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## Anger Rumination is Associated with Restricted and Repetitive Behaviors in Children with Autism Spectrum Disorder

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### Abstract

Children with autism spectrum disorder (ASD) are reported to have greater levels of anger rumination than typically developing children. This study examined anger rumination in children with ASD in comparison to children with disruptive behavior disorder without ASD. We also tested if anger rumination is associated with aggression and the core ASD symptoms of restricted and repetitive behaviors (RRBs). This study included three groups of children aged 8–16 years: 63 had ASD (ASD group), 79 had disruptive behavior disorder (DB group), and 40 healthy controls (HC). ASD and DB groups showed greater anger rumination relative to the HC group. Anger rumination was associated with RRBs in children with ASD, suggesting the link to core ASD symptoms.

### Keywords

Anger rumination; Autism spectrum disorder; Aggression; Emotion regulation; Restricted and repetitive behaviors

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Anger rumination is a cognitive-emotional process that refers to the tendency to dwell on frustrating experiences and to recall past anger experiences (Sukhodolsky et al. 2001). More broadly, rumination also represents a maladaptive form of emotion processing that entails

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**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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remaining focused on the stressor through repetitive and passive dwelling upon distress, past mistakes, regrets, and one's shortcomings (Nolen-Hoeksema 1991; Nolen-Hoeksema et al. 2008). Further, rumination may preclude the use of adaptive emotion regulation strategies such as cognitive reappraisal and problem solving (Connor-Smith et al. 2000; Nolen-Hoeksema et al. 2008). Although rumination is associated with anxiety and depression (Aldao et al. 2010), there is also evidence that rumination may be a factor in other forms of maladaptive behaviors including disruptive behaviors such as anger/irritability and aggression (Aldao et al. 2016; McLaughlin et al. 2014; Nolen-Hoeksema and Watkins 2011).

Autism spectrum disorder (ASD) is characterized by deficits in social communication and interaction, and restricted, repetitive patterns of behavior (RRBs) (American Psychiatric Association 2013). However, over 50% of children with ASD have co-occurring disruptive behavior disorders and/or internalizing disorders (Lecavalier et al. 2019; Sukhodolsky et al. 2008) that cause substantial distress and impair functioning. In addition to concomitant disorders, children and adults with ASD also exhibit elevated levels of rumination relative to typically developing controls (Crane et al. 2011; Mazefsky et al. 2014; Patel et al. 2017). While studies have investigated anger rumination in children without ASD (Smith et al. 2016), the mechanisms of anger rumination in children with ASD has not been well-studied.

Similar to results in non-ASD populations (Aldao et al. 2010), associations between rumination and internalizing symptoms of anxiety and depression were also found in children (Mazefsky et al. 2014; Patel et al. 2017; Pouw et al. 2013) and adults (Crane et al. 2011; Gotham et al. 2014; Keenan et al. 2017) with ASD. Two recent studies reported an association between anger rumination, core ASD symptoms, and disruptive behaviors (Patel et al. 2017; Pugliese et al. 2015). However, only one study to date (Patel et al. 2017) examined anger-focused rumination in a sample of children with ASD and reported greater levels of anger rumination in children with ASD relative to typically developing children. Another study examined anger rumination in young adults in the general population and showed that anger rumination was associated with anxiety symptoms and disruptive behaviors; that is, symptoms of social anxiety predicted greater anger rumination, which was associated with increased levels of disruptive behaviors (Pugliese et al. 2015). Relevant to the current study, the ASD symptom of perseveration was found to augment the relationship between anger-focused rumination and disruptive behaviors (Pugliese et al. 2015). Together, these studies provide preliminary evidence of an increased tendency to engage in anger-focused rumination in ASD and its possible association with ASD core symptoms. Given the high prevalence of co-occurring disruptive behavior in ASD (Lecavalier et al. 2019; Mazurek et al. 2013), a better understanding of the mechanisms underlying anger rumination in ASD may contribute to the development of novel treatments or inform existing clinical interventions addressing disruptive behaviors as well as emotion regulation (Mazefsky and White 2014). However, no studies to date have investigated patterns of anger rumination in children with ASD relative to children with disruptive behavior disorders. Therefore, the present study examines anger rumination in a sample of well-characterized children with ASD compared to children with disruptive behavior disorders without ASD and to matched typically developing controls.

In addition, associations between anger rumination and aggressive behavior was reported in both adults (Denson et al. 2011; White and Turner 2014) and children (Harmon et al. 2017; Smith et al. 2016) without ASD. Children with disruptive behavior disorders were also found to have higher levels of anger rumination than typically developing controls (Smith et al. 2016). Given the high prevalence of individuals with ASD who also meet criteria for comorbid psychiatric disorders, particularly disruptive behavior disorders (Lecavalier et al. 2019; Leyfer et al. 2006; Simonoff et al. 2008; van Steensel et al. 2013), it is important to examine if anger rumination in ASD is associated with symptoms related to disruptive behavior such as aggression. Thus, we also tested if aggressive behavior is associated with anger rumination in children with ASD.

Restricted and repetitive behavior and lack of flexibility have been hypothesized to contribute to emotion dysregulation in children with ASD (Mazefsky et al. 2013). Studies have noted hyper-focus on upsetting events (Crane et al. 2011) and correlation of anger rumination with core ASD symptoms (Patel et al. 2017; Pugliese et al. 2015). In our clinical work, we have also observed that children with ASD, when asked to describe a situation that made them angry during cognitive-behavioral therapy (CBT), often reported events from the distant past and became visibly upset when recalling the frustrating elements of these events (Sukhodolsky and Scahill 2012). Some children with ASD appeared as if they were re-experiencing anger felt when the upsetting situation had actually happened. This clinical observation was reminiscent of the construct of anger rumination, described by Sukhodolsky et al. (2001), that is measured by items such as “memories of certain events from the past still make me angry.” We reasoned that rumination in general, as a cognitive process of over-focusing on negative emotions, is associated with the core ASD symptoms of RRBs including insistence on sameness, inflexible adherence to routines, rigidity of thinking, and perseveration. For example, depressive rumination was associated with perseveration in young adults (Keenan et al. 2017) and adults with ASD (Gotham et al. 2014). However, no studies to date examined the association between ASD symptoms of RRBs and anger rumination. Thus, we tested the association of anger rumination with RRBs in children with and without ASD and varying levels of disruptive behavior.

In the present study, we examined anger rumination in well-characterized samples of children aged 8–16 with and without ASD and clinically significant levels of disruptive behavior. Our primary aim was to examine levels of anger rumination in three groups of children: ASD, Disruptive Behavior without ASD (DB group), and typically developing healthy controls (HC) matched on age, gender, and IQ. We predicted that children with ASD would show greater levels of anger rumination compared to HC children. In the context of a paucity of prior studies directly comparing anger rumination in children with ASD and children with disruptive behavior disorders, we hypothesized that there would be differences in anger rumination between the ASD and DB groups. We restricted the main analyses to the three largest samples (ASD, DB without ASD, and HC) to provide the most statistical power. However, because the focus of this study centered on anger rumination in ASD, ASD subgroups were also formed for post hoc analyses to examine differences in anger rumination in children with ASD with and without co-occurring disruptive behavior. Children with ASD were divided into two groups based on the presence of co-occurring disruptive behavior disorder. Regarding these ASD subgroups, we expected that children

with ASD-plus-disruptive-behavior (ASD/DB+ subgroup) would show greater levels of anger rumination compared to children with ASD-without-disruptive-behavior (ASD/DB– subgroup). Our second aim was to test correlates of anger rumination (i.e., gender, aggression, and RRBs). We expected anger rumination to be associated with aggression and RRBs.

## Methods

### Participants and Procedures

Three groups of children aged 8–16 years were included: 63 verbally fluent children with ASD (ASD group); 79 children with disruptive behavior disorders without ASD (DB group); and 44 typically developing healthy controls (HC group) matched for age, gender, and IQ. Demographic and clinical characterization data for participants are shown in Table 1. Participants with ASD had a DSM-5-de-fined ASD diagnosis that was confirmed with the *Autism Diagnostic Interview-Revised (ADI-R)* (Le Couteur et al. 2003) and *Autism Diagnostic Observation Schedule-2nd edition (ADOS-2)* (Lord et al. 2012) administered by an expert clinician trained to research reliability.

All children received a comprehensive diagnostic evaluation that included the *Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL)* (Kaufman et al. 2016) or the *Anxiety Disorders Interview Schedule for Children and Parents (ADIS-C/P)* (Silverman and Albano 1996), which are structured interviews with excellent reliability that were conducted with parent and child by an expert clinician to establish main DSM-5 diagnoses. Full scale IQ was evaluated with the *Wechsler Abbreviated Scale of Intelligence (WASI)* (Wechsler 1997) or the *Differential Ability Scales-II* (Elliott 2007). Parents and children completed diagnostic evaluations (K-SADS-PL or ADIS) and IQ assessments (WASI or DAS-II) depending on the study that they were enrolled in. Parents and children also completed a battery of self-report measures that was facilitated by a research assistant to ensure understanding and answer any questions. Parents completed demographics and medical history forms.

Children with disruptive behavior were required to meet a cut-off criterion of a T score 65 on the *Aggressive Behavior* scale of the parent-rated child behavior checklist (CBCL), a well-established measure of child psychopathology (Achenbach and Rescorla 2001). This score is 1.5 standard deviation units above the mean in the standardization sample and represents a cut-off for a clinically significant level of aggression. The *Aggressive Behavior* scale includes 16-items reflecting inappropriate anger outbursts as well as verbal and physical aggression. To recruit a representative sample of children with disruptive behavior, children were included in this study regardless of co-occurring psychiatric diagnoses or treatment with psychotropic medication. HC participants were required to have no current or past history of psychiatric disorders and a CBCL-aggression T-score below 55. For post hoc analyses of anger rumination differences within the ASD group, children with ASD were divided into two groups based on the presence or absence of co-occurring disruptive behavior disorder (ASD/DB+ and ASD/DB– groups, respectively), which was based on diagnostic assessments (K-SADS-PL, ADIS).

Children with ASD and children with disruptive behavior disorders participated in clinical trials of behavior therapy at the Yale Child Study Center. This paper combined baseline data from two studies in order to examine anger rumination in children with ASD. Healthy control participants were recruited from the community via advertisements, flyers, and brochures. Each participant's parent provided informed consent according to specifications by the institutional review board at the Yale University School of Medicine. Each child provided assent.

## Measures

The anger rumination scale (ARS)(Sukhodolsky et al. 2001) is a 19-item self-report measure assessing the cognitive processes related to feelings of anger as well as the tendency to think about current anger-provoking situations and to recall past anger episodes. Each item is rated on a 4-point Likert scale of 1 (almost never), 2 (sometimes), 3 (often), and 4 (almost always). The ARS has four subscales including: anger afterthoughts, thoughts of revenge, angry memories, and understanding of causes. The first two subscales (anger afterthoughts and thoughts of revenge) correspond to thinking about a recent episode or recalling and getting angry about a distant episode. The last two subscales (angry memories and understanding of causes) correspond to thinking about causes of an anger episode in order to achieve a meaningful understanding of the anger episode. Higher scores on the ARS indicate a greater level of anger rumination. Within the current sample, high internal reliability was observed for the ARS in the total sample ( $\alpha = 0.89$ ) and within the ASD ( $\alpha = 0.88$ ) and DB ( $\alpha = 0.89$ ) groups. We report mean values and standard deviation on the ARS subscales for descriptive purposes (Table 2). However, due to the sample size of the study, we only use the ARS total score in the analyses.

The social responsiveness scale-second edition (SRS-2) (Constantino 2005) is a 65-item scale that measures symptoms associated with ASD. Items are rated on a 4-point scale from "not true" to "almost always true" by the child's parent or teacher. In the current study, the parent version for children ages 4–18 years was used. Higher scores on the SRS-2 indicate greater social impairment. Total raw scores for the restricted and repetitive behavior (RRB) subscale were used for analyses in this study. High internal reliability was observed for the SRS-2 RRB subscale within the total sample ( $\alpha = 0.89$ ) and within the ASD ( $\alpha = 0.80$ ) and DB ( $\alpha = 0.78$ ) groups.

The ADOS-2 (Lord et al. 2012) is a standardized, semi-structured observational assessment that elicits social interaction, language use, and restricted and repetitive behaviors and circumscribed interests. The ADOS-2 yields two subscale scores of social affect and restricted and repetitive behaviors as well as algorithm-based classifications of autism/autism spectrum or non-spectrum disorder. Item scores are on a scale of 0–2, with higher scores indicating greater severity of symptoms. Module 3 (intended for fluent speakers) was administered to participants in the current study.

The reactive–proactive aggression questionnaire (RPQ) (Raine et al. 2006) is a 23-item parent-report scale that measures aggression on a 3-point Likert scale. Twelve items index proactive aggression (e.g., "Had fights with others to show who was on top") and 11 items index reactive aggression (e.g., "Reacted angrily when provoked by others"). Because

proactive and reactive aggression subscales were highly correlated in this sample ( $r = 0.78$ ), the RPQ Aggression Total score was used as a continuous measure of aggression in the analyses. Internal consistency for the RPQ was high for the total sample ( $\alpha = .93$ ) and for the ASD ( $\alpha = .92$ ) and DB ( $\alpha = .84$ ) groups.

### Statistical analyses

Our primary aim was to examine levels of anger rumination between the three groups of children (ASD, DB, and HC groups). Statistical analyses were conducted with SPSS v24. The differences in levels of anger rumination in children with ASD relative to samples of children with disruptive behavior disorder (DB group) and HC participants were examined using a one-way ANOVA with a statistical threshold of significance set at  $p < .05$  and Bonferroni corrected for multiple comparisons.

Our second aim was to test the association between anger rumination, RRBs and aggression. Thus, we examined zero-order correlations between ARS and other study variables using Pearson correlations. Next, a hierarchical multiple regression was conducted to assess the predictive utility of various potential predictors of anger rumination in five steps. First, gender was entered as a dichotomously coded variable (0 = boys and 1 = girls) to control for possible differences in gender. Next, diagnostic group was entered and dichotomously coded for ASD diagnosis (0 = no and 1 = yes) to understand potential contributions of ASD to anger rumination as well as to examine the interactions between diagnostic group, aggression, and RRBs in predicting anger rumination. In the third step, RPQ aggression total score was entered. In the fourth step, we added SRS-2 RRB subscale scores to examine the association between RRBs and rumination over and beyond other predictors. Finally, interactions were entered in the fifth step that included: ASD diagnosis  $\times$  RPQ Aggression Total, and ASD diagnosis  $\times$  SRS-2 RRB. Continuous variables were centered to the mean before creating these interaction terms. Alpha was set at  $p < .05$  for the multiple regression analysis.

## Results

### Presentation of Anger Rumination

Our hypotheses centered on differences in anger rumination in children with ASD ( $n = 63$ ) compared to children with disruptive behavior disorder without ASD ( $n = 79$ ) and HC participants. Results of a one-way ANOVA conducted across the three groups (ASD vs. DB vs. HC) revealed that there was a significant difference in anger rumination ( $F_{2, 183} = 8.0, p = .001$ ). Post hoc tests revealed that children with ASD showed significantly greater levels of anger rumination relative to HC children ( $p = .02$ ), but similar levels of anger rumination as the DB group ( $p = .54$ ) (see Table 2 and Fig. 1). Children in the DB group showed greater levels of anger rumination relative to HC participants ( $p < .001$ ).

We also examined differences in anger rumination in subgroups of children with ASD with and without co-occurring disruptive behavior. Planned post hoc tests were conducted after dividing the total sample of children with ASD into two subgroups based on the presence or absence of co-occurring disruptive behavior: ASD/DB+ ( $n = 22$ ) and ASD/DB- ( $n = 41$ )

groups, respectively. Independent samples t tests revealed that children with ASD/DB+ showed significantly greater levels of anger rumination relative to children with ASD/DB- ( $p = .03$ ) (Table 2).

We also report between-group differences for the ARS subscales for descriptive purposes. Results of one-way ANOVAs revealed significant differences between the three groups for angry afterthoughts ( $F_{2, 183} = 7.2, p = .001$ ), thoughts of revenge ( $F_{2, 183} = 5.14, p = .007$ ), angry memories ( $F_{2, 183} = 5.68, p = .004$ ), and understanding causes ( $F_{2, 183} = 3.31, p = .039$ ) (see Table 2). Post hoc tests revealed that children with ASD showed levels of angry afterthoughts that were similar to the DB group ( $p > .5$ ), but significantly greater than the HC group ( $p = .01$ ). Children with ASD did not differ significantly from the HC group for thoughts of revenge, angry memories, and understanding causes scales. However, the DB group showed significantly greater levels of angry afterthoughts, thoughts of revenge, angry memories, and understanding causes relative to the HC group (all  $p < .03$ ). The effect size  $\eta^2$  for these comparisons varied from 0.04 to 0.08, which can be interpreted as small to medium effects.

### Correlations Between Study Variables

In the total sample of participants ( $N = 186$ ), anger rumination yielded significant positive correlations with RRBs and aggression (Table 3). There were no significant correlations between anger rumination and age, gender, or full-scale IQ. In the sample of children with ASD ( $n = 63$ ), anger rumination was positively correlated with RRBs. For the DB group ( $n = 79$ ), there were no significant correlations between anger rumination and other variables. Correlations between anger rumination and predictors did not exceed .37, suggesting low risks of multicollinearity.

### Multiple Regression Analyses

We then tested whether anger rumination was associated with aggression and RRBs. Using a dimensional approach, a multiple regression analysis was conducted across the total sample ( $N = 186$ ). Model results from the multiple regression analysis are presented in Table 4. Step 1 indicated that child gender did not significantly predict anger rumination. In Step 2, ASD diagnosis did not predict anger rumination. In Step 3, aggression made a significant independent contribution to the model predicting anger rumination. Further, adding aggression into the model in Step 3 significantly increased the proportion of explained variance ( $R^2$  change .04,  $p = .003$ ) from .1 to 4%. Step 4 showed that RRBs did not significantly predict anger rumination over and beyond other variables and aggression did not remain a significant predictor. Importantly, Step 5 showed that aggression and the interaction between ASD diagnosis and RRBs contributed significantly to the prediction of anger rumination. That is, for children with ASD, high levels of RRBs were related to high levels of anger rumination, but not for children without ASD (Fig. 2). The interaction between ASD diagnosis and aggression did not contribute significantly to the model predicting anger rumination. Note, controlling for age and IQ did not alter the results. The final model accounted for 5.6% of the variance in anger rumination.

To further explore the association between RRBs and aggression in predicting anger rumination in children with ASD, an additional linear regression restricted to children with ASD ( $n = 63$ ) was conducted modeling RRBs and aggression simultaneously. RRBs ( $\beta = .48, p = .017$ ), but not aggression ( $\beta = -.03, p = .87$ ), was found to be a significant predictor of anger rumination across the sample of children with ASD (Fig. 3).

## Discussion

In the current study, we investigated anger rumination and its association with disruptive behavior and core ASD symptoms of RRBs in children with ASD. To our knowledge, this is the first study to examine anger rumination in well-characterized samples of children with ASD with varying levels of disruptive behaviors compared to children with disruptive behavior disorders without ASD. The primary aim of the study was to test if levels of anger rumination differed between children with and without ASD and co-occurring disruptive behavior and HC participants. Consistent with our expectations, children with ASD showed significantly greater levels of anger rumination relative to HC children. Our finding of greater rumination in the ASD group relative to the HC group is consistent with earlier studies (Crane et al. 2011; Gotham et al. 2014; Patel et al. 2017), which could suggest a greater tendency to engage in maladaptive cognitive regulatory patterns in ASD (Mazefsky et al. 2014). Alternatively, greater levels of rumination in the ASD group could also indicate that rumination is related to core ASD symptoms of RRBs such as perseveration, rigidity of thought, and insistence on sameness (Mazefsky et al. 2012). Our findings of greater anger rumination in the DB group compared to HC participants is consistent with studies in non-ASD populations that report associations between rumination and disruptive behaviors (Harmon et al. 2017; McLaughlin et al. 2014; Pugliese et al. 2015; Smith et al. 2016; Sukhodolsky et al. 2001). Additionally, levels of anger rumination were similar between the ASD and DB groups, which may suggest a shared underlying mechanism of emotion impairments across disorders. Further, these findings of similar patterns of rumination between clinically distinct disorders (ASD and DB groups) may lend support to rumination as a transdiagnostic process common across disorders (Aldao et al. 2016). Interestingly, the ASD/DB+ subgroup showed greater levels of anger rumination compared to the ASD/DB- subgroup, which is consistent with studies of non-ASD populations indicating higher anger rumination in youth with disruptive behavior disorders (Harmon et al. 2017; Smith et al. 2016). However, future studies with larger samples of children with ASD with and without co-occurring disruptive behavior disorders should examine anger-focused rumination to disentangle the overlap of ASD symptoms and disruptive behaviors, which could contribute to identifying differences among subgroups of children with ASD. A better understanding of anger rumination in ASD may also support the development of clinical interventions targeting rumination through acquisition of adaptive emotion regulatory strategies and improving a broad range of symptoms, such as disruptive behaviors.

Our second aim was to test whether anger rumination was associated with aggression and RRBs. Using a regression-based approach to model aggressive behavior and RRBs dimensionally, we found that the interaction between ASD diagnosis and RRBs was significant in predicting anger rumination, suggesting that the presence of an ASD diagnosis and high levels of RRBs is related to anger rumination. This finding is consistent with



studies reporting an association between rumination and ASD symptoms of RRBs such as insistence on sameness and perseveration (Gotham et al. 2014; Pugliese et al. 2015). However, a recent study of adults in the general population did not find an association between sadness-focused rumination and perseveration using a self-report measure of ASD symptoms (Keenan et al. 2017). Our finding of an association between anger rumination and RRBs in ASD is noteworthy because RRBs such as rigidity of thinking, insistence on sameness, and perseveration are part of the constellation of core ASD symptoms and could predispose children with ASD to engage in rumination through greater difficulty in disengaging from perseverative, ruminative thoughts focused on the stressor (Mazefsky et al. 2012). On the other hand, it is also possible that impairments in emotional reactivity and regulation coupled with RRBs in ASD may impede the use of adaptive and voluntary emotion regulation strategies such as cognitive reappraisal and problem solving (Jahromi et al. 2012; Mazefsky et al. 2013, 2014; Rieffe et al. 2011). However, given the correlational nature of our study, directionality and causality cannot be inferred from these associations.

While aggression was positively correlated with anger rumination in correlations in the total sample, the interaction between ASD diagnosis and aggression did not emerge as a significant predictor of anger rumination. It is possible that because the sample size was relatively small for children with ASD and co-occurring disruptive behavior (ASD/DB+ subgroup,  $n = 22$ ) compared to the DB group ( $n = 79$ ), our ASD sample could have been underpowered to detect effects of aggression and ASD diagnosis in the regression model. Alternatively, the lack of a significant interaction with diagnostic category may lend support to the use of a dimensional framework to understand the contributions of aggression and emotion dysregulation more broadly in predicting anger rumination in ASD (Ibrahim and Sukhodolsky 2018). However, a recent longitudinal study of rumination showed that the developmental trajectory of worry and rumination predicted increased levels of disruptive behaviors in children with ASD (Bos et al. 2018). It should be noted, however, that Bos et al. (2018) used a broad measure of rumination that assessed worry and the tendency to dwell on a problem, and the sample consisted of only boys. Given that emotion regulation impairments are common in ASD including reliance on involuntary maladaptive strategies such as suppression and rumination rather than adaptive emotion regulation processes such as cognitive reappraisal or problem solving (Mazefsky et al. 2014; Samson et al. 2015a, b), it is possible that the tendency to engage in anger rumination may be related to emotion dysregulation in ASD. Further, the overlap between anger rumination, emotion dysregulation, and RRBs could predispose children with ASD to a heightened risk for disruptive behaviors. However, causal conclusions cannot be made based on the cross-sectional design of the current study. Future studies with larger samples and longitudinal designs are needed to dissociate the role of disruptive behaviors, particularly aggression, in predicting anger rumination in children with ASD.

The present study has limitations that should be considered when interpreting these findings. First, the sample size of the ASD/DB+ subgroup was small, particularly relative to the ASD/DB- subgroup. However, the total sample of children with ASD was well-matched on age, IQ and gender with the DB and HC groups. There were also no significant differences in age, IQ, or gender between the ASD/DB+ and ASD/DB- subgroups. Nonetheless, replication of results with larger samples is needed. In addition, our sample was not

sufficiently powered for a more nuanced analysis of anger rumination between the ASD/DB+ and DB without ASD groups. An exploratory post hoc test indicated no significant difference in levels of anger rumination between the ASD/DB+ and DB groups ( $p = .628$ ), but it is possible that anger rumination may have different underlying mechanisms in different diagnostic groups. Thus, studies are needed with larger samples sufficiently powered to compare anger rumination in children with ASD/DB+ to children with disruptive behavior disorders without ASD to understand the overlap between core ASD symptoms and disruptive behaviors in predicting anger rumination. Further, our sample did not include children with trauma or posttraumatic stress disorder (PTSD). Given the increased prevalence of trauma in children with ASD (Haruvi-Lamdan et al. 2017; Kerns et al. 2015) and the role that rumination may play in strengthening the association between PTSD symptoms and anger (Olatunji et al. 2010; Orth et al. 2008; Spinhoven et al. 2015), future studies are needed that examine the effects of co-occurring trauma in ASD, such as maltreatment and bullying, and its relationship with anger rumination and core ASD symptoms. Second, we used a cross-sectional design, which limits the capacity to assess directionality in the associations between study variables or predictability. Future studies using longitudinal designs will be important to understand anger rumination and its associations with other correlates, such as measures of emotion control. Third, the strength of correlations between the study variables was weak and the final regression model predicted 5% of the variance in anger rumination. This suggests that additional factors should also be explored as predictors of anger rumination in children with ASD such as other clinical and demographic factors. Additionally, this study focused on anger-related rumination and it will be important for future studies to investigate potential positive emotion-focused cognitive processing such as reminiscence (Elias et al. 2015; Meléndez Moral et al. 2015; Westerhof et al. 2010) and recall of positive autobiographical memories (Gadeikis et al. 2017; Kovacs et al. 2015) in ASD. Future studies may examine whether perseverative tendencies of individuals with ASD may be associated with or could be deployed in interventions for anxiety and depression that are focused on recall of positive autobiographic memories. Finally, this study consisted of predominately boys and it will be important to understand gender differences and anger rumination in girls with ASD.

In conclusion, anger rumination in children with ASD was associated with RRBs. To our knowledge, the current study is the first to investigate anger rumination and its association with RRBs in a clinical sample of children with ASD relative to children with disruptive behavior disorders. Children with ASD showed greater levels of anger rumination relative to HC children, but similar levels to a clinical comparison group of children with disruptive behavior disorders without ASD. In addition, we examined anger rumination between subgroups of children with ASD/DB+ and ASD/DB-, which is a first step in understanding the correlates of rumination in distinct clinical subgroups of children with ASD. Children with ASD/DB+ showed higher levels of anger rumination compared to children with ASD/DB-, which could indicate distinct underlying mechanisms of rumination in children with ASD and co-occurring disruptive behavior. Further, a greater tendency to engage in rumination in ASD could be related to emotion regulation impairments and may confer a greater risk of disruptive behaviors. Therefore, a better understanding of rumination in ASD

could support the development of novel clinical interventions as well as inform existing treatments to address negatively valenced rumination.

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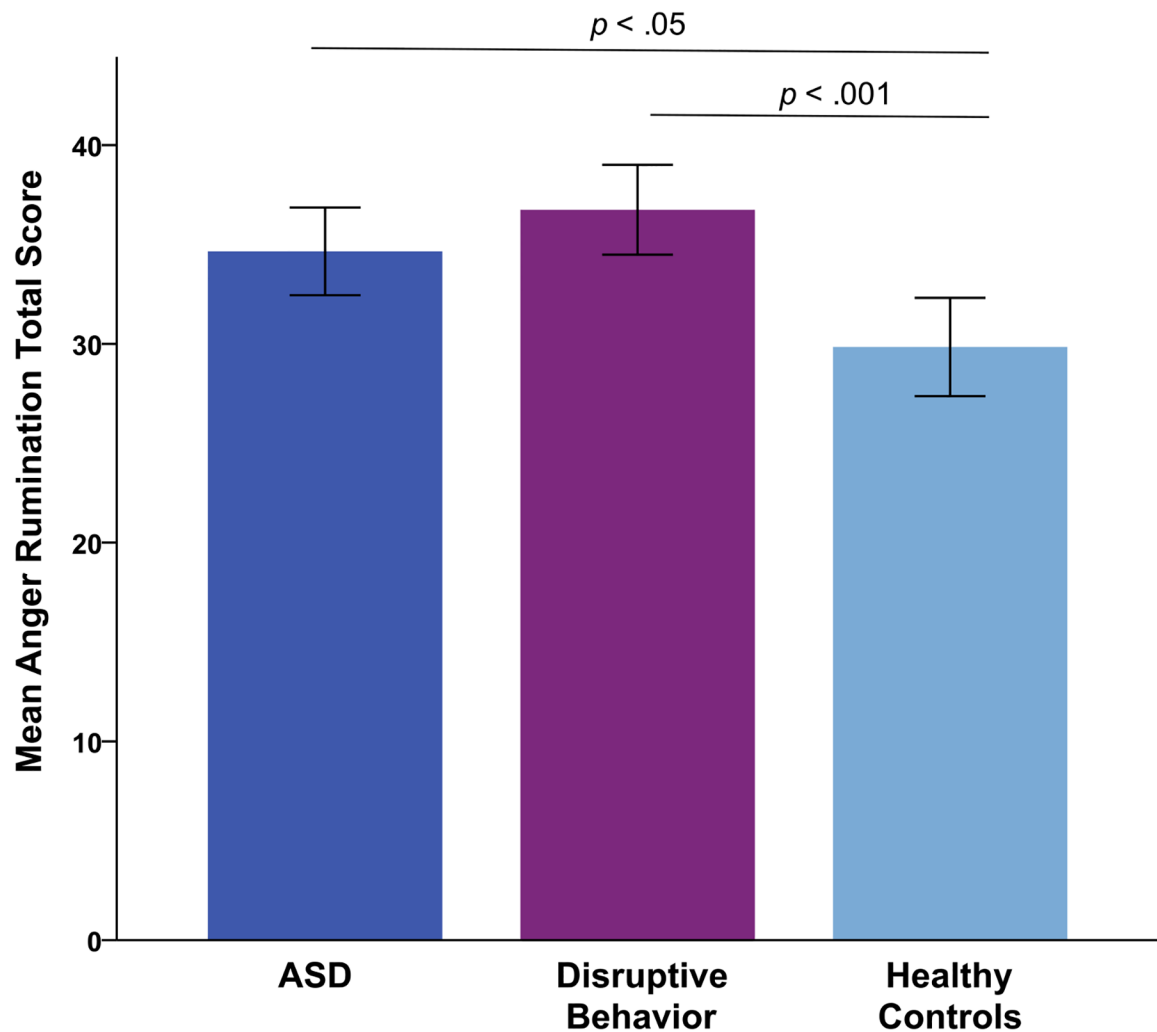
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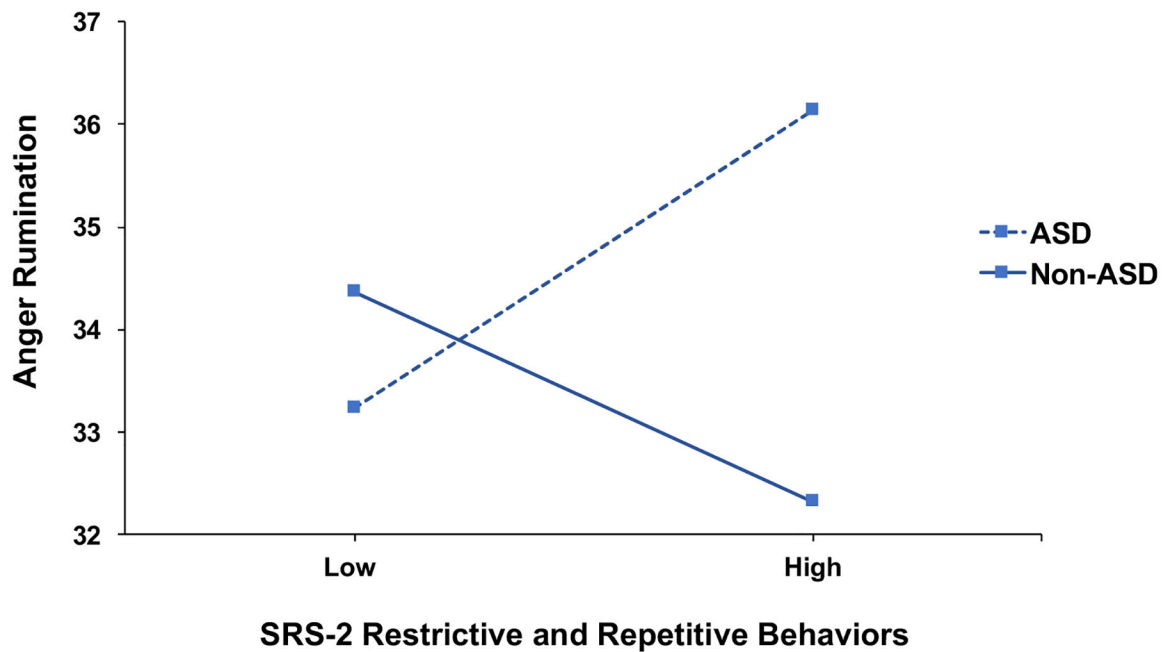
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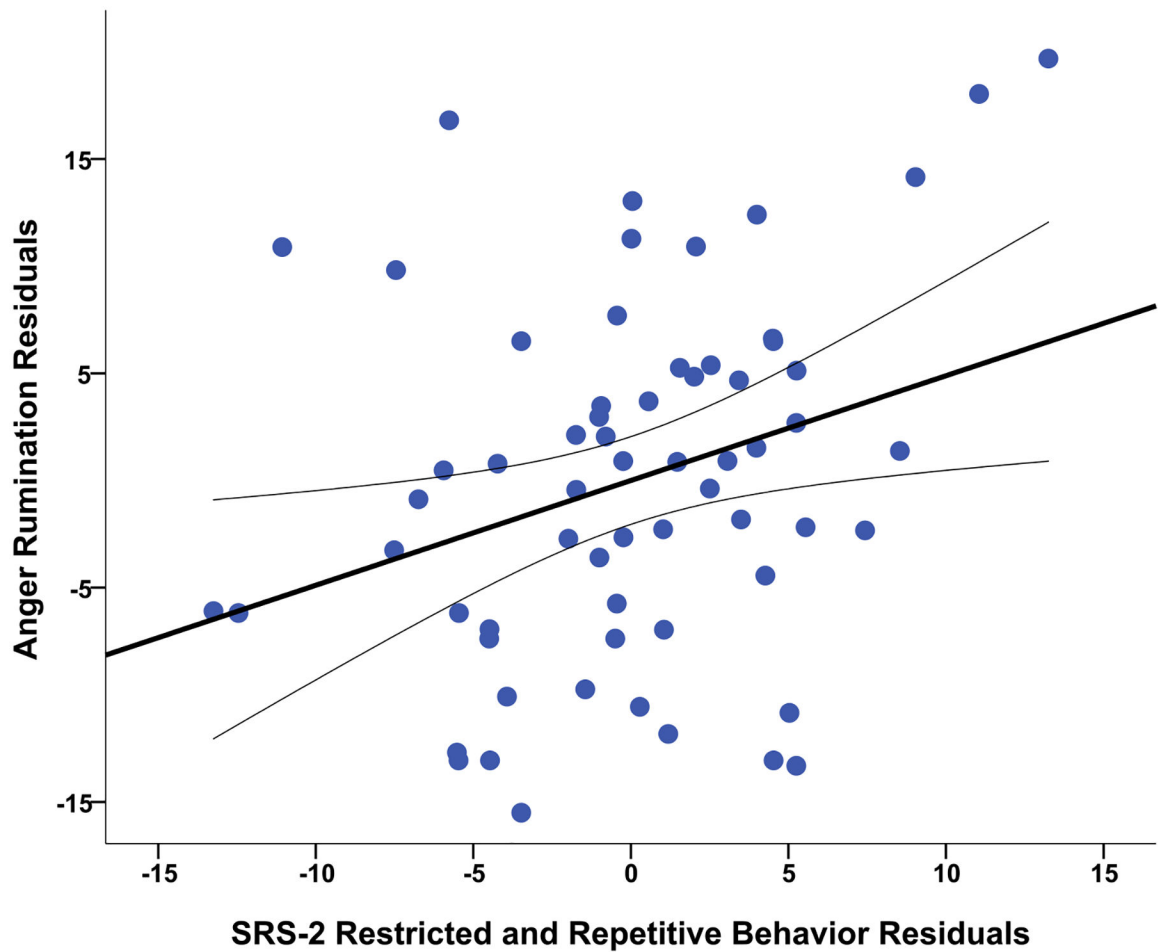
**Fig. 1.** Mean levels of anger rumination across the combined ASD group in comparison to children with disruptive behavior disorders without ASD and healthy controls. Children with ASD ( $n = 63$ ) showed greater levels of anger rumination relative to healthy control children ( $n = 44$ ). However, levels of anger rumination were similar between children with ASD and children with disruptive behavior disorders without ASD ( $n = 79$ ). The figure shows mean anger rumination scale total scores (y-axis). Disruptive behavior group refers to children with disruptive behavior disorders without ASD. Standard error is represented in error bars



**Fig. 2.**

Interaction between ASD diagnosis and restricted and repetitive behaviors is associated with anger rumination in the total sample ( $N = 186$ ). Restrictive and repetitive behaviors are measured using the social responsiveness scale-second edition (SRS-2) restricted and repetitive behaviors scale. Anger rumination is measured using the Anger Rumination Scale total score. The model controls for gender, aggression using the reactive-proactive aggression questionnaire total score, and the interaction between ASD diagnosis and aggression. High and low levels of restrictive and repetitive behaviors were dichotomized using a median split for visualization purposes. The total sample of participants includes children with ASD ( $n = 63$ ), children with disruptive behavior disorder without ASD ( $n = 79$ ), and healthy controls ( $n = 44$ )





**Fig. 3.** Results of a linear regression across the combined ASD group ( $n = 63$ ). The residual plot shows the association between anger rumination and restricted, repetitive behaviors (RRBs) across the ASD group when both the social responsiveness scale-second edition RRB score and reactive-proactive aggression questionnaire total score were modelled simultaneously while controlling for gender. The anger rumination scale total score is used for analyses

**Table 1**

Participant demographics and clinical characteristics

Variable	Total sample			ASD subgroups based on disruptive behavior (DB)		p value	p value
	Healthy controls n = 44	Disruptive behavior n = 79	ASD n = 63	With DB (ASD/DB+) n = 22	Without DB (ASD/DB-) n = 41		
Age, years (SD)	12.3 (1.8)	11.7 (2.1)	12.4 (1.9)	12.5 (2)	12.3 (1.9)		.74
Male (n, %)	29 (65.9)	54 (68.4)	47 (74.6)	17 (77.3)	30 (73.2)		.72
Mean IQ <sup>a</sup> (SD)	111.3 (10)	105.8 (13.7)	104.9 (19.1)	103.7 (16.8)	105.6 (20.3)		.71
Race (n, %)							.09
White	28 (63.6)	58 (73.4)	54 (85.7)	18 (81.8)	36 (87.8)		
Black	9 (20.5)	11 (13.9)	2 (3.2)	2 (9.1)	0		
Asian/Pacific Islander	1 (2.3)	1 (1.3)	1 (1.6)	1 (4.5)	0		
American Indian/Alaska Native	0	2 (2.5)	0	0	0		
Other/more than one race	6 (13.6)	7 (8.9)	6 (9.5)	1 (4.5)	5 (12.2)		
Ethnicity (n, %)							.41
Hispanic	5 (11.4)	14 (17.7)	7 (11.1)	1 (4.5)	6 (14.6)		
Non-Hispanic	39 (88.6)	65 (82.3)	55 (88.7)	21 (95.5)	35 (85.4)		
Mean CBCL aggression T score (SD)	50.5 (1.8)	75.3 (7.2)	60.8 (11.2)	72.9 (8.6)	54.4 (5.8)		<.001 <sup>b</sup>
Mean RPQ aggression total score (SD)	2.5 (2.2)	19.5 (6.7)	10.1 (7.9)	17.5 (7.8)	6.1 (4.3)		<.001 <sup>b</sup>
Mean SRS-2 total T score (SD)	45 (5.7)	62.3 (10.6)	73.5 (9.5)	79.2 (7.6)	70.5 (9.2)		<.001 <sup>b</sup>
Social communication interaction scale	45 (7.7)	63.1 (10.3)	73.3 (9.8)	78.5 (8.1)	70.4 (9.6)		.001 <sup>b</sup>
Restricted and repetitive behaviors scale	43.8 (3.8)	58.4 (11.2)	71.9 (10.8)	79.4 (7.7)	67.9 (10.2)		<.001 <sup>b</sup>
Mean ADOS-2 module 3 total score (SD)							.005 <sup>b</sup>
Social affect scale							.04 <sup>b</sup>
Restricted and repetitive behaviors scale							.01 <sup>b</sup>
Mean ADIR subscale scores (SD)							
Social interaction			19.5 (5.3)	20.2 (5.4)	19.2 (5.2)		.47
Communication			15.3 (3.8)	15.5 (3.5)	15.2 (3.9)		.76
DSM-5 diagnosis (n, %)							

Variable	Total sample		ASD subgroups based on disruptive behavior (DB)				
	Healthy controls n = 44	Disruptive behavior n = 79	ASD n = 63	p value	With DB (ASD/DB+) n = 22	Without DB (ASD/DB-) n = 41	p value
Oppositional defiant disorder		56 (70.9)	22 (28.2)	<.001 <sup>b</sup>	22 (100)	0	<.001 <sup>b</sup>
Conduct disorder		3 (3.8)	0	.25	0	0	
Disruptive behavior disorder NOS		4 (5.1)	0	.13	0	0	
Disruptive mood dysregulation disorder		17 (21.5)	0	<.001 <sup>b</sup>	0	0	
Attention-deficit/hyperactivity disorder		60 (75.9)	35 (55.6)	.01 <sup>b</sup>	19 (86.4)	16 (39)	<.001 <sup>b</sup>
Anxiety disorder		19 (24.1)	33 (52.4)	.001 <sup>b</sup>	9 (40.9)	24 (58.5)	.18
Depressive disorder		5 (6.3)	3 (4.8)	1	0	3 (7.3)	.54
Currently taking medication (n, %)		34 (43)	29 (46)	<.001 <sup>b</sup>	16 (72.7)	13 (31.7)	.002 <sup>b</sup>
Type of medication (n, %)							
Stimulants		25 (31.6)	12 (19)	.09	7 (31.8)	5 (12.2)	.09
Non-stimulants		15 (19)	9 (14.3)	.46	7 (31.8)	2 (4.9)	.006 <sup>b</sup>
Antidepressant		9 (11.4)	11 (17.5)	.30	6 (27.3)	5 (12.2)	.17
Neuroleptics		7 (8.9)	5 (7.9)	.84	4 (18.2)	1 (2.4)	.04 <sup>b</sup>
Mood stabilizers		0	3 (4.8)	.09	3 (13.6)	0	.04 <sup>b</sup>
Benzodiazepines		0	2 (3.2)	.19	2 (9.1)	0	.12

Disruptive behavior group refers to children with disruptive behavior disorder without ASD

ASD/DB+, autism spectrum disorder with co-occurring disruptive behavior disorder; ASD/DB-, autism spectrum disorder without disruptive behavior disorder; ADI-R, autism diagnostic interview-revised; ADOS-2, autism diagnostic observation schedule-2nd edition; CBCL, child behavior checklist; RPQ, reactive-proactive aggression questionnaire; SRS-2, social responsiveness scale-second edition

<sup>a</sup>Full-scale IQ measured by the Wechsler abbreviated scale of intelligence (Wechsler 1997) or the differential ability scales-II (Elliott 2007)

<sup>b</sup>Significant group differences at  $p < 0.05$ , Bonferroni corrected, except for Chi square test for categorical variables and independent samples  $T$  test

<sup>c</sup>ASD > healthy controls; disruptive behavior > healthy controls; disruptive behavior > ASD

<sup>d</sup>ASD > healthy controls; ASD > disruptive behavior; disruptive behavior > healthy controls

Table 2

Between-group differences in anger rumination

Variable	Total sample		Healthy controls n = 44	F	p value	$\eta^2$	ASD subgroups based on disruptive behavior (DB)		p value
	ASD n = 63	Disruptive behavior n = 79					ASD/DB+ n = 22	ASD/DB- n = 41	
ARS total, mean (SD)	34.7 (8.7)	36.7 (10)	29.8 (8.2)	8.00	<.001 <sup>ab</sup>	.08	37.8 (7.4)	32.9 (8.9)	.03 <sup>a</sup>
Angry afterthoughts, mean (SD)	10.4 (3.3)	10.9 (3.4)	8.6 (3.0)	7.15	.001 <sup>ab</sup>	.07	11.4 (3.1)	9.9 (3.3)	.08
Thoughts of revenge, mean (SD)	6.8 (2.4)	7.3 (2.8)	5.7 (2.3)	5.14	.007 <sup>ac</sup>	.05	7.5 (2.6)	6.4 (2.2)	.08
Angry memories, mean (SD)	9.2 (2.6)	10.2 (3.2)	8.3 (2.8)	5.68	.004 <sup>ac</sup>	.06	10.1 (2.5)	8.7 (2.6)	.03 <sup>a</sup>
Understanding causes, mean (SD)	8.2 (2.3)	8.4 (2.8)	7.2 (2.5)	3.31	.039 <sup>ac</sup>	.04	8.7 (2.1)	7.9 (2.4)	.15

Degrees of freedom = 2 for ANOVA. Means for ARS subscales are provided for descriptive purposes. The ARS total score is used for all group-level and multiple regression analyses. Disruptive behavior group refers to children with disruptive behavior disorder without ASD

ARS, anger rumination scale; ASD/DB+, autism spectrum disorder with co-occurring disruptive behavior disorder; ASD/DB-, autism spectrum disorder without disruptive behavior disorder, ASD, autism spectrum disorder

<sup>a</sup>Significant group differences at  $p < 0.05$ , Bonferroni corrected, except for independent samples T-test

<sup>b</sup>ASD > healthy controls; disruptive behavior > healthy controls

<sup>c</sup>Disruptive behavior > healthy controls

**Table 3**

Correlations of anger rumination with demographic and clinical characteristics

Assessment variable	Age	Gender	IQ	SRS-2 SCI	SRS-2 RRB	RPQ aggression total
Anger rumination scale total score						
All participants (n = 186)	0.01	-0.11	-0.11	0.13	<b>0.16*</b>	<b>0.22**</b>
ASD group (n = 63)	0.09	-0.15	-0.06	0.08	<b>0.37**</b>	0.21
Disruptive behavior group (n = 79)	0.03	-0.08	-0.04	-0.09	-0.15	-0.14

Significant correlations are indicated in bold. Correlations are presented for the combined ASD group. Disruptive behavior group refers to children with disruptive behavior disorder without ASD.

\*  $p < .05$ ,

\*\*  $p < .01$

ASD, autism spectrum disorder group combined; RPQ, reactive-proactive aggression questionnaire; SRS-2 RRB, social responsiveness scale-second edition restricted and repetitive behaviors scale; SRS-2 SCI, social responsiveness scale-second edition social communication interaction scale

Table 4

Hierarchical regression results predicting anger rumination in the total sample

Variable	B	SE	$\beta$	p
<i>Step 1.</i> $F_{1,184} = 2.27, p = .134$ ; adjusted $R^2 = .007, R^2$ change = .01, $p = .134$				
Constant	35.09	0.83		
Gender	-2.28	1.52	-0.11	.134
<i>Step 2.</i> $F_{2,183} = 1.14, p = .322$ ; adjusted $R^2 = .001, R^2$ change = 0, $p = .886$				
Constant	35.01	0.99		
Gender	-2.27	1.52	-0.11	.139
ASD diagnosis	0.21	1.48	0.01	.886
<i>Step 3.</i> $F_{3,182} = 3.83, p = .011$ ; adjusted $R^2 = .044, R^2$ change = .047, $p = .003$				
Constant	34.69	0.98		
Gender	-2.07	1.49	-0.10	.169
ASD diagnosis	0.97	1.47	0.05	.509
RPQ aggression total score	0.22	0.07	0.22	<b>.003</b>
<i>Step 4.</i> $F_{4,181} = 3.04, p = .019$ ; adjusted $R^2 = .042, R^2$ change = .004, $p = .412$				
Constant	35.13	1.11		
Gender	-2.01	1.499	-0.09	.181
ASD diagnosis	-0.37	2.194	-0.02	.867
RPQ aggression total score	0.17	0.09	0.17	.073
SRS-2 RRB score	0.11	0.13	0.09	.412
<i>Step 5.</i> $F_{6,179} = 2.82, p = .012$ ; adjusted $R^2 = .056, R^2$ change = .023, $p = .106$				
Constant	34.24	1.18		
Gender	-2.08	1.49	-0.10	.165
ASD diagnosis	-2.46	2.41	-0.12	.308
RPQ aggression total score	0.27	0.11	0.27	<b>.016</b>
SRS-2 RRB score	-0.12	0.17	-0.09	.511
ASD diagnosis × RPQ aggression total score	-0.29	0.22	-0.15	.174
ASD diagnosis × SRS-2 RRB score	0.60	0.28	0.32	<b>.034</b>

Significant results are indicated in bold. ASD diagnosis variable represents children in the total sample with a diagnosis of ASD based on the ADOS-2 and ADI-R. Continuous variables are centered to the mean

ASD, autism spectrum disorder; RPQ, reactive—proactive aggression questionnaire; SRS-2 RRB, social responsiveness scale—second edition restricted and repetitive behaviors scale

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