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Title page

Title of Paper: Emotion regulation in autism spectrum disorder: Where we are and where we need to go

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Number of text pages: 21

Number of Tables: 1

Number of Figures: 0

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Grant sponsor: Cooperative Research Centre for Living with Autism (Autism CRC);

Grant number: 3.016.

Acknowledgement

Ru Ying Cai, Amanda Richdale, Cheryl Dissanayake, and Mirko Uljarević acknowledge the financial support of the Cooperative Research Centre for Living with Autism (Autism CRC), established and supported under the Australian Government's Cooperative Research Centers Program. Andrea Samson was supported by the Swiss National Science Foundation. We would also like to thank Ms Aikaterini Giannadou for her helpful comments on a previous draft of this paper.

Abstract

Emotion dysregulation is a common issue experienced by individuals with autism spectrum disorder (ASD) and has been associated with a wide range of negative mental and physical health outcomes. This commentary highlights the role emotion dysregulation plays in ASD by first considering the literature on emotion regulation (ER) in the general population and then summarizing the ER research in ASD. Based on the evaluation of previous research findings, we conclude that individuals with ASD have more ER difficulties and consistently self-report or demonstrate a less adaptive pattern of ER strategy use. In addition, the higher prevalence of internalizing and externalizing issues seen in ASD are associated with the greater habitual use of some ER strategies and less habitual use of others. Conceptual and methodological limitations are discussed, including the use of coping measures and single-method approaches, and ASD gender distribution. We propose a set of new directions for investigating ER in ASD, incorporating knowledge from other literatures on the role of flexibility in healthy adaptation, overlaps between flexibility and executive function deficits, the adaptive value of up-regulation of positive emotions, and the importance of emotional self-awareness. Increasing our capacity for identifying the mechanisms underlying co-morbid affective disorders can ultimately inform the design of effective interventions to maximize the wellbeing of individuals with ASD.

Lay Summary: Research has shown that people diagnosed with autism tend to have difficulties with regulating their own emotions. This commentary paper summarizes the main information from emotion regulation research conducted both in autism and in other populations. We make suggestions on how we can improve emotion regulation research in autism, with the ultimate goal being to use the learning gained

from research to design effective interventions that can improve the wellbeing of people with autism.

Keywords: emotion regulation, autism spectrum disorder, ASD, flexibility, outcomes, method.

*Knowing what we feel is the first step to knowing why we feel that way. If we are aware of the constant changes in our inner and outer environment, we can mobilize to manage them (*Van der Kolk, 2014).

Anxiety and depression are among the most prevalent affective disorders associated with autism spectrum disorder (ASD; American Psychological Association 2013; Croen et al. 2015; Totsika et al. 2011). Reported prevalence ranges between 14% and 84% for anxiety, and between 17% and 70% for depression (Croen et al. 2015; Kim et al. 2000; Lainhart 1999; Lugnegard et al. 2011; Hofvander et al. 2009; Mazzone et al. 2012; Muris et al. 1998). Higher rates of anxiety and depression in individuals with ASD have been associated with lower life satisfaction and greater social difficulties (Gotham et al. 2015; White & Roberson-Nay 2009), externalizing problems including aggression and self-injury (Folstein 2012), loneliness (White & Roberson-Nay 2009), and insomnia symptoms (Richdale et al. 2014). However reasons for these high rates of co-morbid anxiety and depression remain speculative, and researchers have begun to focus on the potential importance of emotion regulation (ER) as a mental health risk factor in ASD (Weiss et al. 2014; White et al. 2014). ER is a particularly promising avenue for exploration, since emotion dysregulation is shown to be a trans-diagnostic risk factor for mental health conditions in the general population (Aldao et al. 2016; Gross & John 2003) that is malleable by treatment (e.g., Blackledge & Hayes 2011). By way of contextualizing the subsequent discussion of gaps in our knowledge about ER in ASD, this commentary first considers the literature on ER in the general population, next examines nascent ER research in ASD, and then proposes directions for future research on ER in ASD.

Emotion Regulation in the General Population

Traditionally thought to be irrational and to cause problems in adaptive functioning (for an overview, see Damasio 1994), emotions are now suggested to enable our adaption to environmental demands via activation of attentional, behavioral, and physiological resources (Levenson 1994; Barrett & Salovey 2002). Emotion regulation is a complex process that involves the monitoring and modification of emotional responses that is goal-directed (Eisenberg & Spinrad 2004), can be either effortful or automatic (Gyurak et al. 2011), and aims to modify the intensity, duration, and types of emotions experienced (Thompson 1991). Emotion dysregulation occurs when emotions are inappropriately and ineffectively regulated, and may manifest itself in negative affectivity or irritability. The first step of ER is to identify emotions that need regulating (Gross 2015), which then triggers the implementation of ER strategies to either increase or decrease these emotions. We typically accept our positive emotions more openly and try to regulate our negative emotions to help ourselves feel better and solve life and social problems.

Amongst all the frameworks for conceptualizing the approaches people use to regulate their emotions (e.g., Koole 2009; Larsen 2000), the process model of ER (Gross 1998), which describes ER as a multicomponent and dynamic process between the individual and their context, is the most influential and widely known. The process model defines five families of ER strategies: 1) situation selection (e.g., avoiding or approaching specific situations); 2) situation modification (e.g., problem solving); 3) attentional deployment (e.g., paying attention towards or away from information); 4) cognitive change (e.g., modifying appraisals of a situation); and 5) response modulation (e.g., extent to which an emotion is expressed outwardly). Each

family (or category) of ER encompasses strategies that are either adaptive or maladaptive to physical and mental health, and general wellbeing (Gross & John 2003) when they are used in a habitual manner over prolonged periods. For example, cognitive change encompasses negative rumination, which involves a repetitive focus on negative events or feelings such as sadness and apathy (Morrow & Nolen-Hoeksema 1990) and cognitive reappraisal, which involves re-interpretation of the situation to modify emotions (Lazarus & Alfert 1964).

There are a variety of ways to categorize ER strategies, including implicit or explicit (e.g., Eisenberg & Spinrad 2004), intrinsic or extrinsic (e.g., Thompson 1991), conscious or unconscious (e.g., Bargh & Williams 2007), voluntary or involuntary (e.g., Mauss et al. 2007), antecedent- or response-focused (e.g., Gross & Muñoz 1995), and avoidant or approach (e.g., Shaver & Mikulincer 2011). Although a comprehensive discussion on the conceptualization of ER is beyond the purpose and scope of this commentary, we have largely focused on the adaptive and maladaptive categorization of ER strategy types because strategies differentially predict long-term mental health and wellbeing outcomes and are therefore potentially informative in terms of clinical practice.

Generally, it is agreed that healthy ER is characterized by the successful up-regulation of positive emotions and down-regulation of negative emotions (Gross 2002; Giuliani et al. 2008; Ochsner et al. 2004). Research on the down-regulation of negative emotions has shown that the habitual use of certain strategies (such as avoidance, expressive suppression, denial, and negative rumination) is associated with more negative emotions as well as higher sympathetic activation, impaired memory, disrupted communication and social bonds in relationship formation, and internalizing symptoms such as anxiety and depression (Butler et al. 2003; Berking & Wupperman

2012; Campbell-Sills et al. 2006; Compare et al. 2014; Gross 1998; Gross & John 2003; Joormann & Gotlib 2010; Liverant et al. 2011; Richards et al. 2003; Richards & Gross 2000; Silk et al. 2003). Therefore, these strategies are typically considered to be maladaptive for the individual when they are used in a habitual manner due to their relationships with poorer outcomes. In contrast, the habitual use of strategies such as cognitive reappraisal, problem solving, and acceptance is thought to be more adaptive as it is related to reduced negative affect, improved memory, diminished cardiac reactivity, and lower levels of anxiety and depression (Campbell-Sills et al. 2006; Eftekhari et al. 2009; Garnefski et al. 2002; Goldin et al. 2007; Joormann & Gotlib 2010; Liverant et al. 2008; Troy et al. 2010).

Although we have categorized the habitual use of certain ER strategies as adaptive and others as maladaptive, we would like to caution the reader that this does not mean "adaptive" or "maladaptive" strategies are useful or unhelpful respectively across all situations. Evidence from recent research in the general population indicates that the inflexible reliance on particular ER strategies (even if they are generally thought to be adaptive) has negative consequences. For example, even though cognitive reappraisal has generally been shown to be associated with better mental health and wellbeing, this is not evident across all contexts. Troy et al. (2013) showed that this relationship is evident only in the context of stress that is uncontrollable. In controllable stressful situations, higher cognitive reappraisal was associated with poorer psychological health. Instead of cognitive reappraisal, acceptance of both the situation and experience is shown to be more adaptive in uncontrollable situations (Hayes & Wilson 1994).

It is worth noting that emotion dysregulation may not be the result of ER strategy use per se. There are other factors that may cause emotion dysregulation, for

example, the inability to identify one's own emotions or effectively monitor emotional changes post strategy use. Sheppes et al. (2015) listed the regulatory stages where dysregulation may occur, which can then lead to specific mental health conditions (see Table 1 in their review).

Research in the general population has shown the benefits of positive emotions (Lyubomirsky et al. 2005), and that in affective disorders the up-regulation and maintenance of positive emotions are as important as the down-regulation of negative emotions (Carl et al. 2013). It has been suggested that positive emotions broaden individuals' cognitive and behavioral repertoires (Fredrickson, 2004). Specifically, the successful regulation of positive emotions via strategies such as positive rumination, savoring positive experiences, and sharing positive events is associated with increased positive affect, life satisfaction, optimism, self-esteem, happiness, and higher relationship wellbeing including better intimacy and relationship satisfaction (Bryant 2003; Gable et al. 2004; Quoidbach et al. 2010; Raes et al. 2012). Additionally, these studies showed the use of strategies to regulate positive emotions is also negatively related to hopelessness, negative affect, and depression symptoms.

In addition to empirical studies that assessed the relationships between ER strategy use and health outcomes, meta-analytic reviews have revealed: 1) less frequent use of certain ER strategies and more frequent use of other strategies are associated with depressive and anxiety symptoms in adolescents (Schäfer et al. 2016); and 2) a larger magnitude in the relationship between maladaptive strategies and psychopathology than adaptive strategies and psychopathology (Aldao & Nolen-Hoeksema 2010).

Emotion Regulation in ASD

Research on ER in both children and adults with ASD has emerged recently, largely focusing on group differences in overall ER strategy use, and the relationship between ER and a range of outcomes, including mental health and social engagement (see Table 1 for a summary of research to date). More than half of these studies included participants with ASD who had average cognitive capacity overall, whilst other studies either included individuals with lower cognitive capacity, or did not provide information regarding participants' cognitive function. Poor ER may be inherent in ASD (Mazefsky et al. 2013; Mazefsky & White 2014), and recent evidence supports this view (e.g., Konstantareas & Stewart 2006; Nader-Grosbois & Mazzone 2014; Pitskel et al 2014; Richey et al. 2015; Samson et al. 2014; Samson et al. 2016). All ASD core symptoms have been shown to be linked to emotion dysregulation (Berkovits et al. 2017), with restricted and repetitive behaviors, interests, and activities being the strongest predictor (Samson et al. 2014).

Insert Table 1

Overall, ER research shows that when compared to typically developing (TD) participants, individuals with ASD generally have more ER difficulties, are less effective at using ER strategies, and show a maladaptive pattern of strategy use (e.g., Konstantareas & Stewart 2006; Nader-Grosbois & Mazzone 2014; Pitskel et al 2014; Richey et al. 2015; Samson et al. 2014). Examining the use of specific ER strategies, a majority of research has found evidence for less frequent use of adaptive ER strategies among ASD individuals (Bruggink et al. 2016; Jahromi et al. 2012; Konstantareas & Stewart 2006; Rieffe et al. 2011; Rieffe et al. 2014; Samson et al.

2012; Samson et al. 2015a; Samson et al. 2015b; Samson et al. 2015c). Nevertheless, some studies report similar use of adaptive strategies as control participants (Mazefsky et al. 2014; Pouw et al. 2013; Samson et al. 2015b).

Findings concerning maladaptive strategy use have been more diverse, with research showing more (Bruggink et al. 2016; Jahromi et al. 2012; Mazefsky et al. 2014; Samson et al. 2012; Samson et al. 2015b; Samson et al. 2015c;), similar (Pouw et al. 2013; Rieffe et al. 2011; Rieffe et al. 2014; Samson et al. 2015b; Samson et al. 2015a; Samson et al. 2015c), and less frequent (Samson et al. 2015a; Samson et al. 2015c) use in ASD. Samson and colleagues (2015a; 2015c) used both self- and parent-reports of ER in samples of participants with ASD aged 8 to 20 years, and found same amount of expressive suppression use (self-report in Samson et al. 2015c and parent-report in Samson et al. 2015a) and less use of suppression (parent-report in Samson et al. 2015c and self-report in Samson et al. 2015a). The authors suggested their unexpected findings might be due to the difficulty parents may have had reporting their child's use of ER strategies and the wide age range of participants, as controlling emotional expression is more difficult for children and adolescents than for adults. Building on the latter point, the age range of participants in these two papers encompassed separate developmental periods, i.e., childhood, adolescence, and young adulthood. This may have had an impact on the pattern of results found, as ER processes develop and change from infancy to adulthood (Schäfer et al. 2017), with evidence of a maladaptive shift during adolescence between the ages 12 and 15 years (Cracco et al. 2017). To clarify these mixed findings, it would be important to further study suppression in ASD.

Interestingly, studies reporting that individuals with ASD use adaptive strategies at a similar frequency as TD individuals have also found these individuals used more

maladaptive strategies (i.e., Mazefsky et al. 2014; Samson et al. 2015b). Furthermore, studies showing that individuals with ASD using the same amount of maladaptive strategies have also found individuals used fewer adaptive strategies. These findings suggest individuals with ASD consistently self-report or demonstrate an overall less adaptive pattern of ER strategy use (i.e., Rieffe et al. 2011; Rieffe et al. 2014; Samson et al. 2015a; Samson et al. 2015b; Samson et al. 2015c). One exception is the study by Pouw et al. (2013) where the ASD group of children and adolescents self-reported using similar amounts of both adaptive and maladaptive coping strategies when compared with a control group, even though they had significantly higher levels of self-reported depression symptoms. This finding contrasts with Rieffe et al.'s (2014) results using the same coping measure in a sample of participants of similar age range, which showed that the ASD group used less approach coping. One potential explanation for the unique findings reported by Pouw and colleagues might be the different gender distributions across studies. In a non-ASD sample, girls use more approach coping and less avoidant coping than boys (Eschenbeck et al., 2007). Pouw et al. included only boys in their study whereas Rieffe et al. (2014) had a higher proportion of girls in the TD group (55% TD vs. 11% ASD), therefore the group differences found in Rieffe et al. may be due to gender effects. Future work using separate analyses for male and female participants might provide further clarification in terms of group differences in the use of approach and avoidant coping.

We would like to remind the reader that the adaptive and maladaptive categorizations of ER strategies as described above are based on findings in the non-ASD populations. In ASD, studies have consistently found higher use of certain strategies categorized as maladaptive and/or lower use of other strategies categorized as adaptive to be related to the presence and higher severity of internalizing and

externalizing symptoms (Bruggink et al. 2016; Mazefsky et al. 2014; Pouw et al. 2013; Rieffe et al. 2011; Rieffe et al. 2014; Samson et al. 2015a). Among studies showing higher symptoms of internalizing and externalizing problems in ASD compared to the control groups, the ASD groups either reported less use of adaptive strategies and/or more use of maladaptive strategies. The only exception is the Pouw et al. (2013) study, which may be due to the gender distributions as already discussed. Therefore, based on the majority of research findings, it is likely that the use of ER strategies adaptive and maladaptive for individuals without ASD may similarly be adaptive and maladaptive for those with ASD.

There is one category of ER strategies that may have differing effects on the ASD population. ER research has found that the use of avoidant strategies was negatively associated with depression in youth with ASD (Pouw et al. 2013). Furthermore, using a longitudinal design and the same measure used by Pouw et al. (i.e., the Coping Scale [Wright et al. 2010]), Rieffe et al. (2014) found the increase of avoidant strategies contributed to fewer depressive symptoms in both ASD and TD children and adolescents. These observations are not in line with findings from the general population where avoidant strategies are typically characterized as maladaptive as they have been consistently shown to predict more depressive symptoms in TD youth (e.g., Herman-Stahl et al. 1995; Seiffge-Krenke & Klessinger 2000). Rieffe and colleagues suggested that measurement differences could have contributed to these unexpected findings i.e., the avoidant scale items used by Seiffge-Krenke and Klessinger were worded differently and measured different aspects of avoidant strategies. Specifically, Seiffge-Krenke and Klessinger's items reflected less constructive avoidant strategy use whereas Rieffe et al.'s items referred to strategies that aimed to create more distance.

Based on the content analysis of the Coping Scale, we suggest the avoidant items (i.e., internalizing, externalizing, distraction and trivializing subscales) encompass both adaptive and maladaptive strategies. Distraction is seen as an adaptive ER strategy (see review by Joormann & Stanton 2016) and trivializing may be considered as cognitive reappraisal (e.g., 'I think it is not such a big problem' or 'I tell myself that the problem is not very important'), since they downplay the emotional impact of the situation by rephrasing. Another possibility for the varying findings on the relationship between avoidant ER strategy use and depressive symptoms in TD and ASD youth that the use of avoidant strategies may be adaptive for youth with ASD, at least in the short- to medium-terms. It is difficult to determine the longer-term impact of using avoidance for individuals with ASD; therefore further work is needed to determine the long-term adaptive value of avoidance coping in ASD.

Other research has shown relationships between ER and academic performance (Konstantareas & Stewart 2006), social skills (Berkovits et al. 2017), peer social engagement (Jahromi et al. 2013), social adjustment (Nader-Grosbois & Mazzone 2014), and social anxiety (Swain et al. 2015). These findings are mostly consistent with findings in the non-ASD literature.

In the next section, we discuss limitations in the ASD literature relating to ER, including methodological and conceptual issues, and gender effects. In addition to the limitations in the current literature, we venture into research areas outside of ER and ASD to create foundations for a new fruitful avenue of research.

Limitations in the Current ASD Literature and Other Suggestions

One limitation in the ER research in ASD reviewed here is the use of instruments not originally designed to measure ER. From a methodological

perspective, the type of measure used to assess ER sets the boundaries for the phenomenon under focus and thus influences the conceptualization of ER. Several research groups have used coping measures such as the Response to Stress Questionnaire (in Mazefsky et al. 2014), the Coping Scale (in Pouw et al. 2013; Rieffe et al. 2014), and the Cognitive ER Questionnaire (in Rieffe et al. 2011) to capture the construct of ER. Although coping is related to ER, there are conceptual distinctions: coping styles focus solely on dealing with stressful experiences, but ER strategies can be used in non-stressful situations to maintain or up-regulate positive emotions (Eisenberg et al. 1997; Gross & John 2003). Furthermore, Gross and John (2003) argued that coping styles incorporate a broader set of underlying processes that are not only emotion-related: for example, reinterpretation (a coping construct) not only measures reappraisal of the situation but also optimism and learning from experience.

In addition to the lack of conceptual clarity, there are a wide variety of ER assessment methods used, including different types of questionnaires, informant type (self vs. parent reports), or other assessment approaches such as interviews, diaries, and experimental designs. Additionally, there has been a minimal use of mixed-methods approaches in studying ER in ASD (but see Samson et al. 2015c for an example study). A recent review of ER measurement in ASD by Weiss et al. (2014) found that 75% of studies included only one methodological approach to ER measurement, and even when more than one measure was used the approach was typically of the same type (e.g., two self-reports). A single-method approach increases the risk of common method variance contamination, especially in cross-sectional research (Lindell & Whitney 2001). Furthermore, the small number of ASD studies using an experimental design has generally focused on reappraisal only (Pitskel et al.

2014; Richey et al. 2015; Samson et al. 2015b); other strategies that are important predictors of outcomes, such as acceptance of negative emotions and savoring of positive emotions, have not been examined. Therefore, future research investigating ER in individuals with ASD should leverage a wider variety of measures known to target ER processes.

Another observation worth noting is the gender effects in ER. In the general population, gender differences in ER strategy use have been reported (John & Gross 2004; Silk et al. 2003; Tamres et al. 2002). One recent study reported that females engaged in more social support seeking strategies and dysfunctional rumination whilst males employed more passivity, avoidance, and suppression strategies (Zimmermann & Iwanski 2014). In ASD research, with the exception of two studies, most of the other studies focusing on ER had samples with mostly male participants (see Table 1), reflecting the increased prevalence of ASD in males. These gender distributions in ER are unlikely to influence the majority of comparative findings on strategy use between ASD and TD groups as most studies have used gender-matched groups. The only exception is the finding around approach and avoidant coping, as described in the previous section. However it will be important in future research to determine if there are similar gender differences in ER strategy use between males and females with ASD as those found in the general population.

It has been found that the regulation of positive affect is as important as negative affect regulation in predicting wellbeing (Bryant 2003; Gable et al. 2004; Quoidbach et al. 2010; Raes et al. 2012). However, with the exception of two studies, there remains a lack of research on the up-regulation of emotions and regulation of positive affect in ASD. Samson et al. (2015) found that both children and young adults with ASD experienced less amusement (in line with the results from other

studies, see Samson, 2013, for a review), portrayed fewer attempts to regulate amusement, and were also less effective at regulating their positive emotions. A second study found that individuals with ASD had impaired ability to up-regulate activity in the Nucleus Accumbens, when instructed to up-regulate positive emotions (Richey et al. 2015). The Nucleus Accumbens is one of the key structures in the reward circuitry previously implicated as having a role in the conscious increase in positive affect (Grace et al. 2007). So far, no study has examined positive ER strategies in ASD, specifically savoring, positive rumination, and positive sharing, or examined the relationships of these strategies with internalizing and externalizing symptoms. A reduced use of strategies that promote positive affect in individuals with ASD, alone or in combination with the greater use of maladaptive strategies, and the absence/lower use of adaptive strategies to regulate negative affect, may lead to increased rates of psychopathology in this population. We propose that in order to fully understand the impact of ER on short- and long-term mental health and life outcomes in ASD, it is important to assess the regulation of *both* positive and negative affect.

Although it is clear that co-occurring mental health problems are more frequent in ASD than in general population, it is currently less clear whether these problems in ASD, in particular anxiety and depression, are conceptually identical as in non-ASD population (Kerns & Kendall 2012; Mazefsky et al. 2012; Ollendick & White 2012). It is important to disentangle whether symptoms of anxiety and depression in ASD are: 1) a consequence of the same processes that underpin their development and maintenance in the general population (i.e., shared processes), 2) processes that might be unique to ASD such as, for example, impairments in understanding intentions and emotions in others (unique processes), or 3) a

combination of both shared and unique processes. Both Mazefsky et al. (2012) and Rodgers et al. (2016) have observed a pronounced overlap between the symptoms of ASD and mental health conditions. For example, social avoidance, a common symptom of anxiety, can also be a manifestation of the ASD social impairment. Therefore, core ASD symptoms can be wrongly attributed to anxiety. The reverse can also occur; individuals with ASD often present with idiosyncratic mental health symptoms such as unusual specific phobias (e.g., vacuum cleaners, toilets) and fears of change or novelty (Kerns & Kendall 2012; Uljarević et al. 2017), and these anxiety symptoms could be wrongly ascribed to core symptomatology, leading to missed anxiety diagnoses. Therefore, as Mazefsky et al. (2014) argued, in order to gain greater clarity about the role of ER in ASD, better understanding of how co-occurring mental health conditions should be conceptualized and assessed is also needed.

Finally, an important area of ER research in ASD is identifying factors that lead to emotion dysregulation. The extended process model of ER by Gross (2015) emphasizes the importance of emotional self-awareness, or alexithymia, which refers to difficulty in identifying and labeling one's own emotions. Lane et al. (1997) suggested alexithymia occurs when the environment triggers an emotional response and there is an impoverished conscious experience of the emotion. Alexithymia has been shown to be associated with poorer ER across normative populations and individuals with a range of psychiatric and neurodevelopmental conditions. For example, a neuroimaging study found that increased awareness of emotional state reduces emotional arousal (Herwig et al. 2010). These findings suggest that poorer emotional self-awareness can lead to increased arousal, which can have negative long-term effects on mental health. This suggestion is supported by research in clinical populations showing that: a) individuals with generalized anxiety disorder and

lower levels of mindfulness had higher levels of ER difficulties (Roemer et al. 2009), and b) individuals with schizophrenia displayed deficits identifying and describing emotions, and used less cognitive reappraisal and more suppression when compared to controls (Kimhy et al. 2012).

Overall, it has been argued that individuals with ASD show heterogeneity in emotional competence, and that the emotional impairments observed in ASD are due to alexithymia (Bird & Cook 2013). Reduced emotional self-awareness may present obstacles in the ability of individuals with ASD to understand and regulate difficult emotions and, as a consequence, impair psychosocial functioning (Hill et al. 2004). Empirical research indicates there are increased levels of alexithymia in ASD compared with TD individuals (Berthoz & Hill 2005; Hill et al. 2004; Maisel et al. 2016; Rieffe et al. 2007; Rieffe et al. 2010; Samson et al. 2012; Tani et al. 2004), with the majority of these studies using the Toronto Alexithymia Scale (TAS-20; Bagby et al. 1994).

It has been argued that there are psychometric and conceptual issues associated with using the TAS-20, including the overlap between measures of negative affect and the TAS-20, as well as the validity of requesting individuals with emotional awareness difficulties to accurately report their ability to identify internal emotional states (Lane et al. 1997). However, the use of questionnaires does not automatically equate to an invalid measurement of alexithymia, since the use of questionnaires that attempt to capture the individuals' ability to be aware of emotions without self-appraisal can be useful and relevant. Measures such as the Levels of Emotional Awareness Scale (LEAS) developed by Lane et al. (1990), which uses hypothetical scenarios and captures the emotional responses to these scenarios, are able to provide greater insight into individuals' emotional awareness. Importantly,

research using performance-based tasks has also found that individuals with ASD have difficulties identifying their own emotions (Rieffe et al. 2007).

Research has consistently shown a positive relationship between alexithymia and increased affective symptoms in ASD (Hill et al. 2004; Maisel et al. 2016; Rieffe et al. 2010). However, only one study has examined the relationship between alexithymia and ER strategy use in ASD. Using the TAS-20, Samson et al. (2012) found that alexithymia does not account for differences observed in ER strategy use in ASD and TD samples; however, replication of these findings is required using a more valid measure of alexithymia such as the LEAS. Despite the high frequency of poor emotional self-awareness and its association with comorbid psychopathology in ASD, and evidence that poor emotional self-awareness is associated with problems in ER in non-ASD populations, the relationships between problems in emotional self-awareness, emotion dysregulation, and affective disorders in the ASD population have not been examined to date.

Emotion Regulation Interaction and Flexibility: A New Approach in ASD

Our objective in this section is to propose a framework that has previously been examined in non-ASD populations over the last few years, but one that is new to the ASD field. People have a repertoire of ER strategies that they can choose from to regulate their emotions, and this may result in two phenomena: 1) the use of maladaptive strategies may interact with adaptive strategies and this interaction may impact mental health outcomes; and 2) individuals have differing abilities to select strategies and implement them in context specific ways (i.e., to use ER strategies in a flexible manner). Indeed, Aldao and Nolen-Hoeksema (2012b) demonstrated the effect of interactions between adaptive and maladaptive strategy use on outcomes in a

large community sample by creating two composite scores for ER strategy, one for adaptive strategies and the other for maladaptive strategies and running a stepwise regression. They found that adaptive strategies had a negative association with a range of psychopathology symptoms including anxiety, depression and alcohol problems, but only when levels of maladaptive strategies were elevated. This combined approach may have more explanatory power in unraveling the mechanisms of affective disorders in ASD. In general, people spontaneously use a number of different strategies in a given situation, even in situations of short duration (Aldao & Nolen-Hoeksema 2013), and there is growing evidence that healthy adaptation involves the flexible use of strategies that are suitable for specific situational demands (Aldao & Nolen-Hoeksema 2012a; Sheppes et al. 2014).

We suggest the ER strategy interactions as well as flexible strategy use are important aspects of ER in ASD. The interactions between ER strategies are likely to be related to the higher prevalence of psychopathology observed in ASD. Some studies in ASD have included both adaptive and maladaptive strategies in one model to examine shared variance in predicting outcome variables (e.g., Rieffe et al. 2014). Due to the challenges of recruiting participants in clinical groups, most ER studies in ASD had relatively small sample sizes, which limit the capacity to achieve adequate power in interaction analyses. Findings from recent papers examining interactions between adaptive and maladaptive ER strategy use in ASD using approaches other than regression (Cai et al. 2018a; 2018b) suggest the higher use of an adaptive strategy might be a protective factor for psychological wellbeing in individuals who also highly use a maladaptive strategy. Future research can expand on the current findings by the detailed examination of how ER strategies interact using approaches

such as the one used by Aldao and Nolen-Hoeksema (2012b) and assessing the effects of flexible strategy use that are context specific.

In a review encompassing work from diverse areas including ER, mindfulness, personality psychology, and neuropsychology, Kashdan and Rottenberg (2010) provide evidence for the importance of psychological flexibility in mental health. They found that the main feature of mood and anxiety disorders is a stereotyped way of responding to situations, and proposed three key factors that impact psychological flexibility: executive functioning, default mental states, and personality configurations. Executive functions refer to a set of cognitive processes that guide thoughts and actions (Miyake & Friedman 2012), including working memory, attention shifting, and response inhibition (McRae et al. 2012). Cognitive reappraisal has been found to be associated with attention shifting and working memory but not response inhibition (McRae et al. 2012), and high-ruminators have more difficulty switching between internal representations in working memory (Beckwé et al. 2014).

Individuals with ASD frequently have difficulties in executive functions, specifically attention shifting, flexibility, and planning (Ozonoff & Jensen 1999; Rinehart et al. 2001). While older studies have found response inhibition and working memory to be intact in ASD (e.g., Ozonoff & Jensen 1999; Ozonoff & Strayer 2001), a more recent review of research concluded that these executive function components are indeed impaired in this population, and compensatory mechanisms exist to allow normative functioning (O'Hearn et al. 2008). It is thus likely that individuals with ASD have problems regulating their emotions in a flexible manner due to attention-shifting and working memory problems, as these have been found to be associated with reappraisal and rumination (Beckwé et al. 2014; McRae et al. 2012). However, despite the links between ER and executive functions shown in non-ASD populations,

no research to date has explicitly assessed mechanisms underlying the interplay between executive function and emotion dysregulation in ASD. Some of the studies discussed above have controlled for cognitive abilities (e.g., Jahromi et al. 2012; Samson et al. 2015b). However, as there are no strong correlations between intelligence quotient scores and executive functioning (Ardila et al. 2000; Welsh et al. 1991), future studies on ER should also examine executive functions.

Below, we draw on neurological observations to propose a relationship between ER and executive functions. Firstly, the brain regions subserving cognitive reappraisal (dorsomedial, dorsolateral, ventrolateral regions of prefrontal cortex; Buhle et al. 2014; Diekhof et al. 2011; Kalisch, 2009; Ochsner & Gross 2005; Ochsner & Gross 2008) and suppression (dorsal anterior cingulate cortex and dorsolateral, ventrolateral regions of prefrontal cortex; Goldin et al. 2007; see also Etkin et al. 2015) are activated during tasks tapping into attention, cognitive flexibility, response inhibition and working memory. These findings suggest that aspects of executive function and ER are supported by overlapping brain areas and networks (Logue & Gould 2014). Secondly, these regions show atypical patterns of activation in ASD across a range of executive function tasks (Minshew & Keller 2010; Schmitz et al. 2006; Shafritz et al. 2008; Kana et al. 2007), which may explain the deficits in cognitive reappraisal observed in ASD. Finally, research has shown there is less connectivity between frontal regions and the lower limbic brain in individuals with ASD (Samson et al. 2016), and during tasks involving down-regulation of negative emotions, there is decreased engagement of prefrontal regions and lack of amygdala down-regulation in ASD (Pitskel et al. 2014; Richley et al. 2016). It is apparent that these two separate streams of neurological research, one examining executive function and the other emotion regulation, are largely related. As

the brain structures involved in both sets of functions are atypical in ASD, these two areas of research should be considered together in future research in order to tease apart mechanisms underlying executive and ER dysfunction in ASD. Such an approach may assist in determining the role of cognitive flexibility in ER in ASD.

Summary

Emotion dysregulation is common in individuals with ASD and is associated with a wide range of mental and physical health outcomes. This commentary highlights the role of emotion dysregulation in ASD and its relationship with psychopathology. We suggest the habitual use of ER strategies identified to be adaptive and maladaptive for individuals without ASD may play a similar role for those with ASD, however further work is needed to confirm this. We highlight conceptual and methodological limitations and propose new directions for investigating ER in ASD, incorporating knowledge from other literatures on the role of flexibility in healthy adaptation, connections between flexibility and executive function deficits, the adaptive value of up-regulation of positive emotions, and the importance of emotional self-awareness.

Emotion regulation research in ASD is in its early days, and there is a strong imperative to unravel the mechanisms underlying emotion dysregulation in ASD. Apart from directly examining the relationships between ER and internalizing and externalizing problems, we can also infer the role that ER plays in the maintenance of these problems by studying the changes in symptoms post interventions that target ER. Although ER intervention research in ASD is still in its infancy, preliminary results from recent pilot studies are encouraging and indicate that ER intervention approaches including cognitive behavior therapy (Scarpa & Reyes 2011; Thompson et

al. 2015) and mindfulness-based intervention (Conner & White 2017) are feasible and effective, and can improve emotional acceptance, impulse control, negative reactivity, and internalizing and externalizing symptoms in both children and young adults. Research in non-ASD populations has also demonstrated the efficacy of ER intervention in reducing symptoms of mental health disorders (e.g., see Mennin & Fresco 2009). Notably, Fernandez et al. (2016) proposed that ER should be conceptualized as a separate domain in the Research Domain Criteria (RDoC) matrix (Insel et al. 2010), a dimensional framework developed for classifying mental disorders. It is important we continue to advance ER research in ASD through lessons learnt and ideas generated from research in other populations in order to develop evidence-based ER interventions for those with ASD to maximize their wellbeing.

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Table 1. Summary of research: ER and associated outcomes in ASD samples

Paper	ASD Sample	Age range in years	ASD Male (TD Male)	Cognitive function	Outcomes measured	Comparison with control group on outcomes	Regulation strategies		Comparison with control		Measure(s) used for capturing ER	Relationship to outcomes
							Adaptive	Maladaptive	Adaptive	Maladaptive		
Berkovits et al. 2017	108 children	4 – 7	82.4% (N/A)	Estimated FSIQ (WPPSI-III) *M* = 90.3 12% IQ below 70	Social and behavioral functioning	N/A – No control group	N/A – Employed measures do not capture ER strategy use		N/A		Parent-report ER Checklist (Shields & Cicchetti 1997) and Emotion Dysregulation Index (Samson et al. 2014b)	ER predicted social skills, internalizing and externalizing behaviors
Bruggink et al. 2016	121 adults	18 – 62	78.5% (78.5%)	N/A – No mention of cognitive ability	Anxiety and depression	Higher levels of anxiety and depression symptoms	Putting into perspective Positive refocusing Positive reappraisal Acceptance Refocus on planning	Self-blame Other-blame Rumination Catastrophizing	Less	More	Self-report Cognitive ER Questionnaire (Garnefski et al. 2001)	Adaptive strategies predicted anxiety, maladaptive strategies predicted both anxiety and depression
Cai et al. 2017	61 adolescents and young adults	14 – 24	70.4% (N/A)	No cognitive assessment conducted	Anxiety and depression	N/A – No control group	Cognitive reappraisal	Suppression	N/A		Self-report ER Questionnaire (Gross & John 2003)	ER ratio positively associated with anxiety and depression symptoms
Cai et al. 2018	121 adolescents and adults	14 – 79	50.4% (N/A)	No cognitive assessment conducted	Depression	N/A – No control group	Cognitive reappraisal	Suppression	N/A		Self-report ER Questionnaire (Gross & John 2003)	Both types of strategies predicted depression. Individuals with high suppression and low reappraisal scores expressed higher depressive symptoms than individuals with high use of both strategies
Jahromi et al. 2012	20 children	3 – 6	Not specified	Mental age (GCA) *M* = 57.59 months	N/A – No outcomes measured	N/A	Goal-directed action Alternative strategies Distraction Self-speech Social support Self-soothing	Vocal venting Physical venting Disruptive behavior Avoidance	Less	More	Experimental coding of coping strategies (Calkins et al. 1999; Eisenberg et al. 1996; Jahromi et al. 2009)	N/A
Jahromi et al. 2013	20 children	*M* = 5 (range not provided)	90.0% (Not presented – specified matched on gender)	Mental age (GCA) *M* = 57.59 months	Emotional and behavioral school engagement and pro-social peer engagement	Liked school less, no difference on school avoidance. Less emotionally engaged and less pro-social peer engagement.	N/A – Employed measure does not capture ER strategy use		No measure for strategy use. Found ASD children scored lower on overall emotion regulation		Parent-report ER Checklist (Shields & Cicchetti 1997)	ER predicted pro-social peer engagement

Paper	ASD Sample	Age range in years	ASD Male (TD Male)	Cognitive function	Outcomes measured	Comparison with control group on outcomes	Regulation strategies		Comparison with control		Measure(s) used for capturing ER	Relationship to outcomes
							Adaptive	Maladaptive	Adaptive	Maladaptive		
Konstantareas & Stewart 2006	19 children	3 – 10	63.2% (Not presented - specified matched on gender)	No mental age information. Individual DP II scores provided.	N/A – No outcomes measured	N/A	From least to most adaptive: 1. Physical objection 2. Crying/venting 3. Defending 4. Verbal objection 5. Doing nothing 6. Self-distraction 7. Directing situation 8. Engaging in alternative activity 9. Complying		ASD children used less adaptive strategies and a greater range of these strategies		Experimental coding of affect regulation strategies based on Grolnick et al.'s (1996) study	N/A
Mazefsky et al. 2014	25 children and adolescents	12 – 19	96.0% (95.7%)	FSIQ (WASI) *M* = 110 All above 80	Internalizing and externalizing problems and symptoms of anxiety and depression	Higher levels of psychopathology overall	Voluntary engagement	Voluntary disengagement Involuntary engagement Involuntary disengagement	Same	More	Self report Response to Stress Questionnaire (Connor-Smith et al. 2000)	Both types of strategies correlated with internalizing and externalizing symptoms
Nader -Grosbios et al. 2014	39 children	3 – 12	79.3% (N/A)	Intellectual efficiency (EDEI-R) *M* = 95.71	Social adjustment	N/A – No control group	N/A – Employed measure does not capture ER strategy use		N/A		Parent-report ER Checklist (Shields & Cicchetti 1997)	ER correlated with social adjustment
Pouw et al. 2013	63 children and adolescents	9 – 15	100.0% (100.0%)	IQ (WISC) No details provided	Depression symptoms	Higher levels of depression symptoms	Approach coping Avoidant coping (?)	Maladaptive coping	Same	Same	Self-report Coping Scale (Wright et al. 2010)	Both types of strategies predicted depression
Rieffe et al. 2011	66 children	9 – 12	87.9 % (88.1%)	IQ (WISC-R) *M* = 107 All above 90	Depression symptoms, somatic complaints, and worry/rumination	No significant difference on all outcome measures	Adaptive coping strategies (e.g., planning, acceptance)	Maladaptive coping strategies (e.g., catastrophizing and self-blame)	Less	Same	Self-report Cognitive ER Questionnaire for Kids (Garnefski et al. 2007)	Both types of strategies predicted somatic complaints and worry/rumination, only maladaptive strategies predicted depression
Rieffe et al. 2014	81 children and adolescents	9 – 14	89.0% (45%)	IQ indicator (two subsets of WISC) *M* = 11.18	Depression symptoms	Higher levels of depression symptoms	Approach coping Avoidant coping (?)	Worry/rumination	Less approach coping Same avoidant coping	Same	Self-report Coping Scale (Wright et al. 2010)	Both types of strategies predicted depression

Paper	ASD Sample	Age range in years	ASD Male (TD Male)	Cognitive function	Outcomes measured	Comparison with control group on outcomes	Regulation strategies		Comparison with control		Measure(s) used for capturing ER	Relationship to outcomes
							Adaptive	Maladaptive	Adaptive	Maladaptive		
Samson et al. 2012	27 adults	18 – 53	41.0% (41.0%)	No IQ information (assumed high functioning due to educational level)	N/A – No outcomes measured	N/A	Cognitive reappraisal	Suppression	Less reappraisal	More suppression	Self-report ER Questionnaire (Gross & John 2003)	N/A
Samson et al. 2015a	31 children, adolescents, and young adults	8 – 20	87.1% (75.0%)	FSIQ (SB-5) *M* = 100.94 Range = 64-129	Maladaptive behaviors encompassing both internalizing and externalizing problems	Higher levels of maladaptive behaviors	Cognitive reappraisal	Suppression	Self-report Less reappraisal Parent-report Less reappraisal	Self-report Less suppression Parent-report Same suppression	Self-report and parent-report ER Questionnaire (Gross & John 2003)	The low use of an adaptive strategy predicted maladaptive behaviors
Samson et al. 2015b	21 children, adolescents, and young adults	8 – 20	85.7% (72.7%)	FSIQ (SB-5) *M* = 103.33 All 80 or above	N/A – No outcomes measured	N/A	Problem solving Distraction Cognitive reappraisal Relaxation	Avoidance Suppression Venting	Less reappraisal Same amount for other strategies	More suppression Same amount for other strategies	Reactivity and Regulation Situation Task (adaptation of Carthy et al. 2010)	N/A
Samson et al. 2015c	32 children, adolescents, and young adults	8 – 20	90.6% (74.2%)	FSIQ (SB-5) *M* = 104.31 Range = 64-129	N/A – No outcomes measured	N/A	Problem solving Seeking social support Distraction Cognitive reappraisal Acceptance Exercise Relaxation	Avoidance Expressive suppression Repetitive behaviors	Self-report Overall less Parent-report Overall less	Self-report Less avoidance for anger and anxiety, same amount of expressive suppression and repetitive behaviors Parent-report More repetitive behaviors, less suppression for anxiety, same amount of avoidance	Self-report daily diaries Parent-report Emotion Regulation Interview (adapted from Werner et al. 2011)	N/A

Paper	ASD Sample	Age range in years	ASD Male (TD Male)	Cognitive function	Outcomes measured	Comparison with control group on outcomes	Regulation strategies		Comparison with control		Measure(s) used for capturing ER	Relationship to outcomes
							Adaptive	Maladaptive	Adaptive	Maladaptive		
Samson et al. 2016	18 children, adolescents, and young adults	8 – 20	88.9% (83.3%)	FSIQ (SB-5) *M* = 104.00 Range = Not provided	N/A – No outcomes measured	N/A	N/A – Employed measure does not capture ER strategy use		Strategy use was not measured. ASD individuals had more difficulties regulating emotions.		Self-Report Emotional Ability Scale (Freudenthaler & Neubauer 2005)	N/A
Swain et al. 2015	69 adults	17 – 27	71.0% (N/A)	IQ > 70 (eligibility criterion) however no details have been provided	Social anxiety	N/A – No control group	N/A – Employed measure does not capture ER strategy use		N/A		Difficulties in ER Scale (Gratz & Roemer 2004)	ER predicted social anxiety

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Title:
Emotion regulation in autism spectrum disorder: Where we are and where we need to go.

Date:
2018-07

Citation:
Cai, R. Y., Richdale, A. L., Uljarevi#, M., Dissanayake, C. & Samson, A. C. (2018). Emotion regulation in autism spectrum disorder: Where we are and where we need to go.. Autism Res, 11 (7), pp.962-978. https://doi.org/10.1002/aur.1968.