Review*, *30*(1), 50–60. https://doi.org/10.1002/erv.2874

Godier, L. R., & Park, R. J. (2015). A novel measure of compulsive food restriction in anorexia nervosa: Validation of the Self-Starvation Scale (SS). *Eating Behaviors*, *17*, 10–13. https://doi.org/10.1016/j.eatbeh.2014.12.004

Gönner, S., Leonhart, R., & Ecker, W. (2007). Das Zwangsinventar OCI-R - die deutsche Version des Obsessive-Compulsive Inventory-Revised. *PPmP - Psychotherapie · Psychosomatik · Medizinische Psychologie*, *57*(09/10), 395–404. https://doi.org/10.1055/s-2007-970894

Gottesman, I. I., & Gould, T. D. (2003). The Endophenotype Concept in Psychiatry: Etymology and Strategic Intentions. *American Journal of Psychiatry*, *160*(4), 636–645. https://doi.org/10.1176/appi.ajp.160.4.636

Happé, F., & Frith, U. (2006). The Weak Coherence Account: Detail-focused Cognitive Style in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, *36*(1), 5–25. https://doi.org/10.1007/s10803-005-0039-0

Harrison, A., Tchanturia, K., Naumann, U., & Treasure, J. (2012). Social emotional functioning and cognitive styles in eating disorders. *British Journal of Clinical Psychology*, *51*(3), 261–279. https://doi.org/10.1111/j.2044-8260.2011.02026.x

Harrop, E. N., Mensinger, J. L., Moore, M., & Lindhorst, T. (2021). Restrictive eating disorders in higher weight persons: A systematic review of atypical anorexia nervosa prevalence and consecutive admission literature. *International Journal of Eating Disorders*, *54*(8), 1328–1357. https://doi.org/10.1002/eat.23519

Hilbert, A., & Tuschen-Caffier, B. (2016). *Eating Disorder Examination—Questionnaire* (2 edition). PAG Institut für Psychologie AG. http://www.vfp-muenster.de/publikationen/online/EDE_VfP_1.pdf

Hollander, E., Kim, S., Khanna, S., & Pallanti, S. (2007). Obsessive-Compulsive Disorder and Obsessive-Compulsive Spectrum Disorders: *Diagnostic and Dimensional Issues*. *CNS Spectrums*, *12*(S3), 5–13. https://doi.org/10.1017/S1092852900002467

Holliday, J., Tchanturia, K., Landau, S., Collier, D., & Treasure, J. (2005). Is Impaired Set-Shifting an Endophenotype of Anorexia Nervosa? *American Journal of Psychiatry*, *162*(12), 2269–2275. https://doi.org/10.1176/appi.ajp.162.12.2269

Jacobi, C., Hayward, C., De Zwaan, M., Kraemer, H. C., & Agras, W. S. (2004). Coming to Terms With Risk Factors for Eating Disorders: Application of Risk Terminology and

Suggestions for a General Taxonomy. *Psychological Bulletin*, *130*(1), 19–65. https://doi.org/10.1037/0033-2909.130.1.19

Jacobs, M. J., Roesch, S., Wonderlich, S. A., Crosby, R., Thornton, L., Wilfley, D. E., Berrettini, W. H., Brandt, H., Crawford, S., Fichter, M. M., Halmi, K. A., Johnson, C., Kaplan, A. S., LaVia, M., Mitchell, J. E., Rotondo, A., Strober, M., Woodside, D. B., Kaye, W. H., & Bulik, C. M. (2009). Anorexia nervosa trios: Behavioral profiles of individuals with anorexia nervosa and their parents. *Psychological Medicine*, *39*(3), 451–461. https://doi.org/10.1017/S0033291708003826

Jappe, L. M., Frank, G. K. W., Shott, M. E., Rollin, M. D. H., Pryor, T., Hagman, J. O., Yang, T. T., & Davis, E. (2011). Heightened sensitivity to reward and punishment in anorexia nervosa. *International Journal of Eating Disorders*, *44*(4), 317–324. https://doi.org/10.1002/eat.20815

Johnston, J., Shu, C. Y., Hoiles, K. J., Clarke, P. J. F., Watson, H. J., Dunlop, P. D., & Egan, S. J. (2018). Perfectionism is associated with higher eating disorder symptoms and lower remission in children and adolescents diagnosed with eating disorders. *Eating Behaviors*, *30*, 55–60. https://doi.org/10.1016/j.eatbeh.2018.05.008

Jonker, N. C., Glashouwer, K. A., & De Jong, P. J. (2022). Punishment sensitivity and the persistence of anorexia nervosa: High punishment sensitivity is related to a less favorable course of anorexia nervosa. *International Journal of Eating Disorders*, *55*(5), 697–702. https://doi.org/10.1002/eat.23707

Kanakam, N., Raoult, C., Collier, D., & Treasure, J. (2013). Set shifting and central coherence as neurocognitive endophenotypes in eating disorders: A preliminary investigation in twins. *The World Journal of Biological Psychiatry*, *14*(6), 464–475. https://doi.org/10.3109/15622975.2012.665478

Keegan, E., Tchanturia, K., & Wade, T. D. (2021). Central coherence and SET-SHIFTING between NONUNDERWEIGHT eating disorders and anorexia nervosa: A systematic review and META-ANALYSIS. *International Journal of Eating Disorders*, *54*(3), 229–243. https://doi.org/10.1002/eat.23430

Kromeyer-Hauschild, K., Wabitsch, M., Kunze, D., Geller, F., Geiß, H. C., Hesse, V., ..., & Hebebrand, J. (2001). Perzentile für den Body-mass-Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben. *Monatsschrift Kinderheilkunde*, *149*(8), 807–818. https://doi.org/10.1007/s001120170107

Lang, K., Lloyd, S., Khondoker, M., Simic, M., Treasure, J., & Tchanturia, K. (2015). Do Children and Adolescents with Anorexia Nervosa Display an Inefficient Cognitive

Processing Style? *PLOS ONE*, *10*(7), e0131724. https://doi.org/10.1371/journal.pone.0131724

Lang, K., Roberts, M., Harrison, A., Lopez, C., Goddard, E., Khondoker, M., Treasure, J., & Tchanturia, K. (2016). Central Coherence in Eating Disorders: A Synthesis of Studies Using the Rey Osterrieth Complex Figure Test. *PLOS ONE*, *11*(11), e0165467. https://doi.org/10.1371/journal.pone.0165467

Lang, K., Stahl, D., Espie, J., Treasure, J., & Tchanturia, K. (2014). Set shifting in children and adolescents with anorexia nervosa: An exploratory systematic review and meta-analysis. *International Journal of Eating Disorders*, *47*(4), 394–399. https://doi.org/10.1002/eat.22235

Lang, K., Treasure, J., & Tchanturia, K. (2016). Is inefficient cognitive processing in anorexia nervosa a familial trait? A neuropsychological pilot study of mothers of offspring with a diagnosis of anorexia nervosa. *The World Journal of Biological Psychiatry*, *17*(4), 258–265. https://doi.org/lopez

Levinson, C. A., Zerwas, S. C., Brosof, L. C., Thornton, L. M., Strober, M., Pivarunas, B., Crowley, J. J., Yilmaz, Z., Berrettini, W. H., Brandt, H., Crawford, S., Fichter, M. M., Halmi, K. A., Johnson, C., Kaplan, A. S., La Via, M., Mitchell, J., Rotondo, A., Woodside, D. B., … Bulik, C. M. (2019). Associations between dimensions of anorexia nervosa and obsessive–compulsive disorder: An examination of personality and psychological factors in patients with anorexia nervosa. *European Eating Disorders Review*, *27*(2), 161–172. https://doi.org/10.1002/erv.2635

Longo, P., Bevione, F., Amodeo, L., Martini, M., Panero, M., & Abbate-Daga, G. (2024). Perfectionism in anorexia nervosa: Associations with clinical picture and personality traits. *Clinical Psychology & Psychotherapy*, *31*(1), e2931. https://doi.org/10.1002/cpp.2931

Lopez, C., Tchanturia, K., Stahl, D., Booth, R., Holliday, J., & Treasure, J. (2008). An examination of the concept of central coherence in women with anorexia nervosa. *International Journal of Eating Disorders*, *41*(2), 143–152. https://doi.org/10.1002/eat.20478

Lopez, C., Tchanturia, K., Stahl, D., & Treasure, J. (2009). Weak central coherence in eating disorders: A step towards looking for an endophenotype of eating disorders. *Journal of Clinical and Experimental Neuropsychology*, *31*(1), 117–125. https://doi.org/10.1080/13803390802036092

Mandelli, L., Draghetti, S., Albert, U., De Ronchi, D., & Atti, A.-R. (2020). Rates of comorbid obsessive-compulsive disorder in eating disorders: A meta-analysis of the literature. *Journal of Affective Disorders*, *277*, 927–939. https://doi.org/10.1016/j.jad.2020.09.003

McAnarney, E. R., Zarcone, J., Singh, P., Michels, J., Welsh, S., Litteer, T., Wang, H., & Klein, J. D. (2011). Restrictive Anorexia Nervosa and Set-Shifting in Adolescents: A Biobehavioral Interface. *Journal of Adolescent Health*, *49*(1), 99–101. https://doi.org/10.1016/j.jadohealth.2010.11.259

Merwin, R. M., Timko, C. A., Moskovich, A. A., Ingle, K. K., Bulik, C. M., & Zucker, N. L. (2010). Psychological Inflexibility and Symptom Expression in Anorexia Nervosa. *Eating Disorders*, *19*(1), 62–82. https://doi.org/10.1080/10640266.2011.533606

Meyers, J. E., & Meyers, K. R. (1995). *Rey Complex Figure Test and Recognition Trial (RCFT)*. Par.

Micali, N., Hagberg, K. W., Petersen, I., & Treasure, J. L. (2013). The incidence of eating disorders in the UK in 2000–2009: Findings from the General Practice Research Database. *BMJ Open*, *3*(5), e002646. https://doi.org/10.1136/bmjopen-2013-002646

Micali, N., Hilton, K., Natatani, E., Heyman, I., Turner, C., & Mataix-Cols, D. (2011). Is childhood OCD a risk factor for eating disorders later in life? A longitudinal study. *Psychological Medicine*, *41*(12), 2507–2513. https://doi.org/10.1017/S003329171100078X

Miles, S., Gnatt, I., Phillipou, A., & Nedeljkovic, M. (2020). Cognitive flexibility in acute anorexia nervosa and after recovery: A systematic review. *Clinical Psychology Review*, *81*, 101905. https://doi.org/10.1016/j.cpr.2020.101905

Miles, S., Nedeljkovic, M., & Phillipou, A. (2022). Can Cognitive Flexibility and Clinical Perfectionism Be Used to Identify People with Anorexia Nervosa? *Journal of Clinical Medicine*, *11*(7), 1954. https://doi.org/10.3390/jcm11071954

Miskovic-Wheatley, J., Bryant, E., Ong, S. H., Vatter, S., Le, A., National Eating Disorder Research Consortium, Aouad, P., Barakat, S., Boakes, R., Brennan, L., Bryant, E., Byrne, S., Caldwell, B., Calvert, S., Carroll, B., Castle, D., Caterson, I., Chelius, B., Chiem, L., … Maguire, S. (2023). Eating disorder outcomes: Findings from a rapid review of over a decade of research. *Journal of Eating Disorders*, *11*(1), 85. https://doi.org/10.1186/s40337-023-00801-3

Mitchison, D., Morin, A., Mond, J., Slewa-Younan, S., & Hay, P. (2015). The Bidirectional Relationship between Quality of Life and Eating Disorder Symptoms: A 9-Year

Community-Based Study of Australian Women. *PLOS ONE*, *10*(3), e0120591. https://doi.org/10.1371/journal.pone.0120591

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, *9*(3), 353–383. https://doi.org/10.1016/0010-0285(77)90012-3

Neale, J., & Hudson, L. D. (2020). Anorexia nervosa in adolescents. *British Journal of Hospital Medicine*, *81*(6), 1–8. https://doi.org/10.12968/hmed.2020.0099

Nelson, H. E. (1976). A Modified Card Sorting Test Sensitive to Frontal Lobe Defects. *Cortex*, *12*(4), 313–324. https://doi.org/10.1016/S0010-9452(76)80035-4

Petkova, H., Simic, M., Nicholls, D., Ford, T., Prina, A. M., Stuart, R., Livingstone, N., Kelly, G., Macdonald, G., Eisler, I., Gowers, S., Barrett, B. M., & Byford, S. (2019). Incidence of anorexia nervosa in young people in the UK and Ireland: A national surveillance study. *BMJ Open*, *9*(10), e027339. https://doi.org/10.1136/bmjopen-2018-027339

Plana-Ripoll, O., Pedersen, C. B., Holtz, Y., Benros, M. E., Dalsgaard, S., De Jonge, P., Fan, C. C., Degenhardt, L., Ganna, A., Greve, A. N., Gunn, J., Iburg, K. M., Kessing, L. V., Lee, B. K., Lim, C. C. W., Mors, O., Nordentoft, M., Prior, A., Roest, A. M., … McGrath, J. J. (2019). Exploring Comorbidity Within Mental Disorders Among a Danish National Population. *JAMA Psychiatry*, *76*(3), 259. https://doi.org/10.1001/jamapsychiatry.2018.3658

Rhind, C., Mahdi, M., Simic, M., Espie, J., & Tchanturia, K. (2022). Group cognitive remediation therapy for children and adolescents in intensive day-patient treatment for anorexia nervosa: A feasibility study. *Neuropsychiatrie*, *36*(3), 125–135. https://doi.org/10.1007/s40211-022-00420-5

Roberts, M. E., Tchanturia, K., Stahl, D., Southgate, L., & Treasure, J. (2007). A systematic review and meta-analysis of set-shifting ability in eating disorders. *Psychological Medicine*, *37*(8), 1075–1084. https://doi.org/10.1017/S0033291707009877

Roberts, M. E., Tchanturia, K., & Treasure, J. L. (2010). Exploring the neurocognitive signature of poor set-shifting in anorexia and bulimia nervosa. *Journal of Psychiatric Research*, *44*(14), 964–970. https://doi.org/10.1016/j.jpsychires.2010.03.001

Romine, C. B., & Reynolds, C. R. (2005). A Model of the Development of Frontal Lobe Functioning: Findings From a Meta-Analysis. *Applied Neuropsychology*, *12*(4), 190–201. https://doi.org/10.1207/s15324826an1204_2

Rößner, A., Juniak, I., Van Noort, B. M., Pfeiffer, E., Lehmkuhl, U., & Kappel, V. (2017). Cognitive Flexibility in Juvenile Anorexia Nervosain Relation to Comorbid Symptoms

of Depression, Obsessive Compulsive Symptoms and Duration of Illness. *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie*, *45*(5), 371–380. https://doi.org/10.1024/1422-4917/a000493

Saul, J., Rodgers, R. F., & Saul, M. (2022). Adolescent Eating Disorder Risk and the Social Online World. *Child and Adolescent Psychiatric Clinics of North America*, *31*(1), 167–177. https://doi.org/10.1016/j.chc.2021.09.004

Smith, K. E., Mason, T. B., Johnson, J. S., Lavender, J. M., & Wonderlich, S. A. (2018). A systematic review of reviews of neurocognitive functioning in eating disorders: The state-of-the-literature and future directions. *International Journal of Eating Disorders*, *51*(8), 798–821. https://doi.org/10.1002/eat.22929

Spitoni, G. F., Aragonaa, M., Bevacqua, S., Cotugno, A., & Antonucci, G. (2018). An ecological approach to the behavioral assessment of executive functions in anorexia nervosa. *Psychiatry Research*, *259*, 283–288. https://doi.org/10.1016/j.psychres.2017.10.029

Stedal, K., Broomfield, C., Hay, P., Touyz, S., & Scherer, R. (2021). Neuropsychological functioning in adult anorexia nervosa: A meta-analysis. *Neuroscience & Biobehavioral Reviews*, *130*, 214–226. https://doi.org/10.1016/j.neubiorev.2021.08.021

Steegers, C., Dieleman, G., Moskalenko, V., Santos, S., Hillegers, M., White, T., & Jansen, P. W. (2021). The longitudinal relationship between set-shifting at 4 years of age and eating disorder related features at 9 years of age in the general pediatric population. *International Journal of Eating Disorders*, *54*(12), 2180–2191. https://doi.org/10.1002/eat.23633

Steinhausen, H., Jakobsen, H., Helenius, D., Munk-Jørgensen, P., & Strober, M. (2015). A nation-wide study of the family aggregation and risk factors in anorexia nervosa over three generations. *International Journal of Eating Disorders*, *48*(1), 1–8. https://doi.org/10.1002/eat.22293

Steinhausen, H.-C. (2002). The Outcome of Anorexia Nervosa in the 20th Century. *American Journal of Psychiatry*, *159*(8), 1284–1293. https://doi.org/10.1176/appi.ajp.159.8.1284

Stice, E., Marti, C. N., & Rohde, P. (2013). Prevalence, incidence, impairment, and course of the proposed DSM-5 eating disorder diagnoses in an 8-year prospective community study of young women. *Journal of Abnormal Psychology*, *122*(2), 445–457. https://doi.org/10.1037/a0030679

Talbot, A., Hay, P., Buckett, G., & Touyz, S. (2015). Cognitive deficits as an endophenotype for anorexia nervosa: An accepted fact or a need for re-examination? *International Journal of Eating Disorders*, *48*(1), 15–25. https://doi.org/10.1002/eat.22332

Tchanturia, K., Giombini, L., Leppanen, J., & Kinnaird, E. (2017). Evidence for Cognitive Remediation Therapy in Young People with Anorexia Nervosa: Systematic Review and Meta-analysis of the Literature. *European Eating Disorders Review*, *25*(4), 227–236. https://doi.org/10.1002/erv.2522

Tchanturia, K., Harrison, A., Davies, H., Roberts, M., Oldershaw, A., Nakazato, M., Stahl, D., Morris, R., Schmidt, U., & Treasure, J. (2011). Cognitive Flexibility and Clinical Severity in Eating Disorders. *PLoS ONE*, *6*(6), e20462. https://doi.org/10.1371/journal.pone.0020462

Tchanturia, K., Lounes, N., & Holttum, S. (2014). Cognitive Remediation in Anorexia Nervosa and Related Conditions: A Systematic Review. *European Eating Disorders Review*, *22*(6), 454–462. https://doi.org/10.1002/erv.2326

Treasure, J., Lopez, C., & Roberts, M. (2007). Endophenotypes in eating disorders: Moving toward etiologically based diagnosis and treatment focused on pathophysiology. *Pediatric Health*, *1*(2), 171–181. https://doi.org/10.2217/17455111.1.2.171

Treasure, J., & Russell, G. (2011). The case for early intervention in anorexia nervosa: Theoretical exploration of maintaining factors. *British Journal of Psychiatry*, *199*(1), 5–7. https://doi.org/10.1192/bjp.bp.110.087585

Treasure, J., & Schmidt, U. (2013). The cognitive-interpersonal maintenance model of anorexia nervosa revisited: A summary of the evidence for cognitive, socio-emotional and interpersonal predisposing and perpetuating factors. *Journal of Eating Disorders*, *1*(1), 13. https://doi.org/10.1186/2050-2974-1-13

Ulfvebrand, S., Birgegård, A., Norring, C., Högdahl, L., & Von Hausswolff-Juhlin, Y. (2015). Psychiatric comorbidity in women and men with eating disorders results from a large clinical database. *Psychiatry Research*, *230*(2), 294–299. https://doi.org/10.1016/j.psychres.2015.09.008

Van Eeden, A. E., Van Hoeken, D., Hendriksen, J. M. T., & Hoek, H. W. (2023). Increase in incidence of anorexia nervosa among 10- to 14-year-old girls: A nationwide study in the Netherlands over four decades. *International Journal of Eating Disorders*, *56*(12), 2295–2303. https://doi.org/10.1002/eat.24064

Van Eeden, A. E., Van Hoeken, D., & Hoek, H. W. (2021). Incidence, prevalence and mortality of anorexia nervosa and bulimia nervosa. *Current Opinion in Psychiatry*, *34*(6), 515–524. https://doi.org/10.1097/YCO.0000000000000739

Van Noort, B. M., Pfeiffer, E., Ehrlich, S., Lehmkuhl, U., & Kappel, V. (2016). Cognitive performance in children with acute early-onset anorexia nervosa. *European Child & Adolescent Psychiatry*, *25*(11), 1233–1244. https://doi.org/10.1007/s00787-016-0847-0

Weinbach, N., Perry, A., Sher, H., Lock, J. D., & Henik, A. (2017). Weak central coherence in weight-restored adolescent anorexia nervosa: Characteristics and remediation. *International Journal of Eating Disorders*, *50*(8), 924–932. https://doi.org/10.1002/eat.22711

Wentz, E., Gillberg, I. C., Anckarsäter, H., Gillberg, C., & Råstam, M. (2009). Adolescent-onset anorexia nervosa: 18-year outcome. *British Journal of Psychiatry*, *194*(2), 168–174. https://doi.org/10.1192/bjp.bp.107.048686

Wittek, T., Zeiler, M., Truttmann, S., Philipp, J., Kopp, K., Krauss, H., Auer-Welsbach, E., Ohmann, S., Sackl-Pammer, P., Werneck-Rohrer, S., Laczkovics, C., Mitterer, M., Schneider, A., Kahlenberg, L., Schmidt, U., Karwautz, A., & Wagner, G. (2024). Exploring neurocognitive features in adolescents and young adults with anorexia nervosa: Evidence from a longitudinal study. *European Eating Disorders Review*, erv.3127. https://doi.org/10.1002/erv.3127

Wu, M., Brockmeyer, T., Hartmann, M., Skunde, M., Herzog, W., & Friederich, H.-C. (2014). Set-shifting ability across the spectrum of eating disorders and in overweight and obesity: A systematic review and meta-analysis. *Psychological Medicine*, *44*(16), 3365–3385. https://doi.org/10.1017/S0033291714000294

Zerwas, S., Larsen, J. T., Petersen, L., Thornton, L. M., Mortensen, P. B., & Bulik, C. M. (2015). The incidence of eating disorders in a Danish register study: Associations with suicide risk and mortality. *Journal of Psychiatric Research*, *65*, 16–22. https://doi.org/10.1016/j.jpsychires.2015.03.003

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Abstract (English)

Anorexia nervosa (AN) is a severe mental illness that can go along with life-threatening physiological complications. In the attempt to identify etiological factors that contribute to the onset of the disorder, anomalies in cognitive functioning are repeatedly discussed. Literature suggests consistent impairment in central coherence and set-shifting in adult AN patients. In adolescents, however, the results are quite mixed. The present study intended to resolve open questions by additionally taking into account symptoms of obsessive-compulsive disorder (OCD). It was hypothesized that acutely ill patients would display more impairment in cognitive functioning than partially and fully remitted patients and healthy controls. Further, symptoms of OCD were thought to influence this effect. Also, poor set-shifting and central coherence and more symptoms of OCD were expected to predict a longer illness duration and more severe AN symptoms. The results did not reveal any group differences in central coherence. Partially remitted patients displayed significantly poorer set-shifting than acutely ill patients. There was no influence of OCD on group differences in the cognitive measures. Acutely ill patients showed significantly more OCD symptoms than fully remitted patients and healthy controls. More central coherence was associated with a longer illness duration. These results contribute to the body of research that does not find impaired cognitive functioning in adolescent AN patients. There remain unresolved questions about the dynamics of neurocognitive skills in the context of AN that only more complex longitudinal studies can provide an answer to.

Abstract (German)

Anorexia Nervosa ist eine schwere psychische Störung, die mit lebensbedrohlichen körperlichen Komplikationen einhergehen kann. Im wissenschaftlichen Diskurs um mögliche Faktoren, die die Entstehung der Erkrankung begünstigen, werden wiederholt neurokognitive Defizite diskutiert. Studien zeigen wiederholt Beeinträchtigungen in zentraler Kohärenz und Set-shifting bei erwachsenen AN Patientinnen. Bei jugendlichen Patientinnen hingegen sind die Ergebnisse uneindeutig. Diese Studie unternimmt den Versuch, unter Einbezug von Zwangssymptomen bisher ungeklärten Fragen auf den Grund zu gehen. Es wurde die Hypothese aufgestellt, dass akut erkrankte Patientinnen schlechtere zentrale Kohärenz und schlechteres Set-shifting aufweisen als teilweise und vollständig remittierte Patientinnen und gesunde Kontrollprobandinnen. Teilweise und vollständig remittierte Patientinnen sollten schlechtere kognitive Fähigkeiten aufweisen als gesunde Kontrollen. Überdies wurde angenommen, dass diese Gruppenunterschiede zusätzlich von Zwangssymptomen beeinflusst werden. Schlechtere zentrale Kohärenz, schlechteres Set-shifting und mehr Zwangssymptomen sollten zudem schwerere AN Symptome sowie eine längere Krankheitsdauer vorhersagen. Die Ergebnisse zeigten keine Unterschiede zwischen den Gruppen in zentraler Kohärenz. Teilweise remittierte Patientinnen wiesen schlechteres Set-shifting auf als akute Patientinnen. Akut erkrankte Patientinnen hatten häufiger Zwangssymptome als vollständig remittierte Patientinnen und gesunde Kontrollen. Mehr zentrale Kohärenz war mit einer längeren Krankheitsdauer assoziiert. Diese Ergebnisse sind in Einklang mit einer großen Anzahl an früheren Studien, die keine Anomalien in kognitiven Fähigkeiten bei jugendlichen AN Patientinnen feststellen. Es bleiben ungeklärte Fragen, auf die nur komplexere Längsschnittstudien Antworten werden geben können.