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BRIEF REPORT

Brief Report: Inter-Relationship between Emotion Regulation, Intolerance of Uncertainty, Anxiety, and Depression in Youth with Autism Spectrum Disorder

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Abstract The aim of this study was to examine the inter-relationship between emotion regulation (ER), intolerance of uncertainty (IU), and symptoms of anxiety and depression in adolescents and young adults diagnosed with autism spectrum disorder (ASD). Sixty-one individuals aged 14–24 years ($M_{age} = 18.19$; $SD_{age} = 2.19$) completed the ER Questionnaire, IU Scale-12, Diagnostic and Statistical Manual of Mental Disorders-5 Dimensional Anxiety Scales, Patient Health Questionnaire-9, and Autism-Spectrum Quotient-Short. Correlation and mediation analyses were conducted. Results indicated all key variables were associated with each other and IU mediated the relationships between ER and symptoms of anxiety and of depression. Findings have implications for the design of future interventions targeting affective disorders in ASD.

Keywords Emotion regulation · Intolerance of uncertainty · Anxiety · Depression · Autism · Young adults

Introduction

Anxiety and depression are frequent and disabling comorbid psychiatric conditions in individuals with autism spectrum disorder (ASD; Kerns et al. 2015; Lever and Geurts 2016; van Steensel et al. 2011), however, the mechanisms accounting for the high prevalence of these conditions remain poorly understood. Intolerance of uncertainty (IU) and emotion regulation (ER) are among key risk-factors for the development and maintenance of affective disorders in the general population (Aldao et al. 2016; Carleton 2016; Gross and John 2003; McEvoy and Mahoney 2012), and recent research suggests a similar impact of these two factors in ASD (Bruggink et al. 2016; Hodgson et al. 2016; Maisel et al. 2016; Mazefsky et al. 2014; Neil et al. 2016; Pouw et al. 2013; Rieffe et al. 2011, 2014; Samson et al. 2015b; Swain et al. 2015). To date, no research has examined the inter-relationships between ER and IU in predicting anxiety and depression in ASD.

Since the original description by Freeston et al. (1994), various definitions of IU have been proposed (see Birrell et al. 2011; Boswell et al. 2013 for comprehensive overviews). Most recently, IU has been defined as the "dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty" (Carleton 2016, p. 31). Originally thought of as the risk factor for worry and generalised anxiety disorder (GAD; Dugas et al. 1997, 2001; Gentes and Ruscio 2011; Ladouceur et al. 2000; Meeten et al. 2012; Zlomke and Jeter 2014), IU has since been shown to be associated with a range of other psychopathologies, including major depressive disorder (MDD; de Jong-Meyer et al. 2009; Gentes and Ruscio 2011; McEvoy and Mahoney 2012; Miranda et al. 2008; Nelson et al. 2014; Yook et al. 2016), obsessive compulsive disorder (OCD; Lind and Boschen 2009; Steketee et al. 1998; Tolin et al. 2003), and social anxiety (Boelen and Reijntjes 2009; Teale Sapach et al. 2015).

A number of recent studies have explored the role of IU in ASD (Boulter et al. 2014; Hodgson et al. 2016; Maisel et al. 2016; Neil et al. 2016; Wigham et al. 2015). These studies

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have shown that IU, in addition to being more prevalent among individuals with ASD when compared to typically developing (TD) controls, is associated with aspects of the ASD phenotype such as sensory sensitivity, insistence on sameness, and repetitive motor behaviours (Neil et al. 2016; Wigham et al. 2015). Importantly, mirroring findings from the general population, IU has been found to be associated with anxiety in ASD (e.g., Boulter et al. 2014; Maisel et al. 2016; Wigham et al. 2015). The importance of considering IU in ASD is further underscored by findings from a recent study of children with ASD who received modified cognitive-behavioural therapy (Keefer et al. 2016). It was found that higher pre-treatment levels of IU predicted both concurrent levels of anxiety and poorer treatment response. However, only one study (i.e., Maisel et al. 2016) has explored the role of IU in anxiety in young adults with ASD, and to our knowledge, no study to date has examined the potential relationship between IU and depression.

Emotion regulation (ER) has been shown to be a crucial trans-diagnostic process associated with a range of psychopathologies, most notably anxiety and mood disorders (Aldao et al. 2016; Gross and John 2003). ER processes influence the intensity, duration, and types of emotions we experience (Thompson 1991), and individuals employ specific strategies to modify these emotions (Gross 1998). ER strategies have been typically classified as adaptive (e.g., positive rumination, savouring positive experiences, cognitive reappraisal, problem solving, acceptance) or maladaptive (e.g., negative rumination, avoidance, suppression, denial). Habitual use of adaptive strategies have been shown to be associated with positive affect and better mental health and relationship outcomes, whereas maladaptive strategies are related to poorer psychological outcomes (Aldao et al. 2010; Bryant 2003; Butler et al. 2003; Berking and Wupperman 2012; Eftekhari et al. 2009; Gable et al. 2004; Goldin et al. 2007; Gross 1998; Gross and John 2003; Liverant et al. 2011; Quoidbach et al. 2010; Raes et al. 2012; Richards et al. 2003; Richards and Gross 2000; Silk et al. 2003; Troy et al. 2010). Conceptual and empirical evidence suggest that emotion dysregulation is common in ASD, with findings generally showing less use of adaptive ER strategies in this population (Bruggink et al. 2016; Jahromi et al. 2012; Konstantareas and Stewart 2006; Mazefsky and White 2014; Nader-Grosbois and Mazzone 2014; Pitskel et al. 2014; Richey et al. 2015; Rieffe et al. 2011, 2014; Samson et al. 2012, 2014a, 2014b, 2015a, 2015b, 2016).

Cognitive reappraisal and emotion suppression are two of the most extensively studied adaptive and maladaptive strategies (respectively) in the ER literature. Reappraisal involves re-interpreting a situation to modify the emotional impact (Lazarus and Alfert 1964), and is associated with better subjective well-being and lower occurrence of depressive and anxiety symptoms (Garnefski et al. 2002; Gross and Muñoz 1995; Joormann and Gotlib 2010). Suppression involves inhibiting emotional expression (Gross & Levenson 1993), and is associated with less positive and more negative emotions, disruptions in communication and relationship formation, and a range of mental health disorders including depression (Aldao et al. 2010; Butler et al. 2003; Berking and Wupperman 2012; Campbell-Sills et al. 2006; Compare et al. 2014; Gross and John 2003).

Emotion regulation processes develop from infancy to adulthood (Schäfer et al. 2017) with evidence of a maladaptive shift during adolescence. More specifically, use of adaptive emotion regulation strategies has been shown to decrease and the use of maladaptive strategies to increase in individuals aged between 12 and 15 years (Cracco et al. 2017). In addition to this shift in emotion regulation, a related issue is that adolescence is a peak time for the onset of mental health conditions (Paus et al. 2008). For example, a nationally representative study of over 9000 Americans found the peak age of onset for any mental health disorder is 14 years (Kessler et al. 2005). Given these findings, we have decided to focus on a sample of individuals in the age range most likely to be affected by the shifts in ER development, in particular in terms of mental health and well-being.

As individuals with ASD present with higher levels of IU and more ER problems, and both IU and ER strategy use (ERSU) have been found to be independently associated with affective symptoms, it is necessary to examine the nature of the ERSU-IU inter-relationship in predicting anxiety and depression. It is possible that ERSU mediates the relationship between IU and psychopathology symptoms. This model is indirectly supported by findings that rumination and worry, two maladaptive forms of repetitive thinking (see Watkins 2008 for extended discussion) were found to mediate the relationship between IU and both generalised anxiety and major depressive disorders (Yook et al. 2016). Importantly, previous work has suggested that rumination is a cognitive ER strategy used by individuals with depression to suppress negative emotions (Liverant et al. 2011). In addition, counterfactual thinking, another form of repetitive thinking, conceptually overlaps with cognitive reappraisal. Hence, if repetitive thinking is replaced with ERSU in the model described above, it is likely that ERSU mediates the relationship between IU and symptoms of anxiety and depression. On the other hand, it is also possible that IU mediates the relationship between ERSU and psychopathology, as worry has been shown to account for variance in IU (Dugas et al. 2001), and IU predicts anxiety symptoms in ASD (Boulter et al. 2014). Despite the conceptual resemblance between repetitive thought and ERSU, these suggested models have not been examined to date in either ASD or non-ASD populations.

The aim in the current study was to characterise the inter-relationship between ERSU, IU and symptoms

of anxiety and of depression in adolescents and young adults with ASD. As interventions targeting ER and IU (separately) have been shown to be effective in improving mental health outcomes, clarifying the nature of their inter-relationship has the potential to further facilitate the development of interventions (see Berking and Schwarz 2013; Boswell et al. 2013; Dugas and Ladouceur 2000; Mennin et al. 2015). Based on previous findings, we hypothesised high levels of anxiety and depression in the ASD sample. We further hypothesised that higher levels of IU and greater use of maladaptive ER strategy (suppression) relative to adaptive ER strategy (reappraisal; ER ratio) would be associated with higher symptoms of anxiety and depression. We chose to focus on the ER ratio instead of only focusing on reappraisal and suppression scores because ASD research method has historically separated adaptive and maladaptive ER strategies during statistical analyses, in models predicting psychopathology. However, people can choose from and employ a repertoire of strategies (both adaptive and maladaptive), therefore these two types of strategies interact to have a joint impact on psychological well-being (see Aldao and Nolen-Hoeksema 2012 for example). Furthermore, based on the discussion above, it is possible either the presence of IU is the mechanism that explains the relationship between ERSU and anxiety and depression or the presence of ERSU is the mechanism that explains relationship between IU and anxiety and depression. To test these, the following four mediation models were examined: (1) IU as a predictor of anxiety, mediated by ER ratio; (2) IU as a predictor of depression, mediated by ER ratio; (3) ER ratio as a predictor of anxiety, mediated by IU; and (4) ER ratio as a predictor of depression, mediated by IU.

Methods

Participants

Participants were 61 adolescents and young adults with ASD aged 14–24 years who had self-reported a clinical diagnosis of ASD (see Table 1 for demographic information). All participants had an Autism-Spectrum Quotient-Short (AQ-Short) score above the suggested cut-off of 65 ($M = 77.18$; $SD = 9.46$). A further ten participants completed the survey but were not included in the study for the following reasons: (1) seven participants had an AQ-Short score below 65; (2) AQ-Short scores were not calculated for one participant due to missing items; (3) one participant self-reported a partial agenesis of the corpus callosum; and (4) one participant self-reported a co-morbid diagnosis of intellectual disability.

Table 1 Demographic information

	M (*SD*; range) *N* or frequency	
N	61	
Age	18.18 years (2.18; 14.42–24.66)	
Female/Male	18/43	
Self-reported diagnoses	Autism spectrum disorder	20
	Autistic disorder	2
	Aspergers syndrome	28
	High functioning autism	10
	PDD-NOS	1
Highest level of education	Some high school	21
	Completed high school	25
	Certificate/diploma	11
	Undergraduate (university)	3
	Missing	1
Living with	Both parents or one parent	52
	Relative (sister)	2
	House sharing	2
	On campus	1
	Alone	1
	Partner	1

Procedure and Measures

Individuals were recruited for the Study of Australian School Leavers with Autism, funded by the Cooperative Research Centre for Living with Autism. Following ethics approvals, recruitment targeted individuals diagnosed with ASD and their parents via various channels including Australian state-based autism organisations (e.g., Autism Queensland), clinicians, high schools, tertiary education organisations, and participant databases from autism research organisations. Nearly 80% (79.6%) of individuals were recruited through their parents. Participants read an information statement about the study, and provided informed consent in writing. For individuals under 18 years, parental consent was also obtained. Once written consent was received (via email or mail), participants were sent the online survey link using Qualtrics (Qualtrics 2014), a web-based tool for creating and conducting online surveys.

The online survey included demographic information and a range of questionnaires gathering information about diagnosis, physical and mental health, wellbeing, education, work, community engagement and other domains of life. The five self-report questionnaires used in the current study included: AQ-Short (Hoekstra et al. 2011); ER Questionnaire (ERQ; Gross and John 2003); Intolerance of Uncertainty Scale-12 (IUS-12; Carleton et al. 2007); Diagnostic and Statistical Manual of Mental Disorders-5 Dimensional Anxiety Scales (DSM-5 DAS; Knappe et al.

2013; Lebeau et al. 2012; Beesdo-Baum and Knappe 2012); and the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al. 2001).

The AQ-Short is a 28-item abbreviated version of the full 50-item AQ screening questionnaire (Baron-Cohen et al. 2001) relating to behaviours associated with ASD. A score above 65 has a sensitivity of 0.97 and a specificity of 0.82 for ASD, comparable to the full AQ (50 items). Correlation with the 50-item AQ has been shown to be very high, with *r*'s ranging from 0.93 to 0.95 (Hoekstra et al. 2011). The ERQ is a ten-item questionnaire designed to assess the frequency of cognitive reappraisal and emotion suppression use, and has previously been used in the ASD population (Samson et al. 2012, 2015b). In order to assess the proportion of habitual adaptive strategy use vs maladaptive strategy use, an ERQ ratio was calculated by dividing the suppression score by the reappraisal score; thus a higher ratio indicates a greater use of suppression relative to reappraisal. The IUS-12 is a 12 item short version of the 27 item IUS (Freeston et al. 1994) designed to measure responses to uncertainty. The DSM-5 DAS is a brief screening questionnaire designed to provide a dimensional assessment of anxiety symptoms; a cut off score of 14 indicates clinically significant anxiety (Beesdo-Baum et al. 2012), with both sensitivity and specificity of 0.73. The PHQ-9 is a nine-item, norm referenced, questionnaire designed to screen for the presence of depression in general and clinical populations. Scores of 20, 15, 10, and 5 represent severe, moderately severe, moderate, and mild depression, respectively. A score of ten or above had a sensitivity of 0.88 and a specificity of 0.88 for major depression (Kroenke et al. 2001). Higher scores on AQ-Short, IUS-12, DSM-5 DAS, and PHQ-9 indicate more ASD symptoms, higher IU, and greater symptoms of anxiety and depression respectively. Higher scores on ERQ subscales indicate greater habitual use of cognitive reappraisal and emotion suppression. Cronbach's α for the questionnaires in this study were in good to excellent range: 0.77 for AQ-Short, 0.82 for ERQ-suppression (ERQ-S), 0.82 for ERQ-reappraisal (ERQ-R), 0.93 for IUS-12, 0.92 for DSM-5 DAS, and 0.88 for PHQ-9.

Statistical Analysis

Tests of normality using Kolmogorov–Smirnov statistic were conducted, and gender differences on each measure were assessed using the Mann–Whitney U test or *t*-test for independent samples, depending on whether assumptions for parametric tests were met. Pearson r and point bi-serial correlations were used to explore the associations between variables of interest, age, and gender with exclude cases pair-wise and bias-corrected bootstrapping (2000 resamples) to account for the non-normal distributions of variables.

Four simple mediation analyses (Hayes 2013) were conducted to test the hypotheses: (1) IU as a predictor of anxiety, mediated by ER ratio; (2) IU as a predictor of depression, mediated by ER ratio; (3) ER ratio as a predictor of anxiety, mediated by IU; and (4) ER ratio as a predictor of depression, mediated by IU. SPSS Statistics 21 for Mac was used for statistical analysis and the PROCESS macro v2.16 in SPSS with 5000 resamples (Hayes 2013) was used for the mediation analysis.

Results

The severity of depressive symptoms based on PHQ-9 scores were as follows: minimal (39.3%), mild (24.6%), moderate (19.7%), moderately severe (11.5%), and severe (4.9%). A third of the sample (36.1%) reached the criterion for depression, and 42.6% reached the cut-off criterion for anxiety (based on DSM-5 DAS scores).

Participants' scores (all, females, and males) for the ERQ, IUS-12, DSM-5 DAS, and PHQ-9 are presented in Table 2. As IUS-12, PHQ-9, ERQ-R, and ERQ-S scores met all the assumptions for parametric tests, independent samples *t*-tests were used for gender comparisons. Females had higher IUS-12 ($p = .016$, $\eta^2 = 0.09$; medium effect), DSM-5 DAS ($p = .009$, $r = .34$; medium effect), and PHQ-9

Table 2 Scores on the ERQ subscales, IUS-12, DSM-5 DAS, and PHQ-9 measures

	All *M* (*SD*) range	Female *M* (*SD*) range	Male *M* (*SD*) range	Gender comparison statistics *t*, *U*, *z*, *p*, effect sizes
ERQ-R	23.54 (6.41) 6–37	23.83 (6.96) 11–32	23.42 (6.25) 6–37	$t = 0.229$ $p = .820$
ERQ-S	15.46 (5.54) 5–28	17.06 (5.88) 7–27	14.79 (5.32) 5–28	$t = -1.471$ $p = .147$
IUS-12	33.23 (11.98) 12–60	38.89 (12.19) 17–60	30.86 (11.00) 12–56	$t = 2.49$ $p = .016$ $\eta^2 = 0.09$
DSM-5 DAS	13.82 (9.09) 0–35	18.61 (9.87) 0–35	11.81 (8.03) 0–34	$U = 222$ $z = -2.62$ $p = .009$ $r = .34$
PHQ-9	7.74 (6.46) 0–26	11.18 (6.75) 1–26	6.30 (5.83) 0–22	$t = -2.84$ $p = .006$ $\eta^2 = 0.12$

ERQ-R ER Questionnaire-Reappraisal, *ERQ-S* ER Questionnaire-Suppression, *IUS-12* Intolerance of Uncertainty Scale-12, *DSM-5 DAS* Diagnostic and Statistical Manual of Mental Disorders-5 Dimensional Anxiety Scales, *PHQ-9* Patient Health Questionnaire-9

($p = .006$, $\eta^2 = 0.12$; large effect) scores than males; no significant gender differences were found for ERQ-R ($p = .820$) and ERQ-S ($p = .147$) scores.

The correlation analyses showed that ERQ-R was moderately associated with IUS-12 ($r = -.375$, $p = .003$) and PHQ-9 ($r = -.393$, $p = .002$) whilst ERQ ratio was moderately associated with IUS-12 ($r = .409$, $p = .001$) and DSM-5 DAS ($r = .390$, $p = .002$), and strongly associated with ERQ-R ($r = -.646$, $p = .000$), ERQ-S ($r = .622$, $p = .000$), and PHQ-9 ($r = .500$, $p = .000$). IUS-12 was strongly associated with both DSM-5 DAS ($r = .633$, $p = .000$) and PHQ-9 ($r = .628$, $p = .000$). No other correlations, including those with age, were significant (see Table 3).

The first mediation model exploring the relationship between IUS-12 and DSM-5 DAS, mediated by ERQ ratio, was not supported; the path between ERQ ratio and DSM-5 DAS was not significant (Fig. 1a).

The remaining three mediation models were supported. There were significant indirect effects of: (1) IUS-12 on PHQ-9 through ERQ ratio (Model 2; Fig. 1b), with medium

Table 3 Correlations for key variables

	Age	Gender[a]	ERQ-R	ERQ-S	ERQ ratio	IUS-12	DSM-5 DAS
Gender	0.123						
ERQ-R	0.276	0.039					
ERQ-S	−0.180	0.184	−0.028				
ERQ ratio	−0.201	0.108	−0.646*	0.622*			
IUS-12	0.116	0.304	−0.375*	0.114	0.409*		
DSM-5 DAS	0.089	0.338	−0.340	0.263	0.390*	0.633*	
PHQ-9	−0.086	0.331	−0.393*	0.286	0.500*	0.628*	0.719*

ERQ-R Emotion Regulation Questionnaire-Reappraisal, *ERQ-S* Emotion Regulation Questionnaire-Suppression, *ERQ ratio* Emotion Regulation Questionnaire ratio, *IUS-12* Intolerance of Uncertainty Scale-12, *DSM-5 DAS* Diagnostic and Statistical Manual of Mental Disorders-5 Dimensional Anxiety Scales, *PHQ-9*, Patient Health Questionnaire-9

*$p < .008$ (Bonferroni adjustment)

[a]Positive direction indicates female

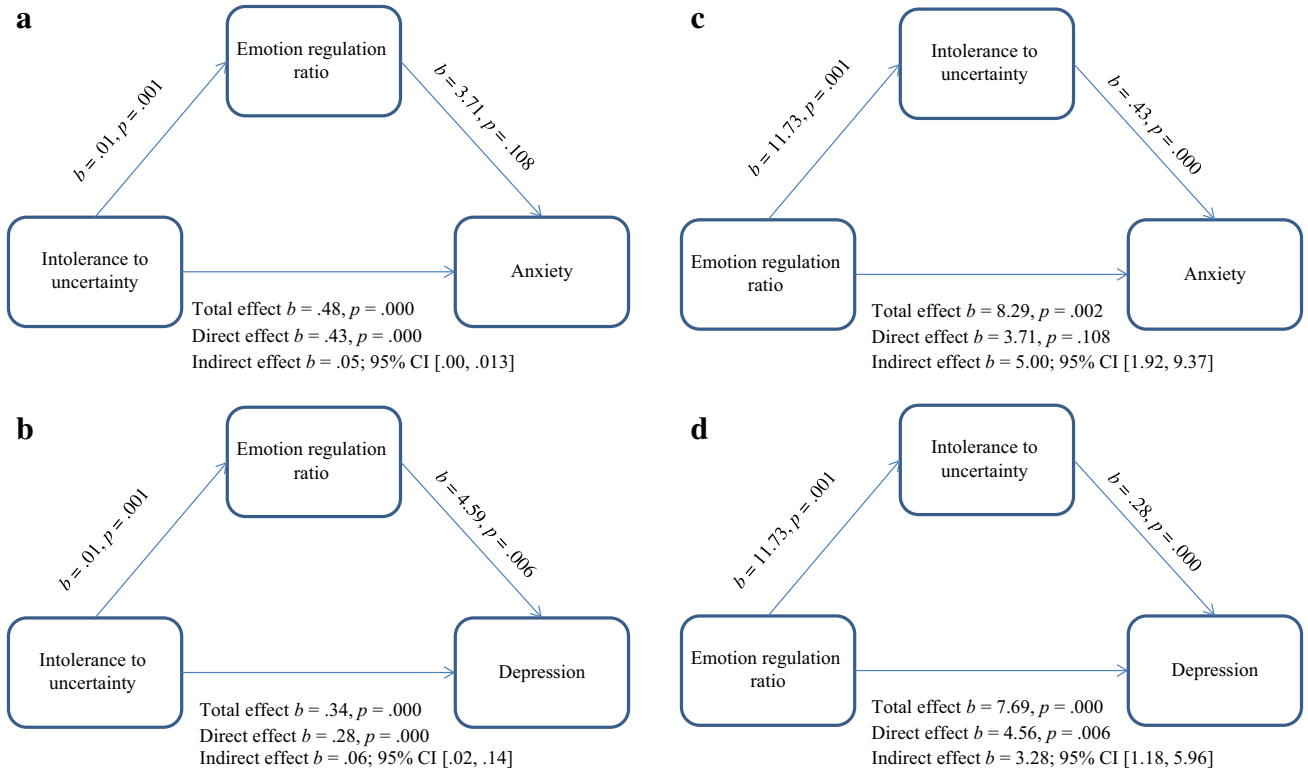

Fig. 1 **a** Mediation model 1, **b** mediation model 2, **c** mediation model and **d** mediation model 4

effect size = 0.112; 95% BCa CI [0.026, 0.247]; (2) ERQ ratio on DSM-5 DAS through IUS-12 (Model 3; Fig. 1c), with large effect size = 0.232; 95% BCa CI [0.067, 0.430]; and (3) ERQ ratio on PHQ-9 through IUS-12 (Model 4; Fig. 1d), with large effect size = 0.203; 95% BCa CI [0.067, 0.371]. It is notable that for Model 3, IUS-12 fully mediated the relationship between ERQ ratio and DSM-5 DAS.

Discussion

The levels of anxiety and depression in the adolescents and young adults who participated here were relatively high, with 43% meeting the cut-off for clinically significant anxiety, and 36% meeting the clinical cut-off for depression. Although the reported frequency of anxiety in ASD has been reported to vary between 13.6% and 84% (Uljarević et al. 2016), the findings from this study are in line with systematic and meta-analytic reviews of children and adolescents that suggest the average rate is about 40% (van Steensel et al. 2011; White and Roberson-Nay 2009). The frequency of depression in our study was at the mid-point of rates reported in previous studies with adults with ASD, which range between 15 and 70% (Lainhart 1999; Lugnegard et al. 2011; Hofvander et al. 2009; Mazzone et al. 2012; Sterling et al. 2008). The female participants self-reported higher levels of anxiety and depression, supporting findings in the general population that women have higher internalising symptoms than males (Gater et al. 1998; Hankin 2009; McLean et al. 2011; Nolen-Hoeksema 2001). Female participants also self-reported higher IU, which differs from previous research that has reported no gender differences (Carleton et al. 2007). We also found no gender differences in self-reported habitual suppression and cognitive reappraisal, in contrast to previous research showing that men scored higher than women on the suppression scale (Gross and John 2003). The reason for IU and ER findings being inconsistent with previous research is likely due to the high prevalence of anxiety and depression reported in our group of female participants.

Our first objective was to examine the relationships between IU and ERSU, and symptoms of anxiety and depression. Individuals with ASD who self-reported both greater levels of IU and increased habitual use of suppression relative to reappraisal also reported higher symptoms of anxiety and depression. These findings are consistent with previous research indicating that IU was positively associated with symptoms of anxiety (Maisel et al. 2016; Wigham et al. 2015), and that cognitive reappraisal negatively predicted maladaptive behaviours, including internalizing symptoms (Samson et al. 2015b). Past research typically analysed adaptive and maladaptive ER strategies separately in their associations with psychopathology. In this study, when the reappraisal and suppression scores were individually correlated with anxiety and depressive symptoms, neither reappraisal nor suppression were individually associated anxiety symptoms and furthermore suppression was not associated with depression symptoms; however when the ERQ ratio was used for the correlation analysis, it associated strongly with the severity of both anxiety and depression symptoms. Thus, the use of ERQ ratio has provided additional information. Interestingly, the associations that anxiety and depression had with IU in this sample were stronger than their associations with ER.

The results build on previous research by providing the first characterisation of the inter-relationships between IU, ERSU, anxiety and depression in ASD. As hypothesized, ER partially mediated the relationship between IU and depression; however, ER did not mediate the relationship between IU and anxiety. We also found that IU fully mediated the relationships between ER and anxiety symptoms, and partially between ER and depression symptoms. The effect sizes in these two latter models, where IU was the mediator, were large. These findings indicate that in this sample of young people with ASD, the presence of IU is the mechanism that explains fully the relationship between ER and anxiety symptoms, and partially explains the relationship between ER and depression symptoms. The findings align with previous work showing that IU predicts anxiety in a sample of children with ASD (Boulter et al. 2014). In addition, the two latter models largely support the cognitive model of anxiety proposed by Boulter and colleagues that rigidity of thought and difficulty with emotion processing predict anxiety through IU.

As this is the first study to assess the inter-relationship of both ER and IU with symptoms of anxiety and symptoms of depression in individuals with ASD, it was largely exploratory in nature, and some limitations should be acknowledged, particularly the concurrent self-report data collected here. The design of this study was cross-sectional therefore the data in the mediation models were collected at one timepoint, which limits our ability to infer causal relationships. Additionally, we were unable to conduct cognitive assessments to confirm the level of cognitive ability and their influence on the findings, or to independently confirm ASD diagnosis with more established diagnostic instruments such as the autism diagnostic interview-revised or autism diagnostic observation schedule.

In this study, we specifically focused on two ER strategies (reappraisal and suppression), given the strong evidence base for their relationship with affective symptoms in general populations (e.g., Garnefski et al. 2002; Gross and John 2003). However, other strategies such as rumination (Yook et al. 2016) have also been implicated in the maintenance of GAD and MDD symptoms in non-ASD populations. Therefore it will be important to further

characterise the inter-relationship of ERSU using a wider range of strategies, IU, and affective disorders, using larger, and well-characterized samples. It is also important to use longitudinal designs rather than the concurrent one used here, to ascertain causation when testing the role of ER and IU in the presentation of psychopathology in ASD. Furthermore, future research should use more objective measures of ER strategy use such as behavioural or physiological measurements to explore the relationships between ER and psychopathology, as well as examine the relationship between self-report and objective measures of ER.

The current findings have significant implications for designing intervention programs to reduce symptoms of anxiety and depression in ASD. Firstly, both IU and ER have individually been shown to improve in response to intervention in non-ASD populations. For example, an 18-week, emotion-focused cognitive behavioural therapy program was found to be effective in reducing IU in patients with GAD and panic disorder, which in turn was related to reduction in symptoms of anxiety and depression (Boswell et al. 2013). Another intervention study found that following a 20-week ER therapy program, individuals with GAD, half who also had MDD, showed reduction in GAD and MDD symptoms as well as improvements in quality of life, mindful attention/accepting, and cognitive reappraisal (Mennin et al. 2015). Intervention programs designed separately to reduce IU and improve ER in children with ASD are promising (Rodgers et al. 2016; Thomson et al. 2015). Given the pattern of inter-relationships between ER, IU, anxiety and depression symptoms found in the current study, it will be important to jointly improve tolerance of uncertainty as well as emotion regulation in future intervention programs, as this combined intervention approach may be most effective for supporting individuals with ASD who have co-morbid affective disorders.

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Author Contributions RC conceived of the study, participated in its design and coordination, collected the data, performed the statistical analysis, drafted the manuscript. AR conceived of the study and participated in its design. CD provided intellectual feedback. MU concevied of the study, participated in its design and coordination, and collected the data. All authors read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of interest All the authors declare that they have no conflict of interest.

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.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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