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Emotion Regulation and Executive Function: Associations with Depression and Anxiety in Autism

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Abstract

Background: Adolescents and young adults with autism spectrum disorder (ASD) are prone to experience co-occurring mental health conditions such as mood or anxiety disorders, as well as impairments in emotion regulation and executive functioning. However, little research has examined inter-relationships among these constructs, despite evidence of additional stressors and increased risk of internalizing disorders at this age, relative to non-autistic individuals. If either emotion regulation or executive functioning are shown to have patterns of association with mental health, this can inform mechanism-based intervention.

Method: Fifty-seven autistic adolescents and adults (16–25 years) with ASD in a transition intervention completed questionnaires and clinician-administered measures at baseline. Analyses

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Author Contribution

All authors contributed to the study conception and design. SWW secured funding for the original trial. ICS, RE, CMC cleaned and analyzed the data. CMC wrote the majority of first draft of the manuscript with sections written by RE and ICS; all authors commented and edited previous versions of the manuscript, including the final version.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Virginia Tech Institutional Review Board.

Consent to participate

Informed consent was obtained from all individual participants included in the study. For all minors who participated, informed consent was obtained from legal guardians and minors provided assent.

assessed whether executive functioning impairment, above and beyond emotion regulation impairment, were associated with depression and anxiety symptoms.

Results: ASD characteristics, emotion regulation, anxiety, and depression were significantly correlated. ASD characteristics was a significant contributor to depression and emotion regulation impairments were significant contributors to anxiety and depression. Findings indicated that inhibition difficulties did not uniquely contribute to depression or anxiety above emotion regulation impairment. Difficulties in cognitive flexibility were associated with depression above and beyond ASD characteristics, IQ, and emotion regulation, but not associated with anxiety.

Conclusions: Although preliminary, findings suggest that inflexibility and regulatory impairment should be considered in depression remediation approaches. Improving ER, on the other hand, may have broader transdiagnostic impact across both mood and anxiety symptoms in ASD.

Keywords

emotion regulation; executive functioning; depression; anxiety; cognitive flexibility; inhibition

Diagnostically, Autism Spectrum Disorder (ASD) is comprised of difficulties in social communication in conjunction with the presence of restricted and repetitive behaviors and sensory differences (APA, 2013). In addition to these core diagnostic features, individuals with ASD commonly present with executive dysfunction, emotion regulation impairment, and co-occurring psychopathology (Conner, White, et al., 2020; Mazefsky et al., 2013). Executive function (EF) is defined as a complex set of skills which allows someone to engage in goal-directed behavior (Diamond, 2013; Miyake & Friedman, 2012; Roberts & Pennington, 1996). These skills follow a developmental trajectory, with full maturity, behaviorally and neurobiologically, by adulthood (Ferguson et al., 2021). EF is also considered a component under the larger construct of self-regulation, defined as one's ability to regulate your own cognitions, emotions, and behaviors (Bridgett et al., 2013; Karoly, 1993). Self-regulation encompasses concepts such as EF, emotion regulation, and self-control (Baumeister & Vohs, 2003). Further, EF has been increasingly examined in context with and without other cognitive processes (termed 'hot' and 'cool' EF, respectively) (Zelazo & Carlson, 2012), which considers how EF is influenced by motivations and emotional factors.

In ASD, there is evidence of impaired EF; however, findings have differed by sample composition (i.e., age, whether community or clinically referred participants) and methodology (i.e., self/parent-report questionnaires vs. performance-based tasks) (Demetriou et al., 2018; Kenworthy et al., 2008; Lai et al., 2017). Impaired levels of EF measured via both questionnaires and performance-based tasks have been associated with core ASD characteristics, such as restricted and repetitive behaviors and interests (Faja & Nelson Darling, 2018; Wallace et al., 2016). Caregiver report of the level of EF impairment increases as their children age into adolescence, suggesting that EF skills may either stall, mature more slowly, worsen, or become more noticeable in youth with ASD as they age (Rosenthal et al., 2013). Further, in ASD, EF impairments have been associated with worse adaptive functioning (Bertollo et al., 2020; Kenny et al., 2019; Pugliese et al., 2016), mental

health (Hollocks et al., 2021; Uljarević et al., 2017; Wallace et al., 2016; Zimmerman et al., 2017), quality of life (de Vries & Geurts, 2015), social functioning (Bertollo et al., 2020; Vogan et al., 2018), and academic outcomes (Dijkhuis et al., 2020; Freeman et al., 2017). Additionally, a cross-sectional study comparing age- and IQ- matched ASD, ADHD, and neurotypical youth suggested that individuals with ASD have less severe and persistent EF symptoms on average compared to those with ADHD, although their profiles of EF differed by diagnosis (Happé et al., 2006). Across the literature, impairments in the facets of cognitive flexibility and inhibition have been observed most frequently in ASD (Ros & Graziano, 2019).

Cognitive flexibility and inhibition are two specific domains of EF which are particularly susceptible to impairment across the lifespan among individuals with ASD (Corbett et al., 2009; Pennington & Ozonoff, 1996; Verté et al., 2006). Cognitive flexibility is the ability to shift between different thoughts or tasks (Monsell, 2003). When faced with a variety of situational demands, ideally an individual flexibly and frequently modifies their behavioral or cognitive approaches. There is some evidence to suggest that individuals with ASD struggle with this aspect of EF more so than neurotypical individuals and at a level comparable to individuals with other developmental disorders such as ADHD (see Uddin, 2021, for review). Further, cognitive inflexibility is associated with mental health symptoms across adolescence (Hollocks et al., 2021). Cognitive inflexibility can be tied to core ASD characteristics such as rigid adherence to behavioral routines and a desire for sameness, and even limited perspective-taking in social situations (Geurts, de Vries, et al., 2014). Relatedly, inhibition encapsulates one’s ability to reduce ruminative thinking, suppress automatic responses or ignore distracting stimuli in order to engage in a more productive behavior (Geurts, van den Bergh, et al., 2014). Meta-analyses of both of these facets of inhibition indicated that they are impaired in ASD (Geurts, van den Bergh, et al., 2014). In fact, difficulties in response inhibition via performance-based tasks remained in a sample of youth with ASD after controlling for ADHD symptoms when compared to both youth with ADHD and neurotypical youth. This suggests that inhibition problems may be uniquely tied to ASD, rather than a result of common ADHD comorbidity (Karalunas et al., 2018).

Self-regulation also concerns the ability to change one’s own emotional states (Baumeister & Vohs, 2003; Hofmann et al., 2012). Emotion regulation (ER) is often defined as one’s ability to manage or modify their emotional state and arousal to accomplish their goals (Thompson, 1994). Previous research has found that youth with ASD frequently have clinically elevated levels of ER impairment by caregiver report (Conner et al., 2021) and that ASD symptomatology is positively associated with the level of caregiver-reported ER impairment (Berkovits et al., 2017; Samson et al., 2014). Furthermore, individuals with ASD have been found to engage in fewer and less adaptive ER strategies and to deploy ER strategies less flexibly as compared to individuals without ASD (Cai et al., 2018; Khor et al., 2014; Mazefsky et al., 2014; Samson et al., 2015). In a study of preschool-aged children with ADHD, ASD and ADHD, and neurotypical children who were administered both lab and caregiver-/teacher-report questionnaires, those with ASD/ADHD were more likely to present with the poorest EF and those with ADHD alone were more likely to present with poorest ER (Ros & Graziano, 2019). While few studies have ever compared older samples

or individuals with only ASD and only ADHD, ER impairment has also been observed in multiple ADHD samples (Bunford et al., 2020; England-Mason, 2020; Ros & Graziano, 2019).

Among people with ASD, both caregiver-reported ER and EF are associated with co-occurring psychopathology (Conner et al., 2021; Lawson et al., 2015). In particular, ER impairment in ASD has been associated with co-occurring psychiatric concerns such as anxiety, depression, and suicidality (Charlton et al., 2020; Conner, Golt, et al., 2020) and has also been correlated with social and academic outcomes and global quality of life (Jahromi et al., 2013). Inflexibility in those with ASD is similarly associated with anxiety and depression (Lawson et al., 2015).

Co-occurring anxiety and depression are highly prevalent and are associated with diminished global functioning and quality of life among individuals with ASD. Although estimates vary, lifetime prevalence figures of approximately 40% have been reported for both anxiety and depression (Hollocks et al., 2019). Other studies have observed higher rates of co-occurring psychiatric conditions and symptoms (Simonoff et al., 2008), including findings that 63% of young adults with ASD were clinically elevated on measures of psychiatric symptoms (McCauley et al., 2020). Prior research has examined whether core ASD characteristics are associated with the presence of co-occurring anxiety and depression. Co-occurring conditions like anxiety could represent a separate co-occurring condition, reflect overlap from core ASD characteristics, or be missed entirely due to diagnostic overshadowing (see Rosen et al., 2018, for review). Hollocks and colleagues (2014) assessed adolescents with ASD to examine the relationships between anxiety, depression, and tasks measuring EF and social cognition (e.g., theory of mind). Findings did not indicate a relationship between the social cognition tasks and anxiety or depression. In a longitudinal study of youth with ASD, social anxiety predicted worse social communication impairment, but the inverse was not found (Duvekot et al., 2017). However, in an adult ASD sample, ASD severity was inversely related to anxiety in terms of quality of life, such that those with less severe ASD characteristics reported lower quality of life if they also had significant anxiety, but anxiety was not associated with quality of life in adults with more severe ASD characteristics (Smith et al., 2019). These internalizing diagnoses are likely to be of particular concern for transition-age youth with ASD, given that this developmental period is associated with increased risk for psychopathology among emerging adults who are neurotypical (Copeland et al., 2014; Lei et al., 2020; McCauley et al., 2020), as well as neural and developmental differences that may render additional social and adaptive skills demands particularly difficult for youth with ASD (Picci & Scherf, 2015). Much less research has examined how EF and ER are temporally related to psychopathology; for instance, whether the transdiagnostic factors increase risk for psychiatric diagnoses, are a byproduct of the presence of psychopathology, or if bi-directional or a mixture of individual temporal relationships best capture these relationships. Prior research in ASD has found that impairments in specific EF components contribute differently to later psychopathology. In a longitudinal study of youth with ASD, Vogan and colleagues (2018) found that poorer parent-rated ability to inhibit, set-shift, and maintain emotional control was predictive of internalizing symptoms (depression and anxiety) and externalizing symptoms two years

later, but that other EF skills (e.g., planning, organization, initiation, monitoring) were not predictive of later psychiatric symptoms.

Since ER and EF appear to be related to a host of outcomes, directly targeting them in interventions may be particularly efficacious. Similar to the push for transdiagnostic treatments for mood and anxiety disorders in neurotypical populations using ER (e.g., Barlow et al., 2017; Ehrenreich-May et al., 2017; Kennedy et al., 2019), targeting EF has been previously demonstrated in ASD. The most well-studied EF intervention is a group-based, transdiagnostic program called Unstuck and On Target (Cannon et al., 2011), which has been studied in school- and clinic-based settings with degrees of parental involvement and training and found improvement in flexibility and problem solving, as well as improvements in ER-related measures (Dickson et al., 2020; Elias et al., 2019; Kenworthy et al., 2014, 2022). These findings suggest that examining ER and EF together may be particularly useful to assess their relationships to anxiety and depression.

The Present Study

Taken together, the relationship between EF, ER, and co-occurring psychopathology remains poorly understood, especially in transition-aged youth with ASD. Much of the prior literature examines the relationship between either ER or EF and psychopathology (or other outcomes) but does not account for the overlap of these transdiagnostic factors. Self-regulatory difficulties, in particular EF (inflexibility, disinhibition) and ER, may differentially relate to co-occurring depression and anxiety symptoms. The aim of the current study was to examine whether and how ER and EF were uniquely associated with anxiety and depression. Specifically, we aimed to assess whether an individual's inhibition difficulties or level of cognitive flexibility, as measured by a performance-based EF test, were associated uniquely, beyond ER impairment, with symptoms of anxiety and depression. We hypothesized that inhibition difficulties and worse cognitive flexibility and would be associated with greater self-reported symptoms of anxiety and depression, above and beyond ER impairment, in a sample of adolescents and emerging adults. Such findings would inform potential treatment targets, including for ER and EF, in individuals with ASD.

Methods

Participants

Participants were 57 adolescents and young adults with ASD (M_{age}= 18.56, *Range*= 16–25 years) enrolled in a randomized controlled trial (RCT). The experimental intervention was a transition support program for secondary or postsecondary students interested in pursuing higher education ((White et al., 2021). For the trial, participants either had to have autism listed as an educational classification in their individualized education plans, or an ASD diagnosis was confirmed by a research-reliable administration of the ADOS-2 (Lord et al., 2012). This approach to diagnostic confirmation is consistent with studies that have demonstrated that a prior community- or school-based diagnosis is largely consistent with a research ADOS administration (Daniels et al., 2012; Maddox et al., 2020). Participants also had a full-scale IQ of ≥ 85 on the WASI-II (Wechsler, 2011). Lastly, RCT eligibility required no changes in psychotropic medications during the course of treatment, and no

participation in concurrent psychotherapy. Approximately one-third of the participants were actively taking a prescribed psychotropic medication, and over 70% of participants met criteria for an anxiety disorder at baseline via either caregiver- or self-report on the Anxiety Disorders Interview Schedule for DSM-5 (Albano & Silverman,in press; Brown & Barlow, 2014). The majority of the sample identified as White (86%) and Male (80%). See (White et al., 2021 for further details on the RCT and exclusion criteria. Recruitment occurred in a southeastern state in both rural and small city/suburban settings, including efforts to recruit through local school districts and two- and four-year postsecondary programs. All measures in the current study were collected at baseline, prior to enrollment in the transition support program (See Table 1).

Measures

Autism Characteristics—Autism Diagnostic Observation Schedule- Second Edition (ADOS-2; Lord et al., 2012). The ADOS-2 is a semi-structured clinical task used to aid clinicians in distinguishing behaviors characteristic of autism from those seen in the typical population. The ADOS-2 was administered by trained, research-reliable clinicians. Module 4, appropriate for older adolescents and adults with fluent verbal speech, was used for this study to confirm ASD diagnoses for participants who did not have autism listed as a diagnosis on a pre-existing individualized education plan, which represented half of the sample.

Social Responsiveness Scale, Second Edition Self-Report (SRS-2; Constantino & Gruber, 2012). The SRS-2 is a 65-item measure of social difficulties and restricted and repetitive behaviors in ASD. The self-report version of this measure was used for the purposes of this study. Items are scored on a four-point Likert scale (1= “not true,” 2= “sometimes true,” 3= “often true,” and 4= “almost always true”). Five treatment subscales (Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted and Repetitive Behaviors) are summed into a Total Score and converted into T-scores. Internal consistency for the self-report Total Score in this study was high (α= .95).

Emotion and Behavior Assessments—Beck Anxiety Inventory (BAI; Beck et al., 1988; Beck & Steer, 1990). The BAI is a 21-item self-report questionnaire for anxiety symptoms. Items are rated on a 4-point Likert scale (from 0= “not at all,” to 3= “severe”), and higher summed scores indicate more severe anxiety symptoms. The BAI has been used extensively in research and clinical settings, including in several previous studies of adults with ASD (McVey et al., 2021). Internal consistency in the current study was high (α= .91).

Beck Depression Inventory, Second Edition (BDI-II; Beck et al., 1996). The BDI-II is a 21-item self-report questionnaire that assesses depression symptoms. Items are rated on a 4-point Likert scale (from 0= “not at all,” to 3= “severe”), and higher summed scores indicate more severe depressive symptoms. The BDI-II also has extensive previous use in research and clinical settings, including among adults with ASD (McVey et al., 2021; Williams, Everaert, et al., 2021). Internal consistency in this study was high (α= .92). Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The DERS is a 36-item, self-report questionnaire that assesses ER impairment. Items are scored on a 5-point Likert scale

from 1 (“almost never”) to 5 (“almost always”), with 11 reverse-scored items. The DERS yields six subscales: Nonacceptance, Goals, Impulse, Awareness, Strategies, and Clarity. Previous research on the DERS has not consistently replicated the six-factor structure and has suggested that the Awareness subscale of the DERS be removed or modified (combined with Clarity) due to low internal consistency (Bardeen et al., 2016; Lee et al., 2016). A recent study examining the DERS in ASD samples observed similar difficulties with the Awareness subscale and recommended against using a DERS Total score (McVey et al., 2021). Thus, the current study used the Nonacceptance, Goals, Impulse, and Strategies subscales only. Internal consistency for these subscales was acceptable in this sample: Nonacceptance $\alpha = .93$, Goals $\alpha = .79$, Impulse $\alpha = .87$, Strategies $\alpha = .97$.

Executive Function Assessments—Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001). The D-KEFS is a series of clinician-administered tests of EF domains (organization, planning, initiation, concept formation, and cognitive flexibility). Each test can be administered separately. For this sample, the Trail-Making, Color-Word Interference, and Card Sorting tasks were administered due to their relationships with cognitive flexibility and inhibition. The Sorting test measures cognitive flexibility and conceptual reasoning. Participants are provided six distinct cards and are asked to sort the cards repeatedly according to perceptual and semantic characteristics. The test yields a Confirmed Correct Sorts score which measures concept formation. Further, this study uses the Total Description Score that assesses the participant’s ability to describe sort categories. The Number-Letter Switching task of the Trail Making Test measures cognitive flexibility. Participants switch between connecting number and letter categories in order (e.g., A-1, B-2, etc.). For the Color-Word Interference Test (CWI), participants are asked to name color words printed in the wrong color (Inhibition) and again where participants are asked to switch to verbalizing the ink color or color written throughout the task (Inhibition/Switching). The D-KEFS has been used in research with both children and adults with ASD (Semrud-Clikeman et al., 2010; Zimmerman et al., 2017). All test scores are scaled scores (M=10, SD=3).

Cognitive Assessments—Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler, 2011). The WASI-II provides a general estimate of cognitive ability for individuals 6–90 years old. For this study, a clinician conducted the two-subscale version (one verbal subtest and one perceptual reasoning subtest) that yields an overall IQ score. The 2-subscale IQ score has strong validity and reliability with a full-scale IQ (Wechsler, 2011).

Analysis

Statistics were computed using IBM SPSS statistics version 27.0. Any participant who had missing DERS, D-KEFS, BDI-II, or BAI scores was removed listwise for analyses (n= 8). Descriptive statistics and Pearson correlations were first calculated to characterize the sample. No outliers (defined as a score > 3 SDs from the mean) were observed. We then conducted two hierarchical linear regressions, one with the BAI total score as the dependent variable and one with the BDI-II total score as the dependent variable. Step one consisted of the WASI-II two-subscale IQ score and the SRS-2 self-report Total T-score, step two included four DERS subscales (Nonacceptance, Goals, Strategies, and Impulse Control), and

step three included the two D-KEFS Sorting subtest scores (Sorting Confirmed Correct Sorts score and Sorting Total Combined Description score). Two additional hierarchical linear regressions were conducted with step three as Inhibition-based tasks (CWI Inhibition, CWI Inhibition/Switching, Trail Making Number-Letter Switching).

Results

First, Pearson correlations were examined. WASI-II two-subscale IQ scores were significantly and positively correlated with the DERS Goals subscale (r = .36, p = .005), D-KEFS confirmed correct sorts (r = .41, p = .002), and D-KEFS total combined description scores (r = .30, p = .02; See Table 2). Correlations among D-KEFS subscales and BAI/BDI-II scores were nonsignificant. SRS-2 self-report total T-scores were significantly and positively correlated with all DERS subscales (rs = .39-.58, ps < .05). Correlations among depression scores, SRS-2 scores, and DERS subscales were moderate to strong and statistically significant (rs = .49-.57, ps < .001). Anxiety symptoms as measured by the BAI demonstrated similar associations with SRS-2 and DERS scores (rs = .33-.59, ps < .01). Next, we conducted the regression analyses and examined model assumptions. No multicollinearity (no variance inflation factor > 3.2), interdependence (Durbin-Watson= 1.91), non-linearity, or heteroscedasticity were detected.

Inhibition

The overall model using inhibition to predict BAI scores accounted for 46% of the model variance. Step 1 contributed about one quarter of the variance, ER impairment added 27% of the model variance, and inhibition added 2.7% additional variance. Significant predictors of higher BAI scores were higher DERS Nonacceptance scores (β= .37, p = .036) and higher DERS Impulse Control scores (β= .38, p = .006).

When using the inhibition model to BDI-II scores, it accounted for 68% of the variance. IQ and ASD characteristics accounted for 43% of the model, ER impairment (step 2) contributed 30%, and inhibition (step 3) only added 1.2% to the model. Higher SRS-2 total scores (β= .22, p = .047), worse DERS Impulse Control (β= .27, p = .01), and worse DERS Strategy use (β= .40, p = .004) were significant predictors of higher BDI-II scores.

Cognitive Flexibility

The overall model using IQ, ASD characteristics, ER impairment, and cognitive flexibility to predict BAI scores accounted for 44% of the score variance (See Table 4). IQ and ASD characteristics (step 1) contributed to 23% of the model, ER impairment (step 2) contributed 27%, and cognitive flexibility (step 3) added only 0.3% to the model. Only higher DERS Nonacceptance scores (β= .39, p = .03) and higher DERS Impulse Control scores (β= .40, p = .004) were significant predictors of anxiety symptoms.

Overall, the model predicting BDI-II scores accounted for approximately 71% of the variance in BDI-II total score (See Table 3). IQ and ASD characteristics (step 1) contributed 40% to the model variance, ER impairment (step 2) added 30%, and cognitive flexibility (step 3) added only an additional 2.7% to the model. Self-reported ASD severity (SRS-2) (β= .21, p = .045), Impulse Control impairment (DERS) (β= .29, p = .004), Strategies

impairment (DERS) (β= .41, p = .002), and inflexibility (lower D-KEFS Sorting Description scores) (β= −.23, p = .046) were significant predictors of depression.

Discussion

The current study investigated how an individual's impairment in inhibition or cognitive flexibility, two facets of EF, were related to anxiety and depression above and beyond self-reported ER impairment in transition-aged individuals with ASD. Little of the prior research in this area has observed both ER and EF in tandem with anxiety or depression, and likewise, much of the previous research has not examined transition-aged youth, a time characterized by a heightened risk for anxiety and depression in ASD and neurotypical samples (Copeland et al., 2014; McCauley et al., 2020; Picci & Scherf, 2015). As expected, poorer ER was correlated with both depression and anxiety symptoms and with ASD characteristics, and poor ER was significantly associated with both depression and anxiety after controlling for IQ and ASD characteristics. Inhibition was not uniquely associated with anxiety or depression symptoms above and beyond ER impairment. Similarly, impairments in cognitive flexibility were not significantly related to anxiety symptoms above and beyond ER impairment. However, poorer cognitive flexibility was uniquely and significantly associated with increased depression symptoms. This finding, while preliminary due to the cross-sectional nature of the study, may suggest that an individual's ability to behaviorally shift between tasks is linked to risk for depressive symptoms.

Across both anxiety and depression, ER (particularly DERS Impulse Control subscale) was more strongly associated than the performance-based EF tasks in the regression analyses. All of the selected DERS subscales were significantly correlated with anxiety and depression symptoms, whereas no EF task was significantly correlated with anxiety or depression. In part, these findings may be due to the fact that ER is more directly related to psychopathology, while EF also encompasses cognitive processes that are not emotional in nature. Prior research has consistently demonstrated that ER is associated with co-occurring psychiatric symptoms in ASD samples (Charlton et al., 2020; Conner et al., 2021). Similarly, ER, anxiety, and depression were also positively correlated with ASD characteristics in the current study. These findings mirror prior research in youth samples that have shown that core ASD characteristics are associated with poor ER (Berkovits et al., 2017; Samson et al., 2014), and that anxiety and depression symptoms are also correlated with ASD characteristics (Hollocks et al., 2014; Keenan et al., 2017; McCauley et al., 2020).

In all models, more variance was explained in self-report depressive symptoms than in self-report anxiety symptoms, which may suggest that the relationship between different facets of self-regulatory impairments and depression symptoms is stronger, perhaps due to ruminative cognition seen in depression (Williams, McKenney, et al., 2021). Research in non-ASD samples has long found an association between poor EF and depression (Holler et al., 2014). Interestingly, a majority of the sample reported a prior diagnosis of an anxiety disorder (>70%), while about one-fifth of the sample reported a prior diagnosis of a mood disorder. The treatment-seeking nature of the current sample may have led to a higher prevalence of anxiety in this sample; additionally, prior research has been inconclusive about whether higher IQ (such as seen in this post-secondary education-seeking sample)

is associated specifically with higher prevalence of anxiety (Hollocks et al., 2014; Witwer & Lecavalier, 2010). Nonetheless, this high prevalence of anxiety diagnoses in the current sample limits the ability to generalize findings to individuals with autism who do not present with anxiety.

EF and ER are commonly considered to be two interrelated components of self-regulation. In previous research and in contrast to the current study, EF impairment (via parent- and self-report questionnaires) has been associated with internalizing and externalizing symptoms in longitudinal studies of children with ASD (Vogan et al., 2018), and both anxiety and depression symptoms in adults on the autism spectrum (Wallace et al., 2016). In accordance with our findings, previous research has found that poor ER has been associated with depression and anxiety symptoms in adolescents and young adults with ASD (Charlton et al., 2020). However, our study is among the first to examine how individual differences in EF and ER, measured via a performance-based task, may be uniquely associated with psychopathology in this population. When examining EF impairment, above and beyond ER, the findings seem less clear. Our finding that poor cognitive flexibility, but not inhibition, is associated with depression diverges from Wallace et al.'s (2016) findings, wherein self-report of poor flexibility was associated with anxiety and metacognitive difficulties (planning, initiation, monitoring) were associated with depression. Perhaps findings differ due to the use of performance-based EF tests versus self-report questionnaires. Cognitive inflexibility, behaviorally manifested as rumination and other cognitive 'stickiness', may be especially salient symptoms for those with ASD and depression (Gotham et al., 2015; Gotham et al., 2018). Lastly, because the current study was underpowered to detect smaller effects, these findings may not reflect the potential relationships between the constructs of EF, ER, and depression or anxiety.

Despite research indicating that poor inhibition is common in ASD (Geurts, van den Bergh, et al., 2014), inhibition was not significantly and uniquely associated with depression or anxiety above and beyond ER impairment in the current study. It is possible that the link to psychopathology in inhibition overlaps with ER impairments. For example, perhaps poor inhibition itself is only associated with co-occurring mental health conditions when paired with heightened emotional reactivity (Mazefsky et al., 2013). In this study, the DERS Impulse Control subscale may have accounted specifically for this specific difficulty with inhibitory functioning in emotion-laden situations. Future research should investigate these potential relationships by measuring and controlling for ER and further assessing how EF may differ when emotionally activated and when not. Again, the current study's findings may also reflect inability to detect small effects due to sample size limitations.

Relatedly, other factors may also have influenced these findings. One example is slow processing speed. While not explicitly measured in this sample, it is possible that slow processing speed, seen commonly in ASD (Duncan et al., 2018; Reinvall et al., 2017), could complicate findings. A study utilizing the same sample as this project found that almost one-third of this sample exhibited clinically significant levels of sluggish cognitive tempo by caregiver-report, which consists of slow processing speed, daydreaming, and mental fogginess ((Brewe, Simmons, Capriola-Hall, & White, 2020). Further, sluggish cognitive tempo was associated with heightened EF impairment and depressive symptoms.

These findings suggest that factors such as poor processing speed may uniquely relate to depression rather than anxiety in ASD. Again, more research is needed to disentangle these factors in adolescents and adults with ASD.

Additionally, overall higher IQ (not assessing for processing speed) was correlated with worse ER but better EF in this sample, but IQ was not a significant predictor of either depression or anxiety. While these findings are discordant with prior research suggesting that higher IQ may be associated with higher levels of anxiety in ASD (Lecavalier et al., 2019), they are consistent with prior studies of individuals with ASD and no cognitive impairment. Further, aside from EF tasks, the current study relied on self-report data of ER, anxiety, depression, and autism characteristics, and common method variance may have thus influenced the results.

This study is not without limitations, foremost of which is reliance on cross-sectional data, which does not allow us to determine causality (i.e., we cannot state that EF or ER causes anxiety and depression symptoms or vice versa), and future longitudinal work will be necessary to assess causal relationships. We also acknowledge that the small sample size and lack of a control or comparison group may have limited our ability to detect smaller effects and draw comparisons to other populations, respectively. Additionally, this study relied on either IEP classification of autism or an ADOS-2, rather than confirming ASD diagnosis via ADOS-2 for all participants, which limits ability to generalize findings. Difficulties with self-regulation and mental health symptoms may also have been overrepresented among our intervention-seeking sample. In addition, this study's sample was predominantly White, male, and required to have a full-scale IQ >85 for participation in the RCTs. These factors may limit generalizability of our findings to non-treatment-seeking samples, females, and individuals with IQ < 85.

The current study has a methodological strength in using self-report measures of ER, depression, and anxiety, and a performance-based measure of EF. On the other hand, reliance on questionnaire data, that are primarily self-report, raises concern about shared method and rater variance, respectively, which could at least partially explaining the relationship between ER and symptoms, with less of a relationship between EF and anxiety and depression symptoms. Future studies can also focus on using self-report measures that are specifically designed for individuals with ASD, including measures of depression, anxiety, and ER (Conner, White, et al., 2020; Rodgers et al., 2020; Williams, Everaert, et al., 2021). Optimally, both multiple reporter and performance-based EF measures would be used to be able to both assess the ecological validity of the performance-based tasks and investigate the real-world impact of EF impairment. Multi-method assessment of ER is also needed in future research, including observational coding and psychophysiological measures alongside questionnaires and clinical interviews (Northrup et al., 2020). In the current study, the majority of participants were diagnosed with a co-occurring anxiety disorder and approximately one-sixth of participants were diagnosed with co-occurring ADHD, which may have influenced results. Thus, future research should consider including other measures of core ASD characteristics as well as controlling for co-occurring psychiatric conditions.

Research into EF and ER in those with ASD continues to accumulate, particularly in the past 20 years. Mapping inter-relationships among these constructs, within a larger self-regulatory framework, may help elucidate reasons for the frequently reported ability-performance discrepancies seen in ASD research (Kenworthy et al., 2008; Tonizzi et al., 2021). As Geurts and colleagues (2009) argued in their review of cognitive inflexibility research in ASD, and others have often posited, there is a large gulf between performance-based tasks and everyday situations that call for EF skills, requiring the field to consider how best to create and use more ecologically based measures. And these real-world challenges are often exacerbated with ER impairment, but much of our research investigates these constructs independently as opposed to intertwined, as opposed to research into 'hot' EF that incorporates how emotionally-laden situations can differ (Zelazo & Carlson, 2012). Instead, research should incorporate measurement of self-regulation-based impairments (EF, ER, and attentional challenges) more broadly, especially into interventions, to better understand the relationships between these constructs and their impacts on overall functioning.

Implications

Professionals and caregivers should attend to mental health symptoms such as anxiety and depression, and their association with self-regulatory difficulties, in transition-aged youth with ASD. Therapies addressing anxiety and depression, while vital, may be optimized by training to improve ER and EF. For example, treating depression using CBT may be augmented with more instruction on coping skills, including identifying when and how to use cognitive flexibility and how to identify and shift perseverative thinking that is more negative (ruminative) in nature. However, while prior research has demonstrated efficacy in treating anxiety in individuals with ASD (Wood et al., 2020), response rates of CBT for youth with ASD are lower in research compared to neurotypical youth (Kreslins et al., 2015; Storch et al., 2021). Mindfulness-based approaches have also demonstrated utility for improving ER in ASD (Conner et al., 2019; Hartmann et al., 2019; Ritschel et al., 2021). It is also important to assess self-regulatory difficulties in clients with ASD using multiple methods, including questionnaires and interviewing clients and caregivers (when relevant) to understand how EF and ER difficulties appear in their daily lives and contribute to presenting concerns. Addressing self-regulation more broadly may be especially pertinent for those with ASD to improve general outcomes.

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Highlights

- Assessed the roles of executive functioning and emotion regulation together
- IQ, autism characteristics, and emotion regulation contribute to depression/anxiety
- Inhibitory difficulties did not uniquely contribute to depression or anxiety
- Cognitive flexibility difficulties contributed minorly to depression, not anxiety

Table 1.

Demographics and Descriptive Data

		***n* (%)**	
Gender	Male	46 (80.70)	
	Female	11 (19.30)	
Race/Ethnicity	Asian	5 (8.77)	
	Black	2 (3.51)	
	White	49 (85.96)	
	Prefer not to indicate	1 (1.75)	
	Hispanic/Latino	3 (5.26)	
Current Psychotropic Medication		21 (36.84)	
Co-occurring psychiatric diagnosis	Any anxiety disorder	42 (71.19)	
	ADHD	10 (16.95)	
	Any mood disorder	11 (18.64)	
	Obsessive-Compulsive Disorder	4 (6.78)	
	PTSD	3 (5.08)	
		M(SD) n (%)	***Range***
Age		18.56 (2.04)	16–24
WASI-II 2 Scale IQ		105.82 (12.40)	84–131
BDI-II total score		13.67 (11.63)	0–42
Minimal range		***13 (24.01%)***	0–13
Mild range		***8***	14–19
Moderate range		***8***	20–28
Severe range		***7***	29–42
BAI total score		11.37 (9.41)	0– 43
Minimal range		***23***	0–7
Mild range		***17***	8–15
Moderate range		***10***	16–25
Severe range		***4***	26–43
SRS-2 parent-report total *T*-score		68.67 (10.33)	48–90
SRS-2 self-report total *T*-score		63.71 (10.12)	44– 83
DERS total score		94.13 (24.79)	46–153
	Nonacceptance	14.23 (7.24)	6– 30
	Goals	16.57 (3.97)	6– 25
	Impulse	13.48 (5.44)	6– 28
	Strategies	19.96 (7.93)	8– 38
D-KEFS Standard Score			
Sorting Test	Confirmed Correct Sorts	9.43 (2.95)	3–15
	Combined Total Description	10.35 (5.21)	2–27
Color-Word Interference Test	Inhibition	9.37 (2.99)	1–14
	Inhibition/Switching	9.04 (2.90)	1–15

Trail Making Test	Number-Letter Switching	7.87 (3.63)	1–13

Note: WASI-II= Wechsler Abbreviated Scale of Intelligence, Second Edition; BDI-II= Beck Depression Inventory, Second Edition; BAI= Beck Anxiety Inventory; SRS-2= Social Responsiveness Scale, Second Edition; DERS=Difficulties in Emotion Regulation Scale; D-KEFS= Delis-Kaplan Executive Function System

Table 2.

Correlations

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. WASI-II	--													
2. BDI-II Total	−.19	--												
3. BAI Total	−.16	.78**	--											
4. DERS Nonacceptance	−.12	.63**	.57**	--										
5. DERS Goals	.36**	.49**	.34*	.60**	--									
6. DERS Impulse	−.09	.54**	.53**	.44**	.46**	--								
7. DERS Strategies	−.07	.72**	.54**	.67**	.63**	.47**	--							
8. DERS Total	−.02	.77**	.64**	.81**	.70**	.69**	.87**	--						
9. SRS-2 Total	−.05	.62**	.51**	.53**	.36**	.38**	.46**	.60**	--					
10. DKEFS Confirmed Correct	.41**	−.03	−.11	−.05	.20	−.01	.05	.10	.07	--				
11. DKEFS Combined Desc	.28*	−.18	−.10	−.03	−.02	−.09	.02	.09	−.07	.63**	--			
12. DKEFS Inhibition	.40**	.10	.16	.07	.17	.14	.01	.13	.28	.29**	.1	--		
13. DKEFS Inhibition/ switching	.45**	.17	.13	.18	.38**	.24	.14	.24	.29	.35**	.13	.72**	--	
14. DKEFS Number/ Letter	.41**	−.05	−.09	−.03	.08	−.01	−.12	−.01	−.03	.28*	.13	.49**	.51**	--

Note: WASI-II= Wechsler Abbreviated Scale of Intelligence Second Edition; BDI-II= Beck Depression Inventory Second Edition; BAI= Beck Anxiety Inventory; SRS-2= Social Responsiveness Scale Second Edition; DERS= Difficulties in Emotion Regulation Scale; D-KEFS= Delis-Kaplan Executive Function System

Table 3.

Regression models predicting Depression

Dependent Variable: Depression (BDI-II)	β	*F*	Adj. R^2	ΔR^2
Step 1		17.20**	.403	--
WASI-II	−.140			
SRS-2	.624**			
Step 2		18.714**	.689	.300**
WASI-II	−.081			
SRS-2	.248*			
DERS Nonacceptance	.183			
DERS Goals	−.042			
DERS Impulse control	.283**			
DERS Regulatory Strategies	.374**			
Step 3 (Sorting)		15.374**	.710	.027
WASI-II	−.045			
SRS-2	.209*			
DERS Nonacceptance	.244			
DERS Goals	−.142			
DERS Impulse control	.288**			
DERS Regulatory strategies	.407**			
D-KEFS Confirmed correct sorts	.177			
D-KEFS Sorting combined description score	−.226*			
Step 3 (Inhibition)		12.323**	.680	.012
WASI-II	−.162			
SRS-2	.222*			
DERS Nonacceptance	.161			
DERS Goals	−.012			
DERS Impulse Control	.267*			
DERS Regulatory Strategies	.397**			
D-KEFS CWI Inhibition	.085			
D-KEFS CWI Inhibition/Switching	−.010			
D-KEFS Trail-making Number-letter switching	.079			

* $p < .05$

** $p < .01$

Note: WASI-II= Wechsler Abbreviated Scale of Intelligence Second Edition; BDI-II= Beck Depression Inventory Second Edition; BAI= Beck Anxiety Inventory; SRS-2= Social Responsiveness Scale Second Edition Total Score; DERS= Difficulties in Emotion Regulation Scale; D-KEFS= Delis-Kaplan Executive Function System; CWI= Color-Word Interference

Table 4.

Regression models predicting Anxiety

Dependent Variable: Anxiety (BAI)	β	*F*	Adj. R^2	ΔR^2
Step 1		8.121*	.229	--
WASI-II	−.133			
SRS-2	.479**			
Step 2		7.903**	.463	.269**
WASI-II	.023			
SRS-2	.130			
DERS Nonacceptance	.376*			
DERS Goals	−.248			
DERS Impulse control	.396**			
DERS Regulatory Strategies	.193			
Step 3 (Sorting)		5.708**	.440	.003
WASI-II	.048			
SRS-2	.124			
DERS Nonacceptance	.387*			
DERS Goals	−.272			
DERS Impulse control	.395**			
DERS Regulatory strategies	.206			
D-KEFS Confirmed correct sorts	.010			
D-KEFS Sorting combined description score	−.062			
Step 3 (Inhibition)		5.466**	.456	.027
WASI-II	−.044			
SRS-2	.075			
DERS Nonacceptance	.365*			
DERS Goals	−.206			
DERS Impulse Control	.377**			
DERS Regulatory Strategies	.225			
D-KEFS CWI Inhibition	.246			
D-KEFS CWI Inhibition/Switching	−.100			
D-KEFS Trail-making Number-letter switching	−.034			

* $p < .05$

** $p < .01$

Note: WASI-II= Wechsler Abbreviated Scale of Intelligence Second Edition; BDI-II= Beck Depression Inventory Second Edition; BAI= Beck Anxiety Inventory; SRS-2= Social Responsiveness Scale Second Edition Total Score; DERS= Difficulties in Emotion Regulation Scale; D-KEFS= Delis-Kaplan Executive Function System; CWI= Color-Word Interference