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A systematic review of emotion regulation in children with Autism Spectrum Disorder

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) has significant negative impacts on a child's development as well as their family's social, emotional, and economic wellbeing. In an effort to better understand the aeitology of ASD and therefore provide interventions for children on the autism spectrum, various factors have been taken into consideration, one of which is emotion regulation (ER) ability. This paper sought to synthesize the current research on ER in children, specifically young children (aged 12–72 months), with ASD to better understand the association between ASD and ER in young children.
Method: Research databases and reference lists of relevant papers were searched systematically for articles on ASD and ER in young children. Fifteen articles were identified that reported on ER in children with ASD and had participants that fell within the 12–72 month age range. These articles were systematically reviewed.
Results: Children with ASD were found to have a different repertoire of ER strategies and rely more on others to regulate their emotions than their typically developing peers; ASD symptom severity and executive functioning ability were associated with ER abilities; and treatments incorporating both parents and children were found to improve ER abilities in children.
Conclusions: Research on ER in young children with ASD is in its infancy with many of the studies reviewed being preliminary in nature. Furthermore, the majority of studies include participants that encompass a broad age range, making it difficult to distinguish the nature and occurrence of ER in toddlers and preschoolers with ASD from ER in older children and adolescence with ASD. Nonetheless, the review provides some insight into the nature of ER in young children with ASD and highlights important directions for future research.

1. Introduction

Autism Spectrum Disorder (ASD), a neurodevelopmental disorder characterized by social and communication impairments as well as restricted, repetitive behaviors, interests and/or activities, affects approximately one in 59 children worldwide (Baio et al., 2018). In addition to being on the autism spectrum, children with ASD are also at an increased risk of being diagnosed with an intellectual disability and/or a language disorder (American Psychiatric Association, 2013; Charman et al., 2011; Loomes, Hull, & Mandy, 2017).

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The difficulties associated with ASD and related neurodevelopmental disorders increase the likelihood of these children developing comorbid mental health conditions (Simonoff et al., 2008), with approximately 70 percent of children with ASD presenting with at least one, and up to 57 percent presenting with multiple, co-morbid mental health disorders (Simonoff et al., 2008). This is concerning given that children with ASD and comorbid mental health issues have been found to have poorer adaptive and global functioning when compared to children with ASD without a comorbid mental health difficulties (Chiang & Gau, 2016). In addition to having a negative impact on a child's functioning, the development of a co-morbid mental health condition is likely to increase the social, emotional, and economic costs already experienced by families with children on the autism spectrum (Benson & Karlof, 2009; Järbrink, Fombonne, & Knapp, 2003). In an effort to better understand the aeitology of ASD and therefore provide interventions for children on the autism spectrum, various factors have been taken into consideration, one of which is emotion regulation (ER) ability.

1.1. What is emotion regulation?

ER has been defined as the capacity to monitor, evaluate, and modify (increase or decrease) one's emotional state in order to achieve a goal (Gross, 2013; Thompson, 1994). ER involves both intrinsic and extrinsic processes (Gross, 2013). Intrinsic ER refers to an individual's capability to regulate their own emotions (e.g., using strategies such as self-soothing, self-talk) while extrinsic ER refers to situations in which an individual's emotions are regulated by an external person (e.g., an infant being soothed by their caregiver through hugs; Gross, 2013). The development of ER begins during the first months of life as infants learn to attain physiological balance (Cicchetti, Ganiban, & Barnett, 1991). Although infants are born with several reflexes that help them reduce physiological discomfort (e.g., sucking, head turning) they rely on caregiver support to regulate their arousal and emotional states (Cicchetti et al., 1991). During these early months, infants express their needs to others through different sates of affect; caregivers learn to interpret these emotional states and respond to their child's needs (Cicchetti et al., 1991). The interactions that infants experience with their caregivers during these early months of life play an important role in aiding the maturation and development of the brain structures that help infants learn to regulate their emotions (Cicchetti et al., 1991). These early experiences with the caregiver are also believed to form the basis of the caregiver-child attachment relationship. Children who have caregivers who are consistently available, sensitive, and responsive to their needs are more likely to develop a secure attachment to their caregiver (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1969). As infants grow and develop, moving from infancy to toddlerhood (18–36 months), their ability to intrinsically regulate their emotions improves (Gross, 2013). Toddlers who are able to intrinsically regulate their emotions respond to emotionally arousing situations in socially appropriate ways while those with emotional dysregulation tend to show excessive emotional reactivity or emotional deficits (Cole, Michel, & Teti, 1994). Common intrinsic ER strategies observed in toddlers include engaging in self-soothing behaviors, avoiding tasks, and self-distraction (Nuske et al., 2017). Although intrinsic ER begins in toddlerhood, caregivers continue to play a vital role in helping to facilitate the ER process throughout toddlerhood, childhood and adolescence, adjusting the strategies they use depending on their child's needs (Cicchetti et al., 1991).

1.2. Measuring emotional regulation

Several methods for assessing ER abilities have been developed, including self-report, informant report, naturalistic/observational, and physiological measures (Weiss, Thomson, & Chan, 2014). Observational measures are a frequently utilized method for assessing ER in children. They often involve placing a child in a situation that evokes emotions of frustration, anger, or fear (e.g., preventing them from attaining a desired object by placing the object in a locked box; Goldsmith & Rothbart, 1999; Weiss et al., 2014). The behaviors that children demonstrate during these tasks are coded for ER strategies (Goldsmith & Rothbart, 1999). Observational methods are popular as they allow researchers to objectively assess ER (Weiss et al., 2014). A limitation, however, of observational methods is that they are time consuming to administer and code and they may not necessarily be reflective of behaviors that occur in a naturalistic environment such as the family home (Gardner, 2000). Due to the disadvantages of observational measures, researchers often opt to use informant-report and self-report measures. Informant- and self-report measures are advantageous as they are quick to administer and easy to score; but they are limited by reporting biases including socially desirable responding or extreme responding (Paulhus & Vazire, 2007). Physiological methods (e.g., heart rate monitor) have also been utilized in the assessment of ER; however, if used in isolation they are only able to assess one aspect of the ER process (Weiss et al., 2014). Thus, in order to capture all aspects of the ER process, the recommended approach is to utilize a combination of ER measures (Weiss et al., 2014).

1.3. Factors associated with emotion regulation in typically developing children

In typically developing (TD) children, poor ER has been linked with poorer academic achievement (Graziano, Reavis, Keane, & Calkins, 2007; Trentacosta & Izard, 2007); poorer language abilities (Eisenberg, Sadovsky, & Spinrad, 2005; Fujiki, Brinton, & Clarke, 2002); lower executive functioning (Jahromi & Stifter, 2008; Riggs, Jahromi, Razza, Dillworth-Bart, & Mueller, 2006); lower levels of physiological regulation (Calkins & Dedmon, 2000); and the development of internalizing and externalizing problems (Calkins & Dedmon, 2000; McLaughlin, Hatzenbuehler, Mennin, & Nolen-Hoeksema, 2011; Perry, Calkins, Dollar, Keane, & Shanahan, 2018; Rubin, Coplan, Fox, & Calkins, 1995; Totsika, Hastings, Emerson, Lancaster, & Berridge, 2011). Calkins and Dedmon (2000), for example, examined ER in 99 TD toddlers (aged 2 years) at high and low risk of externalizing behavior problems. The Child Behavior Checklist (CBCL) Aggressive and Destructive subscales (Achenbach, 1991) were used to identify children at risk of behavior problems (t-scores of 60 or greater indicated high risk and t-score 50 or below indicated low-risk) while physiological (i.e., heart rate) and observational measures (The Laboratory Temperament Assessment Battery (LAB-TAB); Goldsmith & Rothbart, 1993) were used to assess ER. The study found that toddlers at high risk of behavior problems displayed significantly and consistently lower heart rate variability (high heart rate variability has been associated with good developmental outcomes), more negative affect, and more emotional dysregulation than children in the low risk group.

Given that poor ER ability in TD children has been associated with poorer academic achievement and language abilities, lower levels of executive functioning and physiological reactivity, and externalizing and internalizing problems (Calkins & Dedmon, 2000; Fujiki et al., 2002; Graziano et al., 2007; Jahromi & Stifter, 2008), and that children with ASD are at an increased risk of having cognitive and language deficits as well as developing externalizing and internalizing problems, increased understanding of ER in children with ASD could lead to significant improvements in treatment development and thus overall wellbeing in this population. As early intervention models such as Early Intensive Behavior Intervention (empirically supported intervention used to treat skills deficits in children with ASD; Granpeesheh, Tarbox, & Dixon, 2009; Howlin, Magiati, & Charman, 2009) have been shown to lead to the greatest improvements for children on the autism spectrum (Hartley, Sikora, & McCoy, 2008), investigating ER in young children (i.e., toddlers and preschoolers) with ASD would be beneficial as it has the potential to provide support for incorporating strategies that target ER development into early intervention models.

To date, several studies have investigated ER in young children and two narrative reviews have summarized the literature on ER in individuals with ASD (Cai, Richdale, Uljarevic, Dissanayake, & Samson, 2018; Mazefsky et al., 2013). The first review, conducted by Mazefsky et al. (2013), concluded that ER manifests differently in persons with ASD compared to TD individuals. The review was, however, conducted prior to the majority of studies on ER and young children with ASD being published, such as Hirschler-Guttenberg, Golan, Ostfeld-Etzion, and Feldman (2015); Nuske et al. (2017) and Samson et al. (2014), and so does not represent current knowledge in the area. The second review, conducted by Cai et al. (2018), found that compared to TD individuals, children, adolescents and adults with ASD experience more ER difficulties, use less effective ER strategies and show maladaptive patterns of strategy use. Unfortunately, the Cai et al. (2018) review was not systematic in nature and so several relevant studies on ER in young children, such as Guo, Garfin, Ly, and Goldberg (2017) and Valentovich, Goldberg, Garfin, and Guo (2018), were not included. Furthermore, as the focus of the previous reviews was to summarize all existing literature on ER in ASD, neither review provided an in-depth analysis of the literature on the associations between ER and cognitive capabilities, language, executive functioning, physiological reactivity or externalizing and/or internalizing problems (factors found to be associated with ER in TD children). Finally, as neither review focused specifically on young children, neither examined co-regulation between children with ASD and their caregivers. As co-regulation (extrinsic ER) is an important developmental precursor to the development of intrinsic ER and is qualitatively different to the intrinsic ER abilities typically seen in older children, it is pertinent that a review of literature on extrinsic ER in toddlers and preschoolers with ASD is undertaken.

1.4. Aims

This systematic review aimed to examine the literature on ER in young children (aged 12–72 months) with ASD in order to provide a synthesis of the current research, to increase our understanding of the association between ER and ASD in young children and identify gaps in the knowledge base. The review was focused on young children as a systematic review on focusing specifically on young children with ASD had not previously been conducted and information on ER development in this age group would provide valuable information for early intervention development. Although the focus of this review was on young children (toddlers and preschoolers) with ASD it is important to note that the majority of articles included in the review also included participants in their samples who were older than 72 months of age. The inclusion of articles that encompassed participants older than 72 months of age has implications for the interpretation of results. This issue is discussed further in the limitations section of this paper.

The systematic review aimed to address the following research questions:

- What is the nature and occurrence of intrinsic ER among young children with ASD?
- What is the nature and occurrence of extrinsic ER among young children with ASD?
- What factors are associated with ER young children with ASD?
- Are there available interventions targeted at improving ER development in young children with ASD?

2. Method

2.1. Search strategy

This review was based on systematic search of published literature available through December 2018 and conducted as per the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). Two search strategies were implemented to identify relevant studies. First, research databases PsychInfo, Medline, Embase, Scopus, and CINAHL were searched concurrently for entries containing any combination of the following terms in the Title, Abstract, or Keyword search fields: (1) “Autism” or “Autis*” or “Autistic Disorder” or “Autism Spectrum Disorder” or “Asperger’s Syndrome” or “Pervasive Developmental Disorder” and (2) “emotion* dysregulation” or “emotion* regulation” or “emotion* control” or “emotion* intelligence”. The searches were then limited to entries that were conducted on “human” subjects and published in an “English language”, “peer reviewed” journal. Second, the reference lists of articles selected for this review and the reference lists of non-systematic reviews previously conducted on the topic of ER and ASD (Mazefsky et al., 2013; Weiss et al., 2014) were searched manually.

2.2. Inclusion and exclusion criteria

The inclusion and exclusion criteria were determined prior to searches being conducted. Articles were included in the review if: (1) the target population had a diagnosis of ASD (Autism Spectrum Disorder, Autistic Disorder, Asperger’s Syndrome or Pervasive Developmental Disorder- Not Otherwise Specified); (2) the study sample included participants aged between 12–72 months; (3) ER (intrinsic or extrinsic) in the target population was assessed; and (4) the article was published in a peer-reviewed, English language journal. Articles were excluded if: (1) they were not available in English; (2) they were not data-based (e.g., books, theoretical papers, reviews); (3) they were unpublished dissertations/theses; or (4) the target population did not have a diagnosis of ASD.

2.3. Quality assessment and data analysis

The Cochrane Collaboration’s tool for assessing risk of bias (Higgins et al., 2011) and the Newcastle-Ottawa Scale (NOS; Wells et al., 2018) were used to assess the quality of the studies included in this review. The Cochrane Collaboration tool was employed for randomised control trials (RCT). The risk of bias in RCT’s is determined based on six sources: Random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other biases. Each outcome is assessed and assigned a rating of low risk (any bias present is unlikely to alter results seriously), unclear risk (bias raises some doubt about results), or high risk (bias may alter results seriously). These scores are then used to draw conclusions regarding overall risk of bias. Only one study in this review was an RCT and it was identified as having an overall low risk of bias (see Appendix A1).

The NOS (Wells et al., 2018), which has been endorsed by the Cochrane Collaboration as an acceptable tool for the assessment of non-randomized studies (Higgins et al., 2011), was used to assess the quality of cohort studies. For cross-sectional studies an adapted version of the NOS modified by Herzog et al. (2013) was utilized. The NOS quality scores are based on the selection of study sample, the comparability between study groups, and the assessment of outcomes (Herzog et al., 2013; Wells et al., 2018). Maximum scores of 9 and 10 can be awarded for cohort studies and cross-sectional studies, respectively. Cross-sectional studies that achieve scores of seven or greater and cohort studies that achieve scores of six or greater are considered to have a high methodological quality (Jones, Hassanien, Cook, Britton, & Leonardi-Bee, 2012; Orton, Cooper, Lewis, & Coleman, 2014). Nine out of a total of 11 cross-sectional

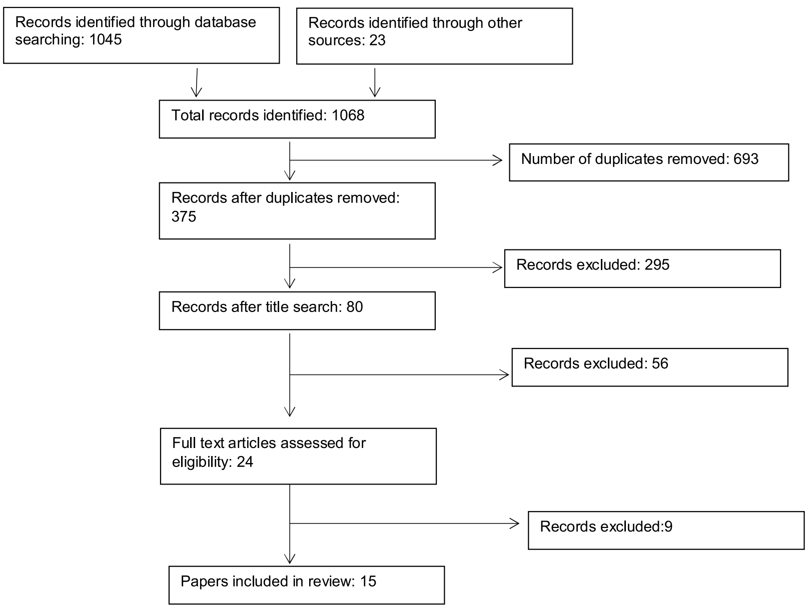

Fig. 1. Database search.

Table 1
Summary of articles included in review.

Authors	Comparison group	N	Age range (months)	Mean age (months)	ER measure	ASD measures	Other Measures
Goldsmith and Kelley (2018)	ASD only	145	60-204	147.6	Emotion Regulation Questionnaire	Autism Quotient	N/A
Valentovich et al. (2018)	ASD; TD	72	Not provided	ASD group: 63.24; TD group: 52.08	Three Boxes Procedure (observational/behaviour coding)	Broader Autism Phenotype Questionnaire	Vineland Adaptive Behaviour Scales
Fenning et al. (2018)	ASD only	46	48-132	76.68	5-min "locked box" independent frustration task (observational/ behaviour coding)	Autism Diagnostic Observation Schedule, second edition	Co-Regulation Task (observational, coded using); Stanford-Binet Intelligence Scales, Fifth Edition; Affective Q-Sensors (electrodermal activity measure)
Guo et al. (2017)	ASD; TD	73	Not provided	ASD group: 63.24; TD group: 52.08	Three Boxes Procedure (observational/behaviour coding)	Broader Autism Phenotype Questionnaire; The Social Communication Questionnaire; Autism Diagnostic Observation Schedule, second edition	N/A
Zantinge et al. (2017)	ASD; TD	69	ASD group: 43-79; TD group: 41-81	ASD group: 59.48; TD group: 55.57	Locked Box Task (observational/ behaviour coding)	Autism Diagnostic Interview-Revised; Autism Diagnostic Observation Schedule	Dutch Wechsler0 Nonverbal Scale of Ability; Wechsler Preschool and Primary Scale of Intelligence; Snijders-Oomen Nonverbal Intelligence Test; Mullen Scales of Early Learning; Behavior Dutch version of the Rating Inventory of Executive Function–Preschool version; The Flexibility scale of the Dutch BRIEF-P; The preschool version of the Social Skills Rating System; The Dutch version of the widely used Peabody Picture Vocabulary Test-III-NL; AcqKnowledge (physiological arousal measure)
Nuske et al. (2017)	ASD; TD	73	ASD group: 24-59; TD group: 24-61	ASD group: 40.89; TD group: 41.79	Laboratory Temperament Assessment Battery (observational/ behaviour coding)	Autism Diagnostic Observation Schedule, second edition; Social Communication Questionnaire	Mullens Scales of Early Learning; Behaviour System for Children, second edition; Child Emotion Wellbeing Scale; Self Development Questionnaire
Berkovits et al. (2017)	ASD only	108	48-84	68.40	Emotion Regulation Checklist; Emotion Dysregulation Index from Child Behavior Checklist	Autism Diagnostic Observation Schedule	Wechsler Preschool and Primary Scales of Intelligence, 3rd edition; Child Behavior Checklist 1½–5 and 6–18; Social Skills Improvement System; Comprehensive Assessment of Spoken Language; Social Responsiveness Scale
Costescu et al. (2016)	ASD; TD	81	ASD group: 60-132; TD group: 60-84	ASD group: 100.8; TD group: 64.6	Robot-enhanced induced tasks: false feedback technique (observational/ behaviour coding)	Autism Diagnostic Observation Schedule – Generic	N/A
Hirschler-Guttenberg et al. (2015)	ASD; TD	79	ASD group: 36-82; TD group: 29-79	ASD group: 58.47; TD group: 63.38	Mask (observational/behaviour coding); Puppets (observational/ behaviour coding)	Autism Diagnostic Observation Schedule, second edition; Childhood Autism Spectrum Test	Stanford-Binet Intelligence Scale; Parent–Child Free Play
Nader-Grosbois and Mazzone (2014)	ASD only	39	36-144	101.28	Emotion Regulation Checklist	Childhood Autism Rating Scale	Differential Scales of Intellectual Efficiency-Revised Edition; Bipolar Rating Scales Based on the Five Factor Model; Social Adjustment Scales

(*continued on next page*)

Table 1 (*continued*)

Authors	Comparison group	N	Age range (months)	Mean age (months)	ER measure	ASD measures	Other Measures
Samson et al. (2014)	ASD; TD	94	ASD and TD group: 72-192	ASD group:121.32; TD group 120	Emotion Dysregulation Index (EDI) using the Child Behavior Checklist	Autism Diagnostic Interview-Revised; Autism Diagnostic Observation Schedule	Kiddie-Schedule for Affective Disorders and Schizophrenia for School-Aged Children; Stanford Binet, 5th Edition; The Social Responsiveness Scale; The Repetitive Behavior Scale-Revised; The Short Sensory Profile
Jahromi et al. (2013)	ASD; TD	40	Not provided	ASD group: 58.95; TD group: 50.20	Emotion Regulation Checklist	Autism Diagnostic Interview-Revised; Social Communication Questionnaire	Preschool Language Scale 4; Differential Abilities Scale II; The Day/Night Task; Behavior Rating Inventory of Executive Function-Preschool Version; Joint engagement states and initiations task; Child Behavior Questionnaire–Short Form; School Liking and Avoidance Questionnaire; Teacher Rating Scale of School Adjustment; Child Behavior Scale
Jahromi et al. (2012)	ASD; TD	40	ASD group: 40-77; TD group: 33-78	ASD group: 58.95 (11.12); TD group: 50.20	Attractive toy in a transparent box task (observational/behaviour coding); Unsolvable puzzles task (observational/behaviour coding)	Autism Diagnostic Interview- Revised	Preschool Language Scale, Fourth Edition; Differential Ability Scales-11
Gulsrud et al. (2010)	ASD only	34	21-36	30.6	Distress episodes identified in videotaped interactions	Autism Diagnostic Interview- Revised; Autism Diagnostic Observation Schedule	The Parenting Stress Index; The Child Behaviour Checklist;
Konstantareas and Stewart (2006)	ASD; TD	42	ASD and TD group: 36-120	ASD group: 73.92; TD group: 76.44	Affect Regulation Manipulation (observational/behaviour coding)	The Childhood Autism Rating Scale	The Children's Behavior Questionnaire; The Developmental Profile II

Note: ASD = Autism Spectrum Disorder; TD = Typically developing.

studies were assessed as having high methodological quality while the remaining two studies were assessed to have low to moderate methodological quality (see Appendix A2). Results of studies assessed as having low to moderate methodological quality were interpreted with caution. All cohort studies were assessed to have high methodological quality (see Appendix A3). A narrative review synthesis was employed to analyse the articles chosen for the review and to ensure that all research studies exploring ER in children with ASD (aged 12–72 months) would be captured.

3. Results

The initial database search resulted in a total of 1045 articles (294 from PsychInfo, 122 from Medline, 254 from Embase, 276 from Scopus, and 99 from CINAHL) and an additional 23 articles were identified through reference list searches (see Fig. 1). After duplicates were excluded a total of 375 articles remained. A further 295 articles were excluded based on title screening, resulting in 80 articles. The abstracts of the remaining 80 articles were reviewed and 56 were excluded on the basis that they did not meet inclusion criteria. The remaining 24 articles were read in-depth with a further 9 articles excluded as they did not meet inclusion criteria. The remaining 15 articles met inclusion criteria and were included in the current review (see Table 1 for list of studies, including measures used to asses for ER and ASD). One study was conducted in Australia, one in the Middle East, four in Europe, and nine in North America. Two reviewers (SC and NC) screened all article titles and abstracts and completed the quality assessment of all articles included in the review. Disagreements regarding study selection and quality assessment were discussed and resolved. A third reviewer (JK) was available in case any disagreements could not be resolved by the primary reviewers.

3.1. Intrinsic emotion regulation in ASD

The systematic review identified eight studies that investigated differences in intrinsic ER between children with and without ASD (Costescu, Vanderborght, & David, 2016; Hirschler-Guttenberg et al., 2015; Jahromi, Meek, & Ober-Reynolds, 2012; Jahromi, Bryce, & Swanson, 2013; Konstantareas & Stewart, 2006; Nuske et al., 2017; Samson et al., 2014; Zantinge, Rijn, Stockmann, & Swaab, 2017). Two studies (Jahromi et al., 2013; Samson et al., 2014) utilized informant report questionnaires and six employed observational/behavior coding measures (Costescu et al., 2016; Hirschler-Guttenberg et al., 2015; Jahromi et al., 2012; Konstantareas & Stewart, 2006; Nuske et al., 2017; Zantinge et al., 2017).

3.1.1. Informant report

Jahromi et al. (2013) used the Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997) to examine ER in children with and without ASD. Their sample included 20 children with high-functioning ASD (*M age* = 54.57 months; 36 males, 4 females), recruited through services for families with children with ASD, and 20 age- and gender- matched TD children (*M age* = 58.95 months), recruited through university-based preschools. The ERC is a 24-item parent report questionnaire that provides two scales: Negativity/lability (i.e., expression of negative affect) and ER (i.e., modulation of emotional expression). Parents were required to indicate on a 4-point Likert-type scale (*rarely* to *almost always*) how often their child exhibited certain behaviors. The study findings showed that children with ASD had significantly lower ER ability as well as decreased school and peer engagement when compared to the control group.

Samson et al. (2014) also employed a parent-report questionnaire to compare emotion dysregulation in children with and without ASD (ASD group: *range* = 72–192 months; *M age* = 121.32 months; TD group: *range* = 72–192 months; *M age* = 120 months).The sample was comprised of 56 children (47 males, 9 females) with ASD, recruited through specialized ASD and developmental disability clinics as well as a research registry, and 38 TD children, recruited through advertisements in areas with similar socioeconomic status of the ASD participants. The study utilized the CBCL (Achenbach, 1991) to derive an emotion dysregulation index (EDI). The EDI was comprised of 18 items which represented various internalizing and externalizing behaviors. The results indicated that children with ASD scored significantly higher on emotional dysregulation than the control group. Although both Jahromi et al. (2013) and Samson et al. (2014) were able to determine that children with ASD show significantly lower ER and higher emotional dysregulation than TD controls, neither study provided details on the qualitative differences (i.e., differences in strategies use to regulate emotions) in ER between children with and without ASD.

3.1.2. Observational/ behavior coding

A study by Konstantareas and Stewart (2006) was the first to assess ER in children with ASD (*range* = 36–120 months; *M age* = 73.92 months) using observational measures. Their sample was comprised of 19 children (7 female, 12 male) with ASD, recruited from local chapters of the Autism Society of Ontario, and 23 age- and gender- matched TD children (*range* = 36–120 months, *M age* = 76.44 months, recruited from daycare centers, schools, and through newspaper ads. ER was examined using a frustration task, adapted from Grolnick, Bridges, and Connell (1996)) study of ER in two-year old children, which required a child handing back a highly attractive toy to the examiner several seconds after the child was given the toy to play with. Two trials of the task were administered with different, but equality attractive, toys. The behaviors displayed by the child within a 15-second period after being asked to return the toy to the examiner were used to code ER. The study's findings showed that for Trial 1 children with

ASD engaged in significantly less adaptive ER strategies (e.g., hiding objects) compared to the control group who were more likely to either attempt to direct the situation or comply, however, in Trial 2 no significant differences between groups were observed. An important factor to consider when interpreting these results is that the Levene's test for equality of variances was significant, with the experimental group showing more variability than the control group. Thus, it cannot be assumed that all children with ASD in Trial 1 employed lower level ER strategies given that some employed more effective strategies. Another factor to keep in mind is that the ER strategies employed by both groups were mostly adaptive suggesting that the frustration task might not have been adequate in inducing frustration.

Jahromi and colleagues (2012) also employed observational measures to assess ER in children with ASD and compare outcomes to TD children (ASD group: *range* = 40–77, *M age* = 58.95 months; TD group: *range* = 33–78, *M age* = 50.20 months).Their sample consisted of 20 children with, and 20 children without ASD recruited from university-based preschools and services for families with children with ASD. Two tasks were utilized to assess ER: 1. Attractive toy in a transparent box task and 2. Unsolvable puzzle task. The attractive toy in a transparent box task (Goldsmith & Rothbart, 1999) involved children choosing one of two toys presented to them to play with, once the toy was chosen the experimenter took the toy, locked it in a clear box and provided the child with keys that could not open the box. During the first two minutes of the task a parent remained in the room completing questionnaires and responded to their child's pleas for help with "I'm busy right now". During the last minute of the task the parent was asked to leave the room, leaving the child alone to continue trying to open the locked box. The unsolvable puzzle task (Smiley & Dweck, 1994) involved presenting children with three puzzles, two of which were "unsolvable". Children were given 2.5 min to work on each unsolvable puzzle. The behaviors engaged in by the children during each task were for ER coded in 10 s intervals. The study found that children with ASD were significantly more likely to display less persistence (i.e., higher levels of resignation), use more negative and fewer positive/neutral vocalizations, and use more venting and avoidance strategies when faced with frustration than TD children. Furthermore, engagement in social support (orientation/ verbalizations to examiner) strategies led to increased persistence (i.e., decreases in resignation) for TD children but not children with ASD while venting and distraction strategies led to significant decreases in facial/bodily negativity for both groups but significantly more so for non-ASD than ASD children. These findings suggest that when faced with a frustrating situation, children with ASD employ different ER strategies than children without ASD and the strategies employed by children with ASD appear to be less effective at regulating emotions than those employed by their TD peers. An important factor to take into consideration when interpreting these results is that Jahromi et al. (2012) sample was comprised of children with high-functioning ASD and therefore these results may not be representative of the entire ASD population. The impact of ASD symptom severity on ER will be discussed in detail in the following sections.

ER in children with ASD was further assessed by Hirschler-Guttenberg et al. (2015) using a cohort of 40 children with ASD (*range* = 36–82, *M age* = 58.47; 35 males, 5 females) and 40 without ASD (*range* = 29–79, *M age* = 63.38; 34 males, 6 females), recruited through psychiatric clinics and special-needs Kindergartens (no information was provided on where TD group was recruited from). Unlike previous studies, Hirschler-Guttenberg et al. (2015) coded ER in response to fearful and positive situations, rather than frustrating situations, and in the presence of mothers and fathers separately. Furthermore, ER was evaluated in a naturalistic environment (child's home) rather than a laboratory setting. Two home visits were undertaken within the same month in order to assess ER with both mothers and fathers separately. The ER tasks involved Masks (fearful) and Puppets (positive; Goldsmith & Rothbart, 1996).The Masks task required that the parent and child sit in front of the experimenter, who put on four masks likely to elicit increasing fear (i.e., rabbit, lion, alligator, and monster), wearing each mask for 15 s. The Puppets task involved the parent and child playing together with colorful hand puppets for five minutes. ER was coded based on the child's behavior during the tasks. The results showed that when compared to non-ASD children, children with ASD employed simpler ER strategies, such as avoidance, self-talk, and venting, to manage emotions.

Costescu et al. (2016) utilized a false feedback technique (Brenner, 2000) to assess ER in children with and without ASD (ASD group: *range* = 60–132 months; *M age* = 100.8; TD group: *range* = 60–132 months; *M age* = 64.6 months). Their sample included 41 children with ASD recruited from the Autism Baia Mare Association and Autism Transylvania Association (Romania), and 40 TD children recruited from a local kindergarten. The task involved presenting participants with several pictures which had a piece missing and asking them to find the missing piece of the picture from three possible options. Prior to beginning the frustration situation, children participated in five training trials during which they received accurate feedback on their performance. After the training trials, children received negative feedback on 10 trials regardless of their performance as a way of inducing negative emotions. To further evoke negative emotions, children were told that they could choose one of three possible prizes and then later told that they would only get the prize if they received positive feedback on the picture task. At the end of the task children were asked to name their emotions and rank the intensity of their emotions on a scale from 1 to 10. Expressions of anger and sadness were coded based on the child's facial expressions, vocalizations, and posture during the task. Emotions were also coded as functional or dysfunctional based on whether they were accompanied by maladaptive (behavioral distraction/avoidance, demands, aggression) or adaptive (approach for help, joint attention, seeking comfort) behaviors. The results showed that children with ASD experienced significantly more irrational beliefs and dysfunctional negative emotions and maladaptive behaviors than TD children. Interestingly, children with ASD continued to implement the same strategy (reasoning) during the entire task without trying alternatives, even though they continued to receive negative feedback compared to TD children who changed their strategy when they noticed that it was incorrect. Costescu et al. (2016) interpreted these findings as suggesting that children with ASD tend to be more rigid in their approach to solving tasks than TD children and suggested that this may contribute to the behavioral problems often observed in children with ASD. These results, however, like those of Jahromi et al. (2012) study, need to be interpreted with caution as Costescu et al. (2016) did not assess for ASD symptom severity in their sample thus it is difficult to determine whether their findings can be generalized to the entire ASD population. Furthermore, the authors do not provide information on whether the coders were blind to the ASD status of the children thus it is possible that their results may be impacted by coder biases.

ER in children with and without ASD (ASD group: *range* = 43–79 months, *M age* = 59.48 months; TD group: *range* = 41–81 months, *M age* = 55.57 months) was also examined by Zantinge et al. (2017). Their sample included 27 children with ASD (25 males, 2 females) recruited through the Autism and Developmental Disorders associations, and 44 TD children (35 males, 9 females) recruited through daycare centers, schools, and advertisements. Like Jahromi et al. (2012); Zantinge et al. (2017) utilized the locked box task (Goldsmith & Rothbart, 1999) to assess ER. Emotion coping strategies were coded based on the data gathered during the frustration task in 10 s intervals. Results indicated that children with ASD engaged in significantly fewer constructive strategies and significantly more venting and avoidance strategies when compared to the control group.

Nuske et al. (2017) also employed the attractive toy in transparent box tasks along with seven other tasks from LAB-TAB (Goldsmith & Rothbart, 1993, 1999) to assess ER in 44 children with ASD and 29 age- and gender- matched TD children (ASD group: *range* = 24–59 months, *M age* = 40.89, 32 males, 12 females; TD group: *range* = 24–61, *M age* = 41.79; 22 males, 7 females). ER strategies were coded based on behaviors displayed during the ER tasks. The results showed children with ASD did not differ from their TD peers when it came to the total number of regulatory behaviors employed, an effect that was seen both within and across tasks, and that the primary strategies used by both groups to regulate emotions were approach (i.e., task engagement) and behavioral distraction (i.e., shifting focus away from stress-related stimulus to engage with another object or another part of same object). Nonetheless, children with ASD were more likely to use familiar than unfamiliar people to regulate their emotion and to rely on others for comfort more than themselves when compared to non-ASD children. Nuske and colleagues (2017) argued that these results suggest that children with ASD employ developmentally delayed ER strategies, when compared to TD peers, indicating a delay in ER development, especially for strategies that facilitate a shift from co-regulation to self-regulation.

Taken together, these studies indicate that children with ASD experience greater ER difficulties (Jahromi et al., 2013; Samson et al., 2014), have a different repertoire of ER strategies, and the ER strategies employed tend to be simpler and less effective at ER than those utilized by TD children (Hirschler-Guttenberg et al., 2015; Jahromi et al., 2012). It has been suggested that the use of simpler ER strategies by children with ASD may be indicative of a delay in ER development (Nuske et al., 2017). Unfortunately, a limitation of the research exploring intrinsic ER is that none of above mentioned studies employed more than one measure to assess ER, as has been recommended by Weiss et al. (2014), and thus each study was only able to capture one aspect of the multifaceted ER process. Thus, future research exploring intrinsic ER in children with ASD would benefit from employing a variety of ER measures to assess ER in order to capture more components of the ER process as well as minimize the limitations (e.g., reporting bias; see above measures section for further limitations) associated with using only one type of measure when assessing a multifaceted process.

3.2. Extrinsic emotion regulation (co-regulation) in ASD caregiver-child dyads

Given the central role that caregivers play in facilitating the development of ER in children, especially during infancy and toddlerhood, examining the co-regulation of emotions in mother-child dyads is important. The review identified four studies that examined co-regulation in ASD mother-child dyads (Gulsrud, Jahromi, & Kasari, 2010; Guo et al., 2017; Hirschler-Guttenberg et al., 2015; Valentovich et al., 2018).

Gulsrud et al. (2010) were the first to look at co-regulation of emotions in mothers and their children with ASD. Their sample was comprised of 34 mother-child pairs recruited from United States. The children ranged in age from 21 to 36 months (*M age* = 30.6 months; 26 males, 8 females). ER was coded from distress episodes identified in videotaped interactions between mother and child. Distress episodes lasting longer than 30 s were coded in 10 s intervals for child negativity, child emotion self-regulation strategies (e.g., cognitive/ verbal self-soothing; physical self-soothing), and maternal co-regulation strategies (e.g., prompting/helping; physical and/or vocal comfort). Results showed that the children engaged in high rates of negativity during interactions with their mothers and that mothers engaged in a range of ER strategies during distress episodes; active (e.g., physical comfort), rather than passive, strategies (e.g., verbal explanations) were most frequently drawn upon during stressful times; and the children used a range of age appropriate ER strategies.

The second study to explore emotion co-regulation in parent-child ASD dyads and the first study to compare ASD parent-child dyads to TD parent child dyads (ASD group: *range* = 36–82 months; *M age* = 58.47 months; TD group: range = 29–79, *M age* = 63.38 months) as well as explore co-regulation with fathers as well as mothers was conducted by Hirschler-Guttenberg et al. (2015). Their results revealed that parents of children with ASD were comparable to parents of TD children in terms of sensitivity, responsiveness, and limit setting; however, children with ASD showed greater rates of withdrawal and displayed lower levels of enjoyment than TD children. Interestingly, findings also showed that during the ER fear paradigm parents of children with ASD employed simpler ER tactics (e.g., physical comforting) to manage their children's emotions; however, during the ER joy paradigm they used comparable numbers of complex ER strategies, while simultaneously using more simple ER strategies, compared with parents of non-ASD children. Like Gulsrud et al. (2010) findings, these results indicated that parents tend to use a variety of ER strategies and adjust the strategies they employ to meet their child's needs.

Guo et al. (2017) also examined emotion co-regulation in mother-child ASD dyads compared to mother-child TD dyads. Their sample was comprised of 47 ASD mother-child dyads (*M age* = 63.24 months; 35 males, 12 females) and 26 TD mother-child dyads (*M age* = 52.08 months; 17 males, 9 females) recruited from the United States. Emotional co-regulation was assessed using the Three Boxes Procedure (NICHD Early Child Care Research Network, 1999). The procedure involved providing mothers with three boxes containing age appropriate toys and then asking the mothers to play with their children as they normally would for ten minutes but open the boxes in numbered order. These interactions were coded in 5 s intervals for child emotion-engagement states (i.e., positive engagement; negative engagement; and disengagement) and mother emotion-engagement states (i.e., positive engagement; negative engagement; and disengagement). The study's results revealed that compared to TD mother-child dyads, ASD mother-child dyads spent more time in mismatched emotion-engagement states (e.g., child negative/mother positive), and exhibited greater flexibility in their emotional states. The highly flexible patterns of co-regulation in children with ASD indicate that they had difficulty sustaining a positive-engagement state but that positive states could be evoked during interactions with their mothers which has implications for treatments targeting improvement of emotional states in children with ASD.

Valentovich et al. (2018) also utilized the Three Boxes Procedure to examine emotional co-regulation in their sample of 72 mother-child dyads. Their sample was comprised of 46 children diagnosed with ASD (*M age* = 63.24 months; 34 males, 12 females) and 26 TD children (*M age* = 52.08; 17 males, 9 females). Similar to Guo et al.'s (2017) findings, Valentovich et al. (2018) found that ASD mother-child dyads displayed more emotional flexibility; engaged in emotional states for a shorter duration; and displayed greater maladaptive behaviors when compared to non-ASD dyads. Furthermore, for children with ASD dyadic-positive engagement moderated the relationship between dyadic flexibility and maladaptive behaviors. The association between ER and behavioral difficulties in young children with ASD will be discussed further in the following sections.

In summary, these studies findings suggest that the emotional states of children with ASD are highly variable and that they engage emotional states for shorter durations than their TD peer (Guo et al., 2017; Hirschler-Guttenberg et al., 2015; Valentovich et al., 2018). Furthermore, parents of children with ASD appear to utilize a wide repertoire of ER strategies, drawing upon different strategies based on the situation and their child needs (Gulsrud et al., 2010; Guo et al., 2017; Hirschler-Guttenberg et al., 2015; Valentovich et al., 2018). Interestingly, Gulsrud et al. (2010) and Guo et al. (2017) both found that during times of child distress parents of children with ASD, but not parents of TD children, tended to use simpler strategies, such as physical comfort, rather than complex strategies, such as verbal explanations, to help their children regulate their emotions. This finding provides support for the theory that children with ASD may be delayed in ER development (Nuske et al., 2017) and thus require simpler ER co-regulation strategies for a longer duration than TD children. Given the limited number of studies exploring co-regulation in ASD parent-child dyads further research needs to be undertaken to solidify the current findings. This is especially the case for father-child dyads as only one study to date has assessed co-regulation between children with ASD and their fathers (Hirschler-Guttenberg et al., 2015) and as fathers continue to take up more parenting responsibilities (Australian Institute of Family Studies, 2018) further research is needed to explore the role that fathers play in the development of ER in children with ASD.

3.3. Factors associated with emotion regulation in children with ASD

Factors that have been found to be associated with ER in children with ASD include: ASD symptom severity (Berkovits, Eisenhower, & Blacher, 2017; Fenning, Baker, & Moffitt, 2018; Goldsmith & Kelley, 2018; Konstantareas & Stewart, 2006; Nader-Grosbois & Mazzone, 2014; Samson et al., 2014); Intellectual Quotient (IQ)/Developmental Quotient (DQ) (Berkovits et al., 2017; Fenning et al., 2018; Jahromi et al., 2013; Konstantareas & Stewart, 2006; Nuske et al., 2017; Samson et al., 2014; Zantinge et al., 2017); language ability (Berkovits et al., 2017; Jahromi et al., 2012; Zantinge et al., 2017); executive functioning (Jahromi et al., 2013; Zantinge et al., 2017); physiological reactivity (Fenning et al., 2018; Zantinge et al., 2017); and externalizing/internalizing problems (Berkovits et al., 2017; Gulsrud et al., 2010).

3.3.1. ASD symptom severity

The review identified six studies that reported on the role that ASD symptom severity plays in ER regulation. Two studies (Goldsmith & Kelly, 2018; Samson et al., 2014) employed parent report questionnaires, while four employed observational measures (Fenning et al., 2018, Berkovits et al., 2017; Konstantareas & Stewart, 2006; Nader-Grosbois & Mazzone, 2014), to examine ASD symptom severity in children with ASD. Interestingly, studies that employed informant report questionnaires indicated an association between ASD symptom severity and ER, while the results of the observational studies were mixed.

3.3.1.1. Informant report. Samson and colleagues (2014) utilized three parent report measures to assess ASD symptom severity in children with ASD (*range* = 72–192 months; *M age* = 121.32). The measures included: The Social Responsiveness Scale (Constantino & Gruber, 2005), which assessed for social and communication deficits; The Repetitive Behavior Scale-Revised (Lam & Aman, 2007), which assessed severity of restricted repetitive behaviors, and; The Short Sensory Profile (McIntosh, Miller, & Shyu, 1999), which assessed sensory processing. The study's results indicated that emotional dysregulation, as measured by the EDI (Achenbach, 1991), was significantly correlated with ASD symptom severity, with greater use of restrictive and repetitive behaviors being the best predictors of emotional dysregulation in children with ASD.

Goldsmith and Kelley (2018) employed the Autism Quotient (AQ; Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008; Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006) to examine ASD symptom severity in their sample of 145 children and adolescents with ASD (*range* = 60–204 months; *M age* = 147.6 months; 111 males, 34 females; recruited through university labs, university lab databases, and ASD organizations). The AQ is comprised of 50 items which divide into five subscales: 1. Social skills; 2. Attention switching; 3. Attention to detail; 4. Communication; and 5. Imagination. ER was assessed using the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). The ERQ is comprised of 10 items with two subscales: 1. Suppression and 2. Reappraisal. The ERQ, usually administered as a self-report measure, was modified by the researchers to be suitable for parent reporting by replacing “I” with “My child”. Results indicated that higher scores on the reappraisal subscale of the ERQ significantly predicted lower scores on the AQ, suggesting that better ER abilities were associated with lower ASD symptom severity. In other words, children and adolescents with lower ASD symptom severity displayed significantly better ER abilities (i.e., reappraisal) than children and adolescents with greater ASD symptom severity.

3.3.1.2. Observational measures. Konstantareas and Stewart (2006) employed The Childhood Autism Rating Scale (CARS), a behavioral rating scale completed by an examiner based on observations made regarding the development (e.g., verbal and nonverbal communication) of the individual being assessed (Schopler, Reichler, DeVellis, & Daly, 1980), to evaluate ASD symptom severity in their participant sample (*range* = 36–120 months; *M age* = 73.92 months). Findings indicated that ASD symptom severity was not associated with ER abilities (assessed using a frustration task). Similarly, Nader-Grosbois and Mazzone (2014) used the CARS to assess ASD symptom severity in their sample of 29 children with ASD (*range* = 36–144 months; *M age* = 101.28 months; 23 males, 6 females) recruited from French-speaking Belgian special schools and psycho-medico-social institutions. To assess ER the French version of the ER Checklist (Shields & Cicchetti, 1997) was utilized. Consistent with Konstantareas and Stewart (2006) findings, Nader -Grosbois and colleagues (2014) results indicated that emotion dysregulation was not associated with ASD symptom severity.

The association between ASD symptom severity and ER using observational measures was further evaluated by Berkovits et al. (2017). Their sample consisted of 108 children with ASD (*range* = 48–84 months; *M age* = 68.4 months; 89 males, 19 females) recruited through community agencies, preschools and elementary schools, websites, and local ASD-specific events. ER was assessed using the ER checklist (Shields & Cicchetti, 1997) and EDI (Achenbach, 1991; Samson et al., 2014) while ASD symptom severity was assessed using the Autism Diagnostic Observation Schedule – 2 (ADOS-2; Lord et al., 2012), a semi-structured observational assessment that evaluates child behaviors related to language, play, repetitive behaviors, social communication, and restricted interests. In contrast to Konstantareas and Stewart (2006) and Nader-Grosbois and Mazzone (2014) findings, this study showed a significant correlation between ASD symptom severity and ER ability, with higher ASD symptomology associated with lower ER ability.

A recent study by Fenning et al. (2018) also employed the ADOS-2 to evaluate ASD symptom severity. Their sample was comprised of 46 children with ASD (*range* = 48–132 months; *M age* = 76.68 months; 37 males, 9 females) recruited from the community. Consistent with Berkovits et al. (2017) results, Fenning et al. (2018) findings showed a significant positive association between ASD symptom severity and emotion dysregulation (assessed using the locked box task ; Goldsmith & Rothbart, 1999).

The discrepancy between Berkovits et al. (2017) and Fenning et al. (2018) results and the results of Konstantareas and Stewart (2006) and Nader-Grosbois and Mazzone (2014) studies may be accounted for by differences in the observational measure employed to assess ASD symptom severity. The recommended administration time of the CARS is 10–15 min while the ADOS-2 takes between 40–60 min to complete. Thus, examiners utilizing the ADOS-2 observe the child for a longer period which allows them to gather more information on ASD symptomology than may be obtained from a 10–15 min observation. The use of different assessment tools may also account for the discrepancies between Samson et al. (2014) and Goldsmith and Kelley (2018) and Konstantareas and Stewart (2006) and Nader-Grosbois and Mazzone (2014) studies as parents may have a greater knowledge of their children’s ASD symptoms than can be ascertained from a 10–15 min observations, however, as previously discussed, parent-reports are also more susceptible to reporting biases (Paulhus & Vazire, 2007).Thus, future studies would benefit from administering both observational and parent report questionnaires concurrently to assess ASD symptom severity to increase the likelihood of obtaining true representations of participants’ ASD symptomology.

3.3.2. Intellectual quotient/ developmental quotient

Intellectual disability affects between 50–55 percent of individuals diagnosed with ASD, making it one of the most common co-occurring disorders with ASD (Charman et al., 2011; Loomes et al., 2017). Therefore, it is appropriate that intellectual and developmental abilities have been assessed to determine whether they play a role in ER difficulty in children with ASD. As with research examining associations between ASD symptom severity and ER, the literature on the relationship between intelligence and developmental ability and ER in children with ASD has produced mixed results.

3.3.2.1. Intellectual quotient. An individual’s intellectual ability is often represented by a score (i.e., IQ score) derived from their performance on standardized assessments. Konstantareas and Stewart (2006) were the first to examine the association between ER and IQ in children with and without ASD (ASD group: *range* = 36–120 months; *M age* = 73.92 months; TD group: *range* = 36–120, *M age* = 76.44 months). In their sample cognitive capabilities were assessed using the Academic subscale of the Developmental Profile II (DP II; Alpern, Boll, & Shearer, 1980). The DP II results were then used to determine participants’ academic age. The study findings showed that cognitive abilities were significantly positively associated with ER (assessed using a frustration task; Grolnick et al., 1996), indicating that higher cognitive abilities led to the use of more advanced ER strategies. Interestingly, when the data for each group (ASD versus control group) were analyzed separately, the effect appeared to only be relevant for the control group. That is, academic age did not predict ER ability in children with ASD, but it did for TD children.

Samson et al. (2014) also explored the association between IQ and ER in children with and without ASD (ASD group: *range* = 72–192 months; *M age* = 121.32 months; TD group: range = 72–192 months; *M age* = 120 months).The Stanford Binet, 5th Edition (SB5; Roid, 2003) was used to assess IQ. The SB5 produced a Full Scale IQ score (FSIQ) which represented the children's overall cognitive capabilities. Like Konstantareas and Stewart (2006), Samson and colleagues (2014) found no association between IQ and ER abilities (assessed using the EDI; Achenbach, 1991) in children with ASD. The mean of the FSIQ of children with ASD was, however, within the average range. The reduced variability in participants IQ scores could have impacted the ability to detect the effects of IQ on ER.

The association between ER and IQ in children with ASD (*range* = 48–84 months; *M age* = 68.4 months) was further examined by Berkovits and colleagues (2017). IQ was assessed using the abbreviated version of the Wechsler Preschool and Primary Scales of Intelligence, 3rd Edition (Wechsler, 2002) which produces an overall IQ score. Consistent with previous studies, Berkovits et al. (2017) found no association between children's IQ and ER ability (assessed using the ER checklist (Shields & Cicchetti, 1997) and EDI (Achenbach, 1991; Samson et al., 2014)). Like Samson et al. (2014) sample, most participants (88%) had an IQ score that fell within the average range, which may have impacted the ability to detect the effects of IQ on ER.

In Zantinge et al. (2017) study on ER in children with ASD (*range* = 43–79 months; *M age* = 59.48 months). IQ was assessed using the Dutch Wechsler Nonverbal Scale of Ability (Wechsler & Naglieri, 2006); the Wechsler Preschool and Primary Scales of Intelligence (Wechsler & Naglieri, 2006); the Snijders-Oomen Nonverbal Intelligence Test (Tellegen, Winkel, Wijnberg-Williams, & Laros, 1998); or the Mullen Scales of Early Learning (MSEL; Mullen, 1995). The raw scores on these assessments were added to produce an overall IQ score for each participant. In contrast to previous studies, Zantinge et al. (2017) found that for children with ASD, IQ was significantly positively correlated with ER (assessed using the locked box task; Goldsmith & Rothbart, 1999), with children with greater cognitive abilities using more effective ER strategies than those with lower cognitive abilities. Lower cognitive abilities were significantly correlated with the use of avoidance strategies.

The most recent study to explore the association between ER and IQ in children with ASD was conducted by Fenning et al. (2018). To assess IQ in their sample of children with ASD (*range* = 48–132 months; *M age* = 76.68 months), Fenning et al. (2018) employed the SB5 (Roid, 2003). Their results also indicated that there was no association between IQ and ER ability (assessed using the locked box task; Goldsmith & Rothbart, 1999) in children with ASD.

3.3.2.2. Developmental quotient. DQ is similar to IQ in that it refers to a score that is derived based on an individual's performance on a standardized assessment, but it represents an individual's development across a range of psychosocial competencies rather than just cognitive abilities. The association between DQ and ER in children with ASD has only been examined in one study. Nuske and colleagues (2017) employed the MSEL (Mullen, 1995) to determine the DQ in their participants (ASD group: *range* = 24–59 months, *M age* = 40.89; TD group: *range* = 24–61, *M age* = 41.79). The MSEL indicated that the sample was varied in ability level (52.3% low-functioning; 13.6% moderately functioning; and 34.1% high-functioning). The study's findings showed a positive association between DQ and the use of avoidance strategies in children with ASD, with greater avoidance correlating positively with lower DQ. The same effect was not seen in TD children.

In summary, there is some evidence that lower IQ/DQ scores in children with ASD are associated with the use of more avoidance strategies to regulate emotions (Nuske et al., 2017; Zantinge et al., 2017), however, the majority of studies found no link between IQ and ER in children with ASD, suggesting that IQ may not be a protective factor when it comes to ER development (Berkovits et al., 2017; Fenning et al., 2018; Konstantareas & Stewart, 2006; Samson et al., 2014). Although no association between IQ and ER was found in four out of five studies, two of these four studies (Berkovits et al., 2017; Samson et al., 2014) had reduced variability in IQ scores. This may have impacted the ability of these studies to detect the effects of IQ on ER. Thus, further research needs to be undertaken before any definitive conclusions regarding ER and IQ/DQ can be drawn.

3.3.3. Language ability

Language skills play an important part in social interactions and are thus thought be essential for ER development (Cole, Zahn-Waxler, Fox, Usher, & Welsh, 1996; Curtis, Kaiser, Estabrook, & Roberts, 2019). The systematic review identified three studies that examined the association between language ability and ER in children with ASD (Berkovits et al., 2017; Jahromi et al., 2012; Zantinge et al., 2017).

Jahromi et al. (2012) utilized the Preschool Language scale, fourth edition (PSL-4; Zimmerman, Steiner, & Pond, 2002) to assess language abilities in their sample of children with and without ASD (ASD group: *range* = 40–77, *M age* = 58.95 months; TD group: *range* = 33–78, *M age* = 50.20 months). The PSL-4, suitable for use with children from birth to 6 years and 11 months, assesses expressive and receptive language skills which are then used to derive an overall language age. The study's results indicated that there were no differences in the overall number of vocalizations expressed by children with and without ASD during the ER assessments (assessed using the attractive toy in a transparent box task; Goldsmith & Rothbart, 1999) and the unsolvable puzzle task

(Smiley & Dweck, 1994), however, children with ASD were found to express more negative and fewer positive/neutral vocalizations than TD children.

Berkovits et al. (2017) employed the Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999) to examine language abilities in their sample (*range* = 48–84 months, *M age* = 68.4). The standardized assessment, suitable for use with individuals aged 3–21 years, was administered orally to participants to assess Syntax (measuring grammatical and syntactical skills) and Pragmatic Judgment (measuring language use in social situations) abilities. The study's findings indicated that ER abilities in children with ASD were independent of language ability.

The association between language ability and ER was also assessed by Zantinge et al. (2017). Zantinge et al. (2017) administered the Dutch version of the Peabody Picture Vocabulary Test-III-NL (Schlichting, 2005) to assess receptive language skills and vocabulary in children with and without ASD (ASD group: *range* = 43–79 months, *M age* = 59.48 months; TD group: *range* = 41–81 months, *M age* = 55.57 months). The non-verbal multiple-choice assessment required that children pick one of four pictures that correspond with the examiner's stimulus word. The study's results indicated that language skills were significantly positively correlated with the use of constructive ER skills.

Taken together, these studies indicate that expressive language skills (use of Syntax and Pragmatic Judgment) appear not to be associated with ER abilities in children with ASD, while there is suggestive evidence that receptive language skills may be. Given the limited number of studies conducted in this area and that all studies have examined different aspects of language, further research needs to be undertaken to confirm the current findings.

3.3.4. Executive functioning

Executive functioning, the cognitive process responsible for planning, working memory, and inhibitory control, and its association with ER in children with ASD has been explored in two studies (Jahromi et al., 2013; Zantinge et al., 2017). The first study, conducted by Jahromi and colleagues (2013), used the Day/Night Task (Gerstadt, Hong, & Diamond, 1994) to assess inhibitory control in children with ASD (*M age* = 54.57 months). This task involved children saying "day" when shown a black card with a picture of a moon and "night" when shown a white card with a picture of the sun. Two practice trials were administered followed by 16 test trials in a fixed random order. Furthermore, the Inhibitory Self-Control Index of the Behavior Rating Inventory of Executive Functioning – Preschool Version (Gioia, Isquith, Guy, & Kenworthy, 2000) was used to assess parent's perceptions of their children's inhibitory control abilities. The scale required parents to report on a 3-point Likert-type scale (*never* to *often*) how frequently specific behaviors had been a problem for their children. Results indicated that executive functioning was positively associated with ER. That is, the greater the inhibitory control abilities of children with ASD, the better their ability to regulate their emotions. The second study was conducted by Zantinge et al. (2017) who also utilized the Behavior Rating Inventory of Executive Functioning – Preschool Version (Gioia, Espy, & Isquith, 2001) to assess inhibition in children with ASD (*range* = 43–79 months, *M age* = 59.48 months). Their results indicated that children with ASD had significantly more inhibitory control difficulties, and engaged in significantly less constructive ER strategies, when compared to TD children. Further research would benefit from focusing on assessing the role that emerging executive functioning plays in ER in toddlers (aged 12–24 months) with signs of ASD as executive functioning is still under development during toddlerhood and may not play as significant a role in ER.

3.3.5. Physiological reactivity

The systematic review identified two studies that examined the role of physiological reactivity in ER in children with ASD (Fenning et al., 2018; Zantinge et al., 2017). Interestingly neither study found an association between physiological reactivity and ER.

Zantinge et al. (2017) assessed the association between physiological reactivity and ER in children with and without ASD (ASD group: *range* = 43–79 months, *M age* = 59.48 months; TD group: *range* = 41–81 months, *M age* = 55.57 months). The study aimed to determine whether differences in ER between children with and without ASD were due to inadequate arousal responses. During the ER task (assessed using the locked box task; Goldsmith & Rothbart, 1999) physiological data (i.e., heart rate) was recorded continuously using AcqKnowledge (Version 4.3.1. BIOPAC Systems Inc.). Results revealed that there were no differences in arousal responses across groups during the ER task. Thus, the differences observed in ER across groups were not the result of differences in physiological reactivity. Physiological reactivity and its relation to ER in children with ASD (*range* 48–132 months, *M age* = 76.68 months) was further assessed by Fenning et al. (2018). Specifically, Fenning and colleagues assessed electrodermal activity using Affect Q-sensors (Picard, Fedor, & Ayzenberg, 2016). Consistent with the findings of Zantinge and colleagues (2017), results indicated that physiological reactivity was not significantly associated with emotional dysregulation (assessed using assessed using the locked box task; Goldsmith & Rothbart, 1999). Although results of both studies suggested that physiological reactivity is not associated with ER in children with ASD, both studies included only a small repertoire of physiological reactivity measures and thus may not have captured all physiological reactivity markers present during the ER task. Future research would benefit from including a larger repertoire of physiological reactivity measures in order to enhance the understanding of physiological processes that occur in children with ASD during task that require the implementation of ER strategies.

3.3.6. Externalizing and internalizing problems

Literature on TD children has found that ER deficits are associated with externalizing and internalizing behavior problems (Eisenberg et al., 2001; Zeman, Cassano, Perry-Parrish, & Stegall, 2006). Given that there is a strong association between ER deficits and externalizing/internalizing problems in TD children and that approximately 70% of children with ASD also experience co-morbid mental health conditions (Hartley et al., 2008), investigating the role that ER plays in externalizing/internalizing problems in children with ASD is important. It was therefore surprising that this review only identified two studies have explored the association between ER and externalizing/internalizing problems in toddlers and preschoolers with ASD.

A study by Gulsrud et al. (2010) was the first to examine the association between ER and maladaptive behaviors in 34 children with ASD (*range* = 21–36 months, *M age* = 30.6). The CBCL (Achenbach & Rescorla, 2000) was used to evaluate behavioral and emotional problems in their participant sample. Results revealed that externalizing and internalizing behaviors were positively associated with child and parent stress, however, no association was found between externalizing and internalizing behaviors and child ER (assessed from distress episodes identified in videotaped interactions between mother and child). Berkovits et al. (2017) also employed the CBCL (Achenbach & Rescorla, 2000) to assess behavioral problems in their sample of children with ASD (*range* = 48–84, *M age* = 68.40 months). In contrast to Gulsrud et al. (2010) findings, but consistent with research on TD children (Eisenberg et al., 2001; Zeman et al., 2006), the study's results revealed that higher ER ability, assessed using the ER checklist (Shields & Cicchetti, 1997) and EDI (Achenbach, 1991; Samson et al., 2014), was associated with lower externalizing and internalizing behavior problems. Furthermore, children with lower ER abilities showed worsening of internalizing and externalizing behavioral problems over a 1-year period.

3.3.7. Summary of factors associated with ER in children with ASD

Research exploring factors associated with ER in children with ASD has indicated that children with greater ASD symptom severity (Berkovits et al., 2017; Fenning et al., 2018) and lower executive functioning abilities (Jahromi et al., 2013; Zantinge et al., 2017) are likely to demonstrate less effective ER abilities. There has also been some evidence to suggest lower IQ/DQ in children with ASD is linked to the use of more avoidance strategies during ER tasks (Nuske et al., 2017; Zantinge et al., 2017); however, the majority of research on the association between IQ and ER in children with ASD has found no relationship between IQ and ER abilities (Berkovits et al., 2017; Fenning et al., 2018). Furthermore, it appears that receptive language, but not expressive language, may be associated with ER in children with ASD with better receptive language resulting in greater ER abilities (Berkovits et al., 2017; Jahromi et al., 2012; Zantinge et al., 2017). Interestingly, no differences in physiological arousal in children with and without ASD have been found, suggesting that the differences in ER abilities observed in children with ASD and non-ASD children may not be the result of differences in arousal levels (Fenning et al., 2018; Zantinge et al., 2017). Finally, research investigating the association between ER and externalizing/internalizing behavior problems in children with ASD is limited. Given that the only two studies on the association between ER and maladaptive behavior in children with ASD have produced conflicting results, further research is needed before definitive conclusions regarding the relationship between ER and externalizing/internalizing behaviors in children with ASD can be drawn.

3.4. Intervention

One study was identified that explored the effectiveness of an intervention aimed at improving ER in children with ASD. Gulsrud et al. (2010) conducted a randomized controlled trial to evaluate the impact of a mother-mediated joint attention intervention on ER in children with ASD. Participants were randomly allocated to waitlist or intervention group. The intervention was carried out 3 days a week for 8 weeks and focused on improving early joint attention, language skills, and joint engagement. The study's findings indicated that the 8-week intervention led to improvements in child ER as well as maternal co-regulation strategies.

4. Summary and future directions

In summary, results of this review suggest that young children with ASD appear to have poorer ER abilities compared to TD children, utilising simpler (e.g., avoidance) and less effective ER strategies during times of distress than their TD peers (Hirschler-Guttenberg et al., 2015; Jahromi et al., 2012). This finding is consistent with the results of the two previous narrative reviews conducted on ER in individuals with ASD (Cai et al., 2018; Mazefsky et al., 2013). Furthermore, young children with ASD appear to rely more on others to regulate their emotions (Nuske et al., 2017) than TD children; suggesting that ER development (i.e., a transition from extrinsic to intrinsic ER strategies) may be delayed in this population. Interestingly, the differences in ER between young children with and without ASD did not appear to be associated with differences in physiological reactivity. Factors that have been found to be associated with poorer ER abilities in children with ASD include ASD symptom severity (Berkovits et al., 2017; Fenning et al., 2018) and lower executive functioning (Jahromi et al., 2013), however, the majority of research has been conducted with populations over the age of 24 months thus the extent to which these factors influence ER in toddlers with signs of ASD is yet to be established. Interestingly, studies exploring the relationship between ER and IQ/DQ and language abilities (Nuske et al., 2017; Samson et al., 2014; Zantinge et al., 2017) and studies exploring the relationship between ER and externalizing/internalizing problems (Berkovits et al., 2017; Gulsrud et al., 2010) have produced mixed results, but given the limited number of studies conducted in these areas further research is required before any definitive conclusions can be drawn. In addition, research on co-regulation of ER in toddlers and preschoolers with ASD highlighted that caregivers of children with ASD are comparable to parents of TD children in terms of sensitivity, responsiveness and limit setting, indicating that child factors, compared to caregiver factors, may play a larger role in accounting for reduced ER abilities in children with ASD.

Notable gaps in literature include limited studies on co-regulation between fathers and children; few studies on the associated between ER and language abilities, ER and externalizing/internalizing problems, and ER and physiological reactivity; limited studies on ER intervention; and a limited number of studies utilizing multiple methods to assess ER. Thus, future work looking into the association between the ER and the above-mentioned factors, utilizing multiple methods to assess ER, is warranted.

4.1. Implications

The studies examined in this review have indicated that children with ASD have poorer ER abilities than their TD peers and that this may be indicative of a delay in ER development. Given the association between ER and externalizing/internalizing problems it is essential that treatments targeted at improving ER in children with ASD are available. As caregivers facilitate the role of emotional development in toddlers and preschoolers (Cicchetti et al., 1991) ER interventions that incorporate both caregiver and child are required.

4.2. Limitations

As the focus of the review was to assess ER in children with ASD aged 12–72 months the reviewers included all studies that reported on participants that were within the age range, however, several studies that were included in the review had some participants that just fell within the chosen age range and several participants over the age of 72 months which meant that the mean age of participants (see Table 1) in six studies was greater than 72 months (Costescu et al., 2016; Fenning et al., 2018; Goldsmith & Kelley, 2018; Konstantareas & Stewart, 2006; Nader-Grosbois & Mazzone, 2014; Samson et al., 2014). The inclusion of studies that had participants over the age of 72 months makes it challenging to distinguish the nature and occurrence of ER in toddlers and preschoolers with ASD from the nature and occurrence of ER in children with ASD who are in middle to late childhood and adolescence. The reviewers decided to include all studies that had participants that fell within the 12–72 month age range due to the small number of studies that have been conducted on ER in toddlers and preschoolers with ASD, however, it was beyond the scope of this paper to explore in detail ER and ASD in children and adolescence as well as toddlers and preschoolers. As more ER research with toddlers and preschoolers with ASD emerges a future review on ER in toddlers and preschoolers with ASD aged 72 months or younger would be beneficial.

A further limitation of this review was that inter-rater reliability for the quality assessment was not calculated. Although considerable effort was made to ensure the reliability of the quality assessment, the calculation of inter-rater reliability would have increased the confidence in the quality assessment outcomes (Gwet, 2014). Another limitation of this review was that authors failed to include the search terms “affect regulation”, “co-regulation”, and “Asperger*” in their database searches. To increase the chances of database searchers finding all articles related to ASD and ER it is recommended that future database searches in this area include the above-mentioned search terms, in addition to the search terms mentioned in the methods section, to their search criteria.

5. Conclusion

To conclude, to the best of our knowledge, this is the first systematic review to look at ER in toddlers and preschoolers with ASD. The review indicated that research on ER in toddlers and preschoolers is still in its infancy. Nonetheless, it provided us with some insight into the ER abilities of toddlers and preschoolers with ASD and factors that are associated with poorer ER abilities in this population.

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Appendix A

See Tables A1–A3.

Table A1
Randomised Control Trial Quality Assessment.

	Selection bias		Performance bias	Detection Bias	Attrition bias	Reporting bias	Other bias	Overall bias
Authors	Random sequence generation	Allocation concealment	Blinding of participants and researchers	Blinding of outcome assessment	Incomplete outcome data	Selective reporting		
Gulsrud et al. (2010)	+	?	?	+	+	+		+

Key: + = low risk; - = high risk;? = unknown risk.

Table A2
Cross-Sectional Studies Quality Assessment.

	Selection				Comparability	Outcome		
Authors	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure	Based on design and analysis	Assessment of outcome	Statistical tests	Total
Goldsmith et al. (2018)	*	*	–	**	**	*	*	8
Fenning et al. (2018)	*	*	*	**	**	**	*	10
Gue et al. (2017)	–	*	*	**	–	**	*	7
Zantinge et al. (2017)	*	*	*	**	*	**	*	9
Nuske et al. (2017)	*	*	–	**	**	**	*	9
Costescu et al. (2016)	*	*	–	*	–	–	*	4
Hirschler-Guttenberg et al. (2015)	*	*	–	**	*	**	*	8
Nader-Grosbois et al. (2014)	*	*	–	**	**	*	*	8
Samson et al. (2014)	*	*	–	**	**	*	*	8
Jahromi et al. (2012)	–	*	–	**	*	–	*	5
Konstantareas et al. (2006)	*	*	–	**	**	**	*	9

Note: The stars (*) represent scores. A study can be awarded a maximum of one star for the following categories: representativeness of sample, sample size, non-respondents, statistical tests. A maximum of two stars can be awarded for the following categories: ascertainment of the exposure, based on design and analysis, assessment outcome. Higher scores reflect greater methodological quality with 10 being the highest score that can be achieved.

Table A3
Cohort Studies Quality Assessment.

	Selection				Comparability	Outcome			Total
Authors	Representativeness of the exposed cohort	Selection of non-exposed cohort	Ascertainment of the exposure	Outcome of interest not present	Based on design and analysis	Assessment of outcome	Follow-up length	Adequacy of follow-up	
Berkovits et al. (2017)	*	–	–	*	**	–	*	*	6
Jahromi et al. (2013)	*	*	–	*	*	*	*	*	7

Note: The stars (*) represent scores. A study can be awarded a maximum of one star for each item within the Selection and Outcome categories while a maximum of two stars can be given for the Comparability category. Higher scores reflect greater methodological quality with 9 being the highest score that can be achieved.

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