A Systematic Literature Review of Emotion Regulation Measurement in Individuals With Autism Spectrum Disorder

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Emotion regulation (ER) difficulties are a potential common factor underlying the presentation of multiple emotional and behavioral problems in individuals with Autism Spectrum Disorder (ASD). To provide an overview of how ER has been studied in individuals with ASD, we conducted a systematic review of the past 20 years of ER research in the ASD population, using established keywords from the most comprehensive ER literature review of the typically developing population to date. Out of an initial sampling of 305 studies, 32 were eligible for review. We examined the types of methods (self-report, informant report, naturalistic observation/ behavior coding, physiological, and open-ended) and the ER constructs based on Gross and Thompson's modal model (situation selection, situation modification, attention deployment, cognitive change, and response modulation). Studies most often assessed ER using one type of method and from a unidimensional perspective. Across the 32 studies, we documented the types of measures used and found that 38% of studies used self-report, 44% included an informant report measure, 31% included at least one naturalistic observation/behavior coding measure, 13% included at least one physiological measure, and 13% included at least one open-ended measure. Only 25% of studies used more than one method of measurement. The findings of the current review provide the field with an in-depth analysis of various ER measures and how each measure taps into an ER framework. Future research can use this model to examine ER in a multicomponent way and through multiple methods.
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Individuals with Autism Spectrum Disorder (ASD) are known to have difficulty with sociocommunicative functioning and restricted or repetitive behaviors or interests [American Psychiatric Association, 2013], and there is considerable evidence that the majority also struggle with associated emotional problems. For instance, in a population derived cohort of 5- to 16-year-olds, Totsika, Hastings, Emerson, Lancaster, and Berridge [2011] found that 85% of youth with ASD without an intellectual disability (ID) had clinically significant levels of hyperactivity, 74% of emotional problems, and 64% of conduct problems, compared to much lower rates in a typically developing comparison group (19% hyperactivity, 18% emotional problems, and 22% conduct problems). Further, youth with ID and ASD had higher rates of emotional disorders than those with only ID (88% vs. 63% for hyperactivity, 71% vs. 42% for emotional problems, and 65% vs. 46% for conduct problems, respectively). There is also considerable co-occurrence of multiple emotional problems in individuals with ASD. Approximately 40–50% of youth with ASD are estimated to meet criteria for two or more psychiatric disorders, often combining attentional or behavioral problems (e.g. ADHD) with internalizing problems (e.g. anxiety disorder), even after taking into account symptoms that may be related to core ASD sociocommunicative and behavioral symptoms [Leyfer et al., 2006; Simonoff et al., 2008]. The assessment of co-occurring psychiatric disorders in adults with ASD is underrepresented in the literature compared to the pediatric and youth populations, though recent evidence supports similar patterns [Ghaziuddin & Zafar, 2008; LoVullo & Matson, 2009]. For example, in a clinic-referred sample of 63 adults with ASD, Joshi et al. [2013] found that on average, adults met criteria for at least three co-occurring psychiatric disorders (42% with ADHD, 68% with anxiety disorders, and 31% with major depressive disorder), and had higher rates of lifetime psychiatric disorders than non-ASD referred individuals. In another sample of 54 young adults with Asperger Syndrome, 70% had one episode of major depression, 50% had recurrent depressive episodes, and 50% had anxiety disorders [Lugnegård, Hallerbäck, & Gillberg, 2011].

Problems with emotion regulation (ER) have been suggested as a potential common factor to explain these high rates of multiple emotional and behavioral problems in individuals with and without ASD [Aldao, Nolen-Hoeksema, & Schweizer, 2010; Mazefsky et al.,

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2013; Mazefsky, Pelphrey, & Dahl, 2012; Mazefsky & White, 2014; Sofronoff, Beaumont, & Weiss, 2014; Trosper, Buzzella, Bennett, & Ehrenreich, 2009; Weiss, in press]. ER can be defined as "the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals" [Thompson, 1994, pp. 27–28, as cited in Adrian, Zeman, & Veits, 2011].

Poor ER has been implicated in a range of emotional problems in children with ASD, such as anxiety [Gadow, Devincent, Pomeroy, & Azizian, 2005; Green, Gilchrist, Burton, & Cox, 2000; Simonoff et al., 2008; Wood & Gadow, 2010], depressive symptoms [Barnhill et al., 2000; Pouw, Rieffe, Stockmann, & Gadow, 2013; Zablotsky, Bradshaw, Anderson, & Law, 2013], and anger [Rieffe, Camodeca, Pouw, Lange, & Stockmann, 2012; Scarpa & Reyes, 2011]. A review of the literature reveals a relative lack of studies of ER in adults with ASD. There is support for their ability to reliably reflect and report on their emotional experiences [Berthoz & Hill, 2005; Hill, Berthoz, & Frith, 2004], and in comparison to adults without ASD, they tend to report less adaptive ER strategies (e.g. cognitive reappraisal), and more frequent maladaptive ER strategies (e.g. emotional suppression) [Samson, Huber, & Gross, 2012], warranting further investigation of ER problems across the life span.

Understanding how these processes function in individuals with ASD is needed to develop comprehensive mental health interventions [Mazefsky & White, 2014]. Although a number of review articles exist summarizing what ER deficits may look like in individuals with ASD [Mazefsky et al., 2012, 2013; Mazefsky & White, 2014], they have not employed a systematic literature review process to ascertain the types of measures or the number of methods used in published studies. These reviews do note that individuals with ASD are at a greater risk than typically developing peers for showing impairments in many of the processes implicated within ER, making this a critical area of study. This includes impairments in sociocommunicative skill, behavioral flexibility, neural circuitry, physiological arousal, cognitive and information processing of emotions, temperament, and mental health. At the same time, reviews caution that the measures used to assess ER in general populations (i.e. self-report questionnaires, observational data) may not be valid for assessing ER in the ASD population [Mazefsky, Kao, & Oswald, 2011; Ozsivadjian, Hibberd, & Hollocks, 2013], and an examination of exactly what measures are being used to tap different components of ER is needed [Mazefsky et al., 2011].

Despite the conceptualization of ER as a multicomponent and dynamic process [Thompson, Lewis, & Calkins, 2008], the operationalization and methods used to study ER in typically developing individuals are largely limited to examining it as a singular construct and through a single methodology (e.g. using a survey or behavioral observation, rather than both ways), making the interpretation of findings across studies difficult [Adrian et al., 2011]. Adrian et al. [2011] recently conducted a review of 35 years of ER research across 42 journals, and examined the types of measures used, including self-report, informant report (parent, teacher), observational, and physiological-biological types. Of the 157 studies reviewed, 42% used self-report (28 unique measures), 41% used informant report (17 unique measures), 57% used observation (47 unique measures), and 24% used physiological-biological means (eight unique measures). The majority of the published research relied on one method (61.1%) versus two, three, or four methods (23.6%, 10.8%, and 4.5% respectively). The authors did not attempt to classify the various ER processes into an overall ER framework, and did not look specifically at how ER is studied in individuals with ASD. The overall purpose of the current systematic review was to identify the various ways and processes of ER that have been studied in individuals with ASD.

Modal Model of ER

ER has been described as an individual-context transactional process that involves multiple strategies that may be consciously (effortful and controlled) or unconsciously (effortless and automatic) implemented in response to emotion-eliciting stimuli, with the aim of influencing the degree or type of an individual's affect or the stimuli [Aldao & Nolen-Hoeksema, 2010; Gross & Thompson, 2007]. Gross and Thompson's [2007] modal model of ER is one commonly employed framework for guiding the selection of measures and operationalizing ER for research and clinical purposes [Aldao et al., 2010; Bilek & Ehrenreich-May, 2012; Campbell-Sills & Barlow, 2007; Johnson, 2009]. It has been used as the basis for advancing the development of cognitive behavioral interventions for youth [Ehrenreich-May, Queen, Bilek, Remmes, & Marciel, 2013; Trosper et al., 2009] and for adults [Moses & Barlow, 2006]. To our knowledge, we are the first to provide an in-depth analysis of ER measures from Gross and Thompson's [2007] framework. The modal model of ER suggests five temporally linked "families" or domains, of ER processes: situation selection, situation modification, attentional deployment, cognitive change, and response modulation. Each domain comprises multiple adaptive and maladaptive ER strategies, and the domains build upon each other as an overall dynamic process of regulation.

Situation selection requires understanding a specific situation, predicting its probable outcomes, and evaluating the consequences of entering into it adaptively

(e.g. avoiding potentially dangerous situations) or maladaptively (e.g. persistently avoiding reasonably safe situations). Individuals with ASD may engage more frequently in the latter due to difficulties in understanding social, unstructured, or novel situations [Lawson, Baron-Cohen, & Wheelwright, 2004], avoidance of novel or uncomfortable situations as a result of behavioral rigidities [e.g. insistence of routine; Gotham et al., 2013], withdrawal from social situations because of sociocommunicative impairments [Dawson & Lewy, 1989; Jawaid et al., 2012], or avoidance of particular situations or environments due to sensory sensitivities [Hilton et al., 2010; Laurent & Rubin, 2004]. These factors may cause difficulties in a second domain of ER, *situation modification*, where one is able to alter a situation in order to regulate potential emotional responses. Individuals with ASD are known to have difficulties with naturalistic problem solving [Channon, Charman, Heap, Crawford, & Rios, 2001] and may have rigid ways of trying to cope with stressors to attain emotional relief [Howlin, Goode, Hutton, & Rutter, 2004].

ER is also founded in *attentional deployment*, the ability to control the way that attention is allocated to or away from the emotion eliciting aspects of a situation. With the ASD population in particular, emotional awareness may be a prerequisite to attentional deployment [Rieffe et al., 2011]. Research suggests that individuals with ASD have difficulties recognizing their own and others' emotions [Baron-Cohen et al., 2000], are significantly more alexithymic than their peers [Hill et al., 2004; Tani et al., 2004; Williams & Happé, 2010], and have a higher likelihood of focusing on negative or irrelevant information than their peers [Embregts & van Nieuwenhuijzen, 2009]. Some preliminary evidence suggests that these irregular patterns of responding in individuals with ASD are based in atypical physiological responses to emotional stimuli, such as less arousal to sad expressions than typical controls [Bölte, Feineis-Matthews, & Poustka, 2008]. Controlled attentional deployment also requires *cognitive flexibility*, defined as "the ability to shift to different thoughts or actions depending on situational demands" [Geurts, Corbett, & Solomon, 2009, p. 74], which can be impaired in individuals with ASD [Geurts et al., 2009; Van Eylen et al., 2011], who are known to be predisposed to rumination [Rieffe et al., 2011; Spek, van Ham, & Nyklíček, 2013]. Emotional reactions are further modified through appraisals of a situation and of the capacity to cope with it, known as *cognitive change*. Individuals with ASD have been found to engage in maladaptive cognitive change strategies, such as cognitive distortions [e.g. all or nothing and catastrophic thinking; Attwood, 2003, 2004a; Sofronoff & Attwood, 2003] and suppression [de Bruin, Zijlstra, & Bögels, 2014], and to benefit from cognitive reappraisal strategies [e.g. Samson, Hardan, Podell, Phillips, & Gross, in press].

Finally, *response modulation* involves the continuum of physiological and behavioral ways of regulating and expressing emotions after they are experienced. Individuals with ASD are known to react to emotionally aversive situations with behaviors that serve escape functions [Jahromi, Meek, & Ober-Reynolds, 2012], and inhibiting prosocial emotion-expressive behavior is also more common in individuals with ASD than in TD peers [Samson et al., 2012]. Individuals with ASD have been noted to have an overall higher rate of physiological arousal, making the regulation of emotional responses more difficult [Bal et al., 2010; Hirstein, Iversen, & Ramachandran, 2001; Kylliainen & Hietanen, 2006]. This arousal may also be influenced by hyper- or hyporesponsivity to environmental (e.g. quiet or loud background noise) and social (e.g. an unexpected tap on the shoulder or a hug) sensory stimuli [Hilton, Graver, & LaVesser, 2007; Liss, Saulnier, Fein, & Kinsbourne, 2006], with the sensory stress acting as emotional triggers [Wood & Gadow, 2010].

The goal of the current systematic review was to provide an overview of how ER has been studied in individuals with ASD, with a particular view on whether researchers have used multiple methods and have studied ER with a multicomponent perspective. We first examined the *types* of methods used to assess ER in individuals with ASD (i.e. self-report, informant report, naturalistic observation/behavior coding, physiological, and open-ended), in line with past systematic reviews of ER in the general population [Adrian et al., 2011]. We then conducted a detailed review of all the available measures that were used in included articles, and determined the ER *domain* that was assessed, using the modal model of emotion as a framework [i.e. situation modification, situation selection, attentional deployment, cognitive control, and response modulation; Gross & Thompson, 2007], resulting in a matrix to indicate how the *type* of method employed was related to ER *domains*.

Methods

This review was based on a systematic search of published articles available through May 2014, and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [Moher, Liberati, Tetzlaff, & Altman, 2009]. The Medline Ovid and PsycInfo online databases were searched concurrently for entries using the established keywords from the most comprehensive ER literature review to date [Adrian et al., 2011] and contained any combination of the following terms in the Title, Abstract, and Keyword search fields: (1) "autism" or "Asperger" or "pervasive developmental disorder" and (2) "emotion regulation" or "emotional regulation" or "emotion management" or "affect regulation"

or "emotional competence" or "effortful control." Abstracts of identified articles were then screened for the following inclusion criteria: (a) target population included having a diagnosis of ASD (Autism, Asperger's, PDD-NOS, or ASD), and (b) symptoms of ER in the target population were assessed. There were no restrictions on minimum sample size. Articles were excluded if they were: (a) not data-based (e.g. books, theoretical papers, or secondary reviews), (b) unpublished dissertations/theses, (c) studies not published in English, (d) examined populations not explicitly identified as having a diagnosis of ASD, or (e) did not include at least one measure of ER.

The initial literature search resulted in a total of 299 findings (44 from Medline Ovid and 255 from PsycInfo; see Fig. 1). After the initial search, Mazefsky et al. [2013] published a review article on ER and ASD. We then cross-referenced the articles that were reviewed in Mazefsky et al. [2013] with our initial search and identified six additional records. Excluding duplicates of these 305 findings led to a total of 265 unique findings. We further excluded 97 articles (55 books, 19 unpublished dissertations/theses, and 23 not published in English) on a surface scan, resulting in a total of 168 article findings. Finally, the authors reviewed these 168 articles in a more in-depth review and reached a consensus to further exclude 136 articles (70 did not involve participants with an ASD diagnosis, 42 were theoretical papers or secondary reviews, 15 did not include at least one ER measure, and 9 did not involve participants with an ASD diagnosis and were theoretical papers or secondary reviews), resulting in 32 articles that met the criteria and were included in the current review. Reference lists from the 32 studies were also reviewed [see asterisks in reference list for final included studies; specifically, three were ultimately identified through Bal et al., 2010; Mazefsky et al., 2013; Sofronoff, Attwood, Hinton, & Levin, 2007; Van Hecke et al., 2009].

Articles were reviewed for any measures that were purported to assess ER. Each measure was then coded along two dimensions: (a) the *type* of method (coded as either self-report, informant report, naturalistic observation/behavior coding, physiological or open-ended) and (b) the ER *domain(s)* assessed (situation selection, situation modification, attentional deployment, cognitive change, response modulation). We reviewed descriptions of the measures, and in nearly all the cases (86%), examined the individual items of each measure. More specifically, we accessed 78% of the self-report measures, 72% of the informant report measures, 100% of the open-ended measures, and obtained detailed descriptions of 100% of the naturalistic/behavioral observation and physiological measures. Content was then coded into the five ER domains according to the definitions of each in the Appendix, with some measures tapping into multiple

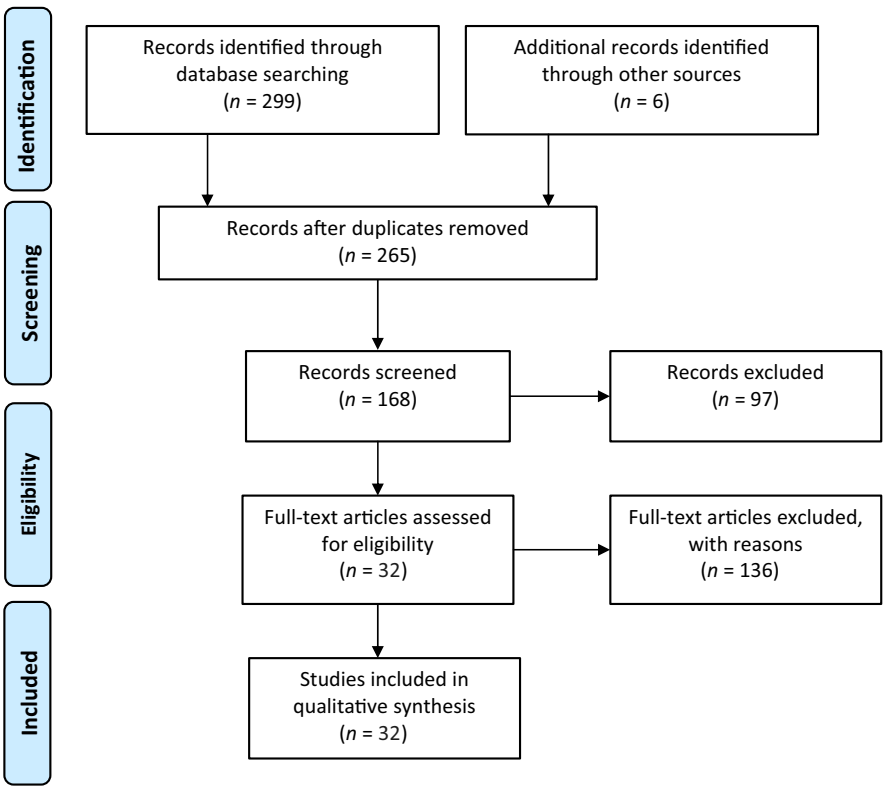

Figure 1. PRISMA flow diagram.

domains. All measures were coded by two raters. To assess coding reliability, we compared two of the authors' ratings on a subsample (26%) of the total measures, which yielded 83% agreement. In cases where there was a discrepancy in coding, all three authors discussed the items in question and came to consensus.

Results

Method of Measurement

There were a total of 64 different ER measures used across the 32 studies; 50% ($n = 16$) of the studies included one measure of ER, 16% ($n = 5$) included two measures, and 32% ($n = 10$) employed three or more measures. The ER measures were then coded by *type*: self–report, informant report, naturalistic observation/behavior coding, physiological, or open-ended. Across the 32 studies, 38% ($n = 12$) included at least one self-report measure, 44% ($n = 14$) included at least one informant report measure; 31% ($n = 10$) included at least one naturalistic observation/behavior coding measure; 13% ($n = 4$) included at least one physiological measure; and 13% ($n = 4$) included at least one open-ended measure (see Table 1). We also examined the total number of *types of ER methods* used in the 32 studies. That is, if one self-report measure was used and two informant reports were used, each *type* would be counted only once as a measure of ER across the 32 studies (e.g. one self-report and one informant report). In this case, 75% ($n = 24$) of studies included only one type of ER measure and the rest ($n = 8$) included two or more types. In Table 1, the majority of measures were used with school-age children (ages 5 to 18 years) and had acceptable levels of internal consistency and interrater reliability, when reported.

As shown in Table 1, 20 of the 64 ER measures were *self-report type* and were used in 38% of the studies ($n = 12$). Each of the self-report measures were used in only one of the 32 studies included in the review, except for three measures: (a) the *Toronto Alexithymia Scale* [TAS-20; Bach, Bach, de Zwaan, Serim, & Bohmer, 1996; Bagby, Parker, & Taylor, 1994], a self-report measure of alexithymic deficits, was used in two of the studies [Berthoz & Hill, 2005; Samson et al., 2012]; (b) the *Response to Stress Questionnaire* [RSQ: Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000], a self-report measure of voluntary and involuntary cognitive and behavioral ER processes, was used in two studies [Khor, Melvin, Reid, & Gray, 2014; Mazefsky, Borue, Day, & Minshew, 2014]; and (c) *The Mood Questionnaire* [Rieffe, Meerum Terwogt, & Bosch, 2004], a self-report measure of affective states for basic emotions in children, was also used in two studies [Pouw, Rieffe, Oosterveld, Huskens, & Stockmann, 2013; Rieffe et al., 2012].

A number of studies used multiple self-report measures. For example, Samyn, Roeyers, and Bijttebier [2011] used the *Early Adolescent Temperament Questionnaire-Revised* [EATQ-R; Ellis & Rothbart, 2001], to assess inhibitory, attentional, and activation control; the *Effortful Control Scale* [ECS; Lonigan & Phillips, 2001], to assess the behavioral and attention components of ER; and the *Attentional Control Scale* [ACS; Derryberry & Reed, 2002], to measure self-reported ability to focus and shift attention according to various situational demands (see Table 1).

Fourteen of the 64 ER measures were *informant report type* and were used in 44% of the total studies ($n = 14$). Only two of the informant report measures, the *Social Skills Questionnaire* [SSQ; Spence, 1995] and the *Emotion Regulation and Social Skills Questionnaire* [ERSSQ; Beaumont & Sofronoff, 2008] involved teacher informants; the remaining informants were parents. As shown in Table 1, all measures were used by only one study except for three: (a) the *Emotion Regulation Checklist* [ERC; Shields & Cicchetti, 1997], a parent report measure of children's typical ways of managing emotional experiences, was used in two of the studies [Jahromi, Bryce, & Swanson, 2013; Scarpa & Reyes, 2011]; (b) the ERSSQ [Beaumont & Sofronoff, 2008] was used in two studies [Beaumont & Sofronoff, 2008; Butterworth et al., 2013]; and (c) the *Strengths and Difficulties Questionnaire* [SDQ; Goodman, 1997; Muris, Meesters, & van den Berg, 2003], a parent report of adjustment and psychopathology of children and adolescents, was used as such in Rieffe et al. [2011] and was also used as self-report [Khor et al., 2014]. Two of the studies used more than one informant report measure [Beaumont & Sofronoff, 2008; Scarpa & Reyes, 2011]. For example, Beaumont and Sofronoff [2008] used the ERSSQ [Beaumont & Sofronoff, 2008], a parent report questionnaire of a child's ER and social competency, and the SSQ [Spence, 1995], a parent and teacher evaluation of child's social competence that also measures ER processes in a social context (see Table 1).

Twenty of the 64 ER measures were *naturalistic observation/behavior coding type* and were used in 32% of the studies ($n = 10$). Six of the 10 studies that included naturalistic observation/behavior coding did so for more than one behavior. For example, Jahromi et al. [2012] included naturalistic observation/behavioral codes for four separate behavioral indicators (i.e. negative and non-negative vocalizations, resignation behaviors, facial affect and bodily negativity, and ER coping strategies) while completing two frustration eliciting tasks [attractive toy in a transparent box; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999, and unsolvable puzzles task; Smiley & Dweck, 1994].

Four of the 64 ER measures were *physiological type* and were used in 13% of total studies ($n = 4$). The *Sinus Arrhythmia/Heart Rate* measure was used in three of the four studies [Bal et al., 2010; Neuhaus, Bernier, & Beauchaine, 2014; Van Hecke et al., 2009], and the remaining three measures were each used in only one of

Table 1. Emotion Regulation Matrix

Method/measure	Studies that used method/measure	Sample characteristics[a,b]	Psychometric properties	Construct(s) assessed	Gross and Thompson [2007] Emotion REGULATION Domain				
					Situation selection	Situation modification	Attentional deployment	Cognitive change	Response modulation
Self Report (n = 20)	**(n = 12)**								
Bermond and Vorst Alexithymia Questionnaire-Form B [BVAQ-B; Vorst & Bermond, 2001]	Berthoz and Hill [2005]	*ASD* (n = 27) Age range: 26–79 (M = 35.07, SD = 12.26). *Control* (n = 35) Age range: 29–64 (M = 32.18, SD = 11.25).	α = 0.76	Self-report measure of alexithymic deficits			√		√
Cognitive Emotion Regulation Questionnaire for Kids [CERQ; Garnefski, Rieffe, Jellesma, Meerum Terwogt, & Kraaij, 2007]	Rieffe et al. [2011]	*HFA* (n = 66) Age range: 10–13 (M = 11.5, SD = 0.84). *Control* (n = 118) Age range: 10–13 (M = 11.5, SD = 0.66).	α = 0.70–0.80	Self-report to measure cognitive ER strategies				√	
Coping Scale [Wright, Banerjee, Hoek, Rieffe, & Novin, 2010]	Pouw, et al. [2013]	*ASD* (n = 63) Age range: not specified (M = 11.7, SD = 1.3). *Control* (n = 57) Age range: not specified (M = 11.5, SD = 1.3).	α = 0.77–0.85	Self-report of coping strategies		√	√	√	√
Ecological Momentary Assessment [EMA; Stone & Shiffman, 1994]	Khor et al. [2014]	*AD* (n = 31) Age range: 12–18 (M = 14.46, SD = 1.83).	N/A	Self-report of stress and coping using mobile phone			√		√
Emotion Awareness Questionnaire [EAQ30; Rieffe et al., 2008; Rieffe et al., 2007]	Rieffe et al. [2011]	*HFA* (n = 66) Age range: 10–13 (M = 11.5; SD = 10.1). *Control* (n = 118) Age range: 10–13 (M = 11.5; SD = 7.9).	α = 0.64–0.68	Self-report to measure key aspects of emotional awareness			√		√
Emotion Regulation Questionnaire [ERQ; Gross & John, 2003; Abler & Kessler, 2009]	Samson, Huber, and Gross [2012]	*AS/HFA* (n = 27) Age range: 18–53 (M = 33.56, SD = 12.82). *Control* (n = 27) Age range: 18–64 (M = 35.22, SD = 12.82).	α = 0.86	Self-report measure of frequency of reappraisal and suppression				√	√
Emotional Competencies Scale [Sharma & Bhardwaj, 2007]	Srivastava and Mukhopadhyay [2011]	*ASD* (n = 10) Age range: 3–7 (M and SD not specified).	Reliability coefficient = 0.76 (split half)	Self-report measure of emotional competencies of parents of children with autism					√
Emotional Intensity Scale for Children [EISC; Braaten & Rosen, 2000]	Lynn, Carroll, Houghton, and Cobham [2013]	*ASD* (n = 9), *ADHD* (n = 12), *Anxiety/Depression* (n = 6), *ODD* (n = 1), *Control* (n = 33) Age range: 3–12 (M = 9.86, SD = 1.49).	α = 0.90	Self-report measure of emotions that correspond with situations familiar to children (positive and negative)			√		√
Parashar Optimistic-Pessimistic Attitude Scale [Parashar, 1998]	Srivastava and Mukhopadhyay [2011]	ASD (n = 10) Age range: 3–7 (M and SD not specified).	Reliability coefficient = 0.74 (test retest).	Self-report measure of parent optimism-pessimism attitudes					√
Positive and Negative Affect Schedule [PANAS; Watson, Clark, & Tellegen, 1988; Krohne, Egloff, Kohlmann, & Tausch, 1996]	Samson, Huber, and Gross [2012]	*AS/HFA* (n = 27) Age range: 18–53 (M = 33.56, SD = 12.82). *Control* (n = 27) Age range: 18–64 (M = 35.22, SD = 12.82).	α = 0.70–0.93	Self-report measure of positive and negative affect			√		
Response to Stress Questionnaire [Connor-Smith et al., 2000]	Mazefsky, et al. [2014]; Khor, Melvin, Reid, and Gray [2014]	*ASD* (n = 25) Age range: 12–19 (M = 15.22, SD = 2.25). *Control* (n = 23) Age range: 12–19 (M = 15.56, SD = 2.76); *AD* (n = 31) Age range: 12–18 (M = 14.46, SD = 1.83).	α = 0.78–0.96	Self-report measure of voluntary/involuntary cognitive and behavioral emotion regulation processes	√	√	√	√	√
Self Report Instrument for Reactive and Proactive Aggression (IRPA; Rieffe, Faber, Kouwenberg, Güroğlu, & Tsutsui, in revision)	Pouw et al. [2013]	*ASD* (n = 63) Age range: not specified (M = 11.7; SD = 1.3). *Control* (n = 57) Age range: not specified (M = 11.5; SD = 1.3).	α = 0.91–0.94	Self-report of aggressive behavior			√		√

Strengths and Difficulties Questionnaire [SDQ; -self report version Goodman, 1997; Muris et al., 2003]	Khor et al. [2014]	AD (n = 31) Age range: 12–18 (M = 14.46, SD = 1.83).	α = 0.86–0.89	Self-report to measure adjustment and psychopathology of children and adolescents	√	√	√		√
The Attentional Control Scale [ACS; Derryberry & Reed, 2002]	Samyn et al. [2011]	*ASD* (n = 27) Age range: not specified (M = 12.73, SD = 1.46). *ADHD* (n = 27) Age range: not specified (M = 13.21, SD = 1.57). *Control* (n = 27) Age range: not specified (M = 12.91, SD = 1.43).	α = 0.83	Self-report to measure ability to focus and shift attention according to various situational demands	√		√	√	
The Early Adolescent Temperament Questionnaire-Revised [EATQ-R; Ellis & Rothbart, 2001]	Samyn et al. [2011]	ASD (n = 27) Age range: not specified (M = 12.73, SD = 1.46). *ADHD* (n = 27) Age range: not specified (M = 13.21, SD = 1.57). *Control* (n = 27) Age range: not specified (M = 12.91, SD = 1.43).	α = 0.83	Self-report and parent report to assess inhibitory control, attentional control, and activation control	√		√		√
The Effortful Control Scale [ECS; Lonigan & Phillips, 2001]	Samyn et al. [2011]	*ASD* (n = 27) Age range: not specified (M = 12.73, SD = 1.46). *ADHD* (n = 27) Age range: not specified (M = 13.21, SD = 1.57). *Control* (n = 27) Age range: not specified (M = 12.91, SD = 1.43).	α = 0.86	Self-report to assess the behavioral and attention components of ER	√	√	√	√	√
The Mood Questionnaire [Rieffe et al., 2004]	Rieffe et al. [2012]; Pouw et al. [2013]	*HFA* (n = 64) Age range: 9–15 (M = 11.75, SD = 1.26). *Control* (n = 74) Age range: 10–15 (M = 11.5, SD = 1.29); *ASD* (n = 63) Age range: not specified (M = 11.7; SD = 1.3). *Control* (n = 57) Age range: not specified (M = 11.5; SD = 1.3).	α > 0.77	Self-report measure of affective states for basic emotions in children			√		
Toronto Alexithymia-Scale [TAS-20; Bagby et al., 1994; Bach et al., 1996]	Berthoz and Hill [2005]; Samson et al. [2012]	*ASD* (n = 27) Age range: 26–79 (M = 35.07; SD = 12.26). *Control* (n = 35) Age range: 29–64 (M = 32.18; SD = 11.25). *AS/HFA* (n = 27) Age range: 18–53 (M = 33.56, SD = 12.82). *Control* (n = 27) Age range: 18–64 (M = 35.22, SD = 12.82).	α > 0.81	Self-report measure of alexithymic deficits			√	√	
What Makes Me Angry [Faupel, Henick, & Sharp, 1998]	Sofronoff et al. [2007]	*AS* (n = 52) Age range: 10–14 (Intervention Group: M = 10.79, SD = 1.12; Wait-List: M = 10.77, SD = 0.87). Note: Of the 52 participants with AS, 20 also had a diagnosis of ADHD.	N/A	Self-rating of anger			√		
Worry/Rumination Questionnaire for Children [Rieffe et al., 2007; Rieffe et al., 2008]	Rieffe et al. [2011]	*HFA* (n = 66) Age range: 10–13 (M = 11.5; SD = 10.1). *Control* (n = 118) Age range: 10–13 (M = 11.5; SD = 7.9).	α = 0.82	Self-report to assess tendency to dwell on problems versus coping adapatively			√		
Informant Report (n = 14)	**(n = 14)**								
Children's Behavior Questionnaire [Rothbart et al., 2001]	Konstantareas and Stewart [2006]	*ASD* (19), PDD-NOS (9), AD (10) Age range: 6–10 (M = 6.16, SD = 2.13). *Control* (n = 23) Age range: 6–10 (M = 6.37, SD = not specified).	α = 0.73	Parent report of temperament in children ages 3–7	√	√	√		√

Table 1. Continued

Method/measure	Studies that used method/measure	Sample characteristics[a,b]	Psychometric properties	Construct(s) assessed	Gross and Thompson [2007] Emotion REGULATION Domain				
					Situation selection	Situation modification	Attentional deployment	Cognitive change	Response modulation
Children's Behavior Questionnaire-Short Form [CBQ-S; Putnam & Rothbart, 2006]	Adamek, Nichols, Tetenbaum, Bregman, Ponzio, and Carr [2011]	*ASD* (n = 111) Age range: 2–8 (M = 4.2, SD = 1.5).	α = 0.60; Interrater reliability coefficients = 0.53–0.80	Parent report of child's temperament	√	√	√		√
Children's Inventory of Anger-Parent [ChIA-P; Sofronoff, 2003; adapted from the Children's Inventory of Anger; Nelson & Finch, 2000]	Sofronoff, Attwood, Hinton, and Levin [2007]	*AS* (n = 52) Age range: 10–14 (Intervention Group: M = 10.79, SD = 1.12; Wait-List: M = 10.77, SD = 0.87). Note: Of the 52 participants with AS, 20 also had a diagnosis of ADHD.	α = 0.93	Parent report of various aspects of a child's experience of anger					√
Emotion Regulation and Social Skills Questionnaire [ERSSQ; Beaumont & Sofronoff, 2008]	Beaumont and Sofronoff [2008] (parent version); Butterworth et al. [2013] (teacher version)	*AS* (n = 49) Age range: 7.5–12 (Intervention Group: M = 9.64, SD = 1.21; Wait-List: M = 9.81, SD = 1.26); *ASD* (n = 84) Age range: 7.97–14.16 (M = 10.65, SD = 1.50).	α = 0.89; concurrent validity with parent ratings on SRQ (r = 0.73, p < 0.01)	Parent/teacher report of child's ER and social skill competency.	√	√		√	√
Emotion Regulation Checklist [ERC; Shields & Cicchetti, 1997]	Jahromi, Bryce, and Swanson [2013]; Scarpa and Reyes [2011]	*ASD* (n = 20) Age range: not specified (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: not specified (M = 4.18, SD = 0.93); *ASD* (n = 11) Age range: 4.5–7 (M and SD not specified).	α = 0.84	Parent report of perceptions of their child's typical methods of managing emotional experience		√	√		√
Multidimensional Social Competence Scale [MSCS; Yager & Iarocci, 2013]	Yager and Iarocci [2013]	*HFA* (n = 22) Age range: 11–18 (M = 14.17, SD = 2.25). *Control* (n = 22) Age range: 11–18 (M = 14.12, SD = 2.27).	α = 0.84–0.94	Parent report of social competence including emotion regulation					√
Parent Observation of Child Adaptation [POCA; Ialongo et al., 1999]	Zablotsky et al. [2013]	*ASD* (n = 1221) Age range: 6–15 (M = 10.57, SD = 2.89).	α = 0.85	Parent report of their child's behaviors and levels of psychological distress					√
Self Confidence Rating Scale [Scarpa & Reyes, 2011]	Scarpa and Reyes [2011]	*ASD* (n = 11) Age range: 4.5–7 (M and SD not specified).	N/A	Parent report of self-confidence in their children's abilities to handle their emotions related to anger or anxiety					√
Social Skills Questionnaire [Spence, 1995]	Beaumont and Sofronoff [2008]	*AS* (n = 49) Age range: 7.5–12 (Intervention Group: M = 9.64, SD = 1.21; Wait-List: M = 9.81, SD = 1.26).	α = 0.91–0.94	Parent and teacher evaluation of child's social competence	√	√			√
Social Skills Rating System-Elementary Parent Form [SSRS; Gresham & Elliot, 1990]	Van Hecke et al. [2009]	*HFASD* (n = 28) Age range: 8–12 (M = 9.95, SD = 1.62). *Control* (n = 16) Age range: 8–12 (M = 9.93, SD = 1.59).	α = 0.73–0.90	Parent report of social skills and problem behaviors					√
Weekly Coping Questionnaire [Khor et al., 2014]	Khor et al. [2014]	*AD* (n = 31) Age range: 12–18 (M = 14.46, SD = 1.83).	N/A	Parent report of child stressors, level of stress and coping	√	√		√	√
Spence Children's Anxiety Scales-Parent [SCAS-P; Nauta et al., 2004]	South et al. [2012]	*ASD* (n = 30) Age range: 11–16 (M = 14.31, SD = 1.70). *Control* (n = 29) Age range: 11–16 (M = 14.21, SD = 1.76).	α = 0.88 (total score) α = < 0.70 (three of six subscales)	Parent report of anxiety		√	√		√

Strengths and Difficulties Questionnaire [SDQ; Goodman, 1997; Muris et al., 2003]	Rieffe et al. [2011]	*HFA* (n = 66) Age range: 10–13 (M = 11.5, SD = 0.84). *Control* (n = 118) Age range: 10–13 (M = 11.5, SD = 0.66).	α = 0.68–0.71	Parent report to measure adjustment and psychopath-ology of children and adolescents	√	√	√	√
Toddler Behavior Assessment Questionnaire-Revised [TBAQ-R; Goldsmith, 1996; Rothbart, Ellis, Rueda, & Posner, 2003]	Garon et al. [2009]	*ASD siblings* (n = 34), *Non-ASD siblings* (n = 104), *Control* (n = 73) Age range: 2–3 (M and SD not specified).	α = 0.90	Parent report of temperament of children 18–35 months				√
***Naturalistic Observation/Behaviour Coding* (*n* = 20)**	**(n = 10)**							
Attractive toy in a transparent box task [from the Laboratory Temperament Assessment Battery, LABTAB; Goldsmith et al., 1999]	Jahromi, Meek, and Ober-Reynolds [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	N/A	Measure of frustration				√
Behavior Monitoring Sheet [BMS; Scarpa & Reyes, 2011]	Scarpa and Reyes [2011]	*ASD* (n = 11) Age range: 4.5–7 (M and SD not specified).	N/A	Measure of frequency and duration of reactions to stressful or frustrating events				√
Behavioral Assessment [Masi, Cosenza, Mucci, & Brovedani, 2001]	Masi et al. [2001]	*AD* (n = 19) PDD-NOS (n = 5) Age range: 3.6–6.6 (M = 4.6, SD = .67).	N/A	Direct observation of behavioral and social-emotional skills during 60-minute play sessions				√
Behavioral Strategy Combinations [Grolnick, Kurowski, McMenamy, Rivkin, & Bridges, 1998]	Gulsrud, Jahromi, and Kasari [2010]	*ASD* (n = 34) Age range: 2–3 (M = 2.55, SD = 0.33).	Inter-rater reliability for Child: α = 0.63–0.97; Maternal: α = 0.83–0.98.	Measure of both maternal and child ER strategies (e.g., maternal vocal comfort, child comfort seeking)				√
Child Negativity [Gulsrud et al., 2010]	Gulsrud et al. [2010]	*ASD* (n = 34) Age range: 2–3 (M = 2.55, SD = 0.33).	Inter-rater reliability for Facial negativity: α = 0.72; Bodily negativity: α = 0.84.	Measure of child negativity coded in 10-second intervals on 4-point scale				√
Child Self-Regulation Strategies (Goldsmith & Rothbart, 1996)	Gulsrud et al. [2010]	*ASD* (n = 34) Age range: 2–3 (M = 2.55, SD = 0.33).	Inter-rater reliability α = 0.63–1.0	Measure of child self-regulation strategies in 10-second intervals				√
Children's Psychiatric Rating Scale [CPRS; Fish, 1985]	Masi et al. [2001]	*AD* (n = 19) PDD-NOS (n = 5) Age range: 3.6–6.6 (M = 4.6, SD = .67).	Intraclass correlation coefficient r > 0.075	Assess behavioral symptoms (e.g., lability of affect) in children with autism				√
Clinical Global Impression-Improvement [CGI-I; Guy, 1976]	Masi et al. [2001]	*AD* (n = 19) PDD-NOS (n = 5) Age range: 3.6–6.6 (M = 4.6, SD = .67).	Intraclass correlation coefficient r > 0.075	Single-item rating scale of improvement in behavior				√
Coping strategies for emotion regulation [Jahromi et al., 2012]	Jahromi et al. [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	Inter-rater reliability κ = 0.81–1.0	ER strategies coded in 10-second intervals				√
Facial or bodily negativity [Ekman & Friesen, 1978]	Jahromi et al. [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	Interrater reliability, κ = 0.74	Facial affect and bodily negativity coded using Facial Action Coding System while completing frustration task				√
Facial or bodily negativity [Ekman & Friesen, 1978]	Jahromi et al. [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	Interrater reliability, κ = 0.74	Facial affect and bodily negativity coded using Facial Action Coding System while completing frustration task				√
Frustrating Situation [Konstantareas & Stewart, 2006]	Konstantareas and Stewart [2006]	*ASD* (n = 19), *PDD-NOS* (n = 9), *AD* (n = 10) Age range: 6–10 (M = 6.16, SD = 2.13). *Control* (n = 23) Age range: 6–10 (M = 6.37, SD = not specified).	Interrater reliability, κ = 0.78	Measure of frustration and affect regulation				√

Table 1. Continued

Method/measure	Studies that used method/measure	Sample characteristics[a,b]	Psychometric properties	Construct(s) assessed	Gross and Thompson [2007] Emotion REGULATION Domain				
					Situation selection	Situation modification	Attentional deployment	Cognitive change	Response modulation
Global Rating Scale (adapted from the Maternal Scaffolding Coding System [Maslin-Cole & Spieker, 1990])	Gulsrud et al. [2010]	*ASD* (n = 34) Age range: 2–3 (M = 2.55, SD = 0.33).	Inter-rater reliability for Emotional scaffolding: $\alpha = 0.78$; Motivational scaffolding: $\alpha = 0.85$.	Measure of maternal emotional and motivational scaffolding					√
Go/No-Go Computer Task [Nosek & Banaji, 2001]	Raymaekers et al. [2007]	*HFA* (n = 4) Age range: 7–13 (M = 10.5, SD = 2.2). *ADHD* (n = 9) Age range: 7–13 (M = 9.6, SD = 1.9). *Control* (n = 8) Age range: 7–13 (M = 10.5, SD = 2).	N/A	Measure of implicit social cognition					√
Maternal Co-Regulation Strategies [Grolnick et al., 1998]	Gulsrud et al. [2010]	*ASD* (n = 34) Age range: 2–3 (M = 2.55, SD = 0.33).	$\alpha = 0.83$–0.98	Measure of maternal strategies (following child's lead, active ignoring, emotional following, physical/vocal comfort, etc.) in 10-second intervals					√
Negative and nonnegative vocalization [Jahromi et al., 2012]	Jahromi et al. [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	Interrater reliability, $r = 0.88$	Vocalizations coded in terms of content and tone in 10-second intervals while completing frustration task					√
Parent Monitor Measure [Sofronoff et al., 2007]	Sofronoff et al. [2007]	*AS* (n = 52) Age range: 10–14 (Intervention Group: M = 10.79, SD = 1.12; Wait-List: M = 10.77, SD = .87). Note: Of the 52 participants with AS, 20 also had a diagnosis of ADHD.	N/A	Parent observation of child's outbursts of anger at home					√
Resignation [Jahromi et al., 2012]	Jahromi et al. [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	Interrater reliability, $\kappa = 0.83$	Resignation behaviors coded in 10-second intervals while completing frustration task					√
Temperament and Atypical Behavior Scale [TABS; Gomez & Baird, 2005]	Glaser and Shaw [2011]	*ASD* (n = 19) Age range: 5–18 (M = 9.48, SD = 3.81). *22q13* (n = 18) Age range: 5–18 (M = 12.57, SD = 3.17).	Internal consistency, $r = 0.95$ (split half)	Measure of dysfunctional emotion and self-regulatory behaviors in children					√
Unsolvable puzzles task [Smiley & Dweck, 1994]	Jahromi et al. [2012]	*ASD* (n = 20) Age range: 3–6 (M = 4.91, SD = 0.96). *Control* (n = 20) Age range: 3–7 (M = 4.18, SD = 0.93).	N/A	Measure of frustration					√
Verbal vocal expression of emotion task and Non-verbal vocal expression of emotion task [V-VE and NV-VE; Sauter, 2006; Sauter, Eisner, Calder, & Scott, 2010]	Jones, Pickles, Falcaro, Marsden, Happé, Scott, and Charman [2011]	*ASD* (99) Age range: not specified (M = 15.5, SD = 5.5). *Control* (57) Age range: not specified (M = 15.5, SD = 5.75).	N/A	Test of expression of emotion identification from verbal and non-verbal vocalizations			√		
Physiological (n = 4)	**(n = 4)**								
EEG	Van Hecke et al. [2009]	*HFASD* (n = 28) Age range: 8–12 (M = 9.95, SD = 1.62). *Control* (n = 16) Age range: 8–12 (M = 9.93, SD = 1.59).	N/A	Measure of electrical activity on scalp as index of ER					√

Eye Gaze	Bal et al. [2010]	*HFASD* (n = 17) Age range: 8–12 (M = 10.30, SD—2.22). *Control* (n = 36) Age range: 8–12 (M = 11.16, SD = 2.89).	N/A	Measure of eye gaze in response to emotional expressions	√		
Respiratory Sinus Arrhythmia (RSA)/heart rate	Bal et al. [2010]; Van Hecke et al. [2009]; Neuhaus, Bernier, and Beauchain, [2014]	*HFASD* (n = 17) Age range: 8–12 (M = 10.30, SD—2.22). *Control* (n = 36) Age range: 8–12 (M = 11.16, SD = 2.89); *HFASD* (n = 28) Age range: 8–12 (M = 9.95, SD = 1.62). *Control* (n = 16) Age range: 8–12 (M = 9.93, SD = 1.59); *ASD* (n = 18) Age range: not specified (M = 9.99, SD = 1.1). *Control* (n = 18) Age range: not specified (M = 10.02, SD = 0.93).	N/A	Measure of RSA and heart rate in response to emotional expressions			√
Skin Conductance	South et al. [2012]	ASD (n = 30) Age range: 11–16 (M = 14.31, SD = 1.70). Control (n = 29) Age range: 11–16 (M = 14.21, SD = 1.76).	N/A	Electrical skin conductance of skin as index of ER			√
Open-Ended (n = 6)	**(n = 4)**						
Child report of quantity of emotion regulation skills [Scarpa & Reyes, 2011]	Scarpa and Reyes [2011]	ASD (11) Age range: 4.5–7 (M and SD not specified).	N/A	Child report of ER strategies			
Child's emotion regulation ability [Scarpa & Reyes, 2011]	Scarpa and Reyes [2011]	ASD (11) Age range: 4.5–7 (M and SD not specified).	N/A	Child report of ER strategies			
Dylan is Being Teased [Attwood, 2004b]	Beaumont and Sofronoff [2008]; Sofronoff et al. [2007]	AS (n = 49) Age range: 7.5–12 (Intervention Group: M = 9.64, SD = 1.21; Wait-List: M = 9.81, SD = 1.26); AS (n = 52) Age range: 10–14 (Intervention Group: M = 10.79, SD = 1.12; Wait-List: M = 10.77, SD = .87) Note: Of the 52 participants with AS, 20 also had a diagnosis of ADHD.	Interrater reliability, $\kappa = 0.82$, ($r = 0.98$)				
James & the Maths Test [Attwood, 2004c]	Beaumont and Sofronoff [2008]	AS (n = 49) Age range: 7.5–12 (Intervention Group: M = 9.64, SD = 1.21; Wait-List: M = 9.81, SD = 1.26).	Interrater reliability, $\kappa = 0.84$, ($r = 0.98$)	Measure of child social-cognition			
Reactivity and Regulation Situation Task [Carthy, Horesh, Apter, & Gross, 2010]	Samson et al. [in press]	ASD (n = 21) Age range: 8–20 (M = 12.71, SD = 3.62) Control (n = 22) Age range: 8–20 (M = 13.00, SD = 2.99).	Interrater reliability, $\kappa = 0.83$, (0.69–1.0)	Measure of emotional reactivity and regulation			
Teacher Interview [Sofronoff et al., 2007]	Sofronoff et al. [2007]	AS (n = 52) Age range: 10–14 (Intervention Group: M = 10.79, SD = 1.12; Wait-List: M = 10.77, SD = .87) Note: Of the 52 participants with AS, 20 also had a diagnosis of ADHD.	N/A	Measure of changes in behavior as a result of program			

[a]Diagnosis: AD , autistic disorder/Asperger disorder; AS; Asperger's syndrome; HFA, high-functioning autism; PDD-NOS, Pervasive-Developmental Disorder-Not Otherwise Specified; ASD, sample not categorized by specific diagnoses; ADHD, attention deficit hyperactivity disorder; ODD, oppositional defiant disorder; 22q13, 22q13 deletion syndrome.

[b]Age is in years unless otherwise specified.

the studies. Two of the four studies used more than one physiological measure [Bal et al., 2010; Van Hecke et al., 2009].

Six of the 64 ER measures were *open-ended type* measures and were used in 13% of the total studies ($n = 4$). As shown in Table 1, Beaumont and Sofronoff [2008] and Sofronoff et al. [2007], both used the *Dylan is Being Teased* [Attwood, 2004b], measure of social cognition. Three of the four studies that used open-ended measures used more than one. For example, Beaumont and Sofronoff [2008] also used *James and the Math Test* [Attwood, 2004b], another measure of social cognition and ER.

ER Domains

We examined how often each of the Gross and Thompson [2007] ER domains was assessed by the reviewed measures ($n = 64$) overall, and across studies ($n = 32$). As shown in Table 2, situation selection was assessed by 17% ($n = 11$) of the total ER measures, and was represented in 25% ($n = 8$) of the total studies. Situation modification was assessed by 19% ($n = 12$) of the total measures, and 38% ($n = 12$) of the total studies. Attentional deployment was assessed in 38% ($n = 24$) of the 64 ER measures and represented in 34% ($n = 11$) of the studies. Cognitive change was assessed by 14% ($n = 9$) of the total ER measures and 28% of the total studies ($n = 9$). The most frequently assessed ER domain was response modulation, which was assessed by 77% ($n = 49$) of the ER measures and represented in 88% ($n = 28$) of the total studies. The total percentage of measures that assessed the ER domains is greater than 100%, as some measures tapped multiple domains. Table 2 summarizes in detail the specific measures that assess each ER domain.

ER Domains by Type of Measure

Self-report (20 measures). As shown in Table 2, self-report measures were most frequently used to assess attentional deployment (80% of self-report measures, $n = 16$). Response modulation was the second most common ER domain tapped by self-report measures (65% of self-report measures, $n = 13$). Cognitive change, situation selection, and situation modification were assessed by 35% ($n = 7$), 25% ($n = 5$), and 20% ($n = 4$) of the self-report measures, respectively. As shown in Table 1, a number of the self-report measures assessed multiple ER domains. The ECS [Lonigan & Phillips, 2001], a self-report measure used to assess the behavioral and attention components of ER, and the RSQ [Connor-Smith et al., 2000], a self-report measure of voluntary and involuntary cognitive and behavioral ER processes, were the only measures to tap into all of the ER domains.

Informant report (14 measures). As shown in Table 2, the informant report type measures most frequently assessed response modulation (100% of informant report measures, $n = 14$), followed by situation modification (57%, $n = 8$). Situation selection, attentional deployment, and cognitive change were represented in 43% ($n = 6$), 36% ($n = 5$), and 14% ($n = 2$) of the total measures, respectively, of the total informant report measures. None of the informant report measures tapped into all of the ER domains, although the ERSSQ [Beaumont & Sofronoff, 2008], a parent report of child's ER and social skill competency, assessed all of the domains except attentional deployment, and the *Children's Behavior Questionnaire* [CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001], a parent questionnaire of child's temperament, and the SDQ [Goodman, 1997; Muris et al., 2003], a brief informant report to measure adjustment and psychopathology, tapped into each of the ER domains except cognitive change (see Table 1).

Naturalistic observation/ behavior coding (20 measures). As shown in Table 2, response modulation was the most frequently assessed domain in the naturalistic observation/behavior coding type, represented in 95% ($n = 19$) of measures, followed by attentional deployment which was represented in 5% ($n = 1$) of the measures. For example, the *Go/No-Go Computer* task, a measure of implicit social cognition [Nosek & Banaji, 2001], and the *Behavior Monitoring Sheet* [BMS; Scarpa & Reyes, 2011], a measure of the frequency and duration of reactions to stressful or frustrating events, both assessed response modulation. None of the measures assessed situation selection, or situation modification, or both

Table 2. Frequency of Each Type of Measure that Assessed Each Domain

	Self-report	Informant report	Naturalistic observation/ behavior coding	Physiological methods	Total across types
Situation selection	5	6	0	0	**11**
Situation modification	4	8	0	0	**12**
Attentional deployment	16	5	1	1	**24**
Cognitive change	7	2	0	0	**9**
Response modulation	13	14	19	3	**49**
Total across domains	**49**	**35**	**20**	**4**	

attentional deployment and response together (see Table 1).

Physiological methods (4 measures). As indicated in Table 2, two of the ER *domains* were represented in physiological measures, with 25% ($n = 1$) assessing attentional deployment [i.e. eye gaze; Bal et al., 2010], and 75% ($n = 3$) assessing response modulation [e.g. skin conductance; South, Newton, & Chamberlain, 2012]. The physiological type of measures did not assess more than one type of ER domain, and did not assess the situation selection, situation modification, or cognitive change domains (see Table 1).

Discussion

This literature review of 32 studies and 64 measures of ER is the first to systematically examine the measurement of ER in individuals with ASD. ER has been conceptualized as a multicomponent process [Thompson et al., 2008], and the literature to date recommends that it should be studied as such [Adrian et al., 2011]. Given that research recommends that multiple and different levels of measurement be used to assess ER processes in the typically developing population [Adrian et al., 2011], we examined if ER was assessed in this way in the context of ASD research. The majority of studies (50%) included in the review used more than one measure of ER. Upon further analysis though, 75% of studies ($n = 24$) included only one type of method to measure ER (e.g. self-report, informant report, naturalistic/behavior coding, physiological), and few measures tapped into all of the domains of ER as described in the modal model [Gross & Thompson, 2007]. If more than one measure was used, it was typically of the same *type* of method (e.g. two self-reports, two informant reports, or two naturalistic/behavior coding measures) rather than including multiple types (e.g. one self-report, one informant report, and one naturalistic/behavior coding measure). These findings are consistent with Adrian et al. [2011] who reviewed ER literature in the typically developing population, and found that although the majority of studies used more than one ER measure, 61.1% used only one method to assess ER. Such unimethod assessments of ER risk missing the nuances of the multidimensional ER process. An informal comparison of the ER measures from Adrian et al. [2011] with the results of the current review indicated that some overlap exists in terms of assessments of ER in the typically developing population and individuals with ASD [e.g. RSQ; Connor-Smith et al., 2000; EATQ-R; Ellis & Rothbart, 2001; and Respiratory Sinus Arrhythmia (RSA)]. However, there are other ER measures used in the general population that were not included in our review of measures used in the ASD population [e.g. *Emotion Regulation Strategies*; Schmidt, Tinti, Levine, & Testa, 2010; *Emotion Regulation Rating Scale*; Carlson & Wang, 2007; *Emotion/Affect Regulation Interview* (ERI, ARI); Zeman and Garber, 1996; *Entry task with peer*; Putallaz, 1983; *"Beat the Bell" competitive task*; Cassidy, Parke, Butkovsky, & Braungart, 1992; Lutkenhaus, Grossmann, & Grossmann, 1985; and *Meta-Emotion Interview*; Gottman, Fainsilber Katz, & Hooven, 1996], which warrant further investigation.

It is clear from this review that a large number of measures have been utilized to assess ER in individuals with ASD. However, it should be noted that other than the psychometric properties noted in Table 1, the current review does not assess in depth whether the ER measures are valid or reliable in measuring ER with the ASD population. Most of the ER measures that have been used with the ASD population assess for one or two specific processes. We found that naturalistic observation was the most commonly used methodology. Observational methods may be popular due to the ability to capture various aspects of ER [Adrian et al., 2011], which is further validated by our finding that observational methods most often assessed response modulation processes, the most observable of the five domains [Gross & Thompson, 2007]. Relying solely on this method though would lead researchers to being able to only talk about ER as either a response modulation or attentional deployment issue, missing other integral ER processes. Self-report and informant report were also frequently used, and contrary to the behavioral observation method, often touch on at least three out of five ER domains. Although self and informant report measures are advantageous because they are easy to administer, and can be completed by respondents with minimal assistance from research staff, the results of these types of measures should be interpreted with caution in this population, given that children with ASD typically have impairments in communication skills [Mazefsky et al., 2011], and may have the tendency to inaccurately report about their inner experience [White, Schry, & Maddox, 2012]. There was also variability in the choice of questionnaires used for self and informant report, and greater consensus on the measures that best capture ER domains would facilitate more accurate comparisons across studies.

Physiological methods were the most underrepresented type in the ASD population, with 50% fewer measures than were used in the general literature [Adrian et al., 2011]. This difference may be partially explained by the invasiveness and complexity of physiological methods compared to other methodologies [e.g. structural magnetic resonance imaging procedures require the individual to remain still for long periods of time in an MRI machine; Nordahl et al., 2008]. As individuals with ASD are prone to sensory sensitivities and behavioral rigidities, standard physiological measures may be too demanding and risk causing distress. At the same time, this approach can improve our ability to detect regulation

in individuals who may lack the ability to communicate about their processes [Mazefsky et al., 2013]. Determining the best physiological ways of assessing ER is especially critical, given that multiple ER-related neurological impairments have been noted in individuals with ASD [e.g. abnormal prefrontal cortex activity and amygdala activation; Mazefsky et al., 2013].

Using a combination of ER measures across method types would be most conducive to tapping into the multidimensional aspects of ER, and the benefits of doing so likely outweigh potential costs. Developing a strong theoretical understanding of ER in individuals with ASD would be greatly advanced by "understanding the functional measurement equivalence (i.e. the degree of similarity in precursors, consequents, and correlates of scores) and congruence within and across different aspects" [Adrian et al., 2011, p. 187]. Approaching this task with *a priori* theoretical models of normative ER processes can structure the inevitable increased complexity of findings. Assessing multiple components can also serve to elucidate the interactions among process in this population, reflecting more validly the reality of what it means to regulate emotion. Further, conducting studies where similar processes are measured across multiple methods would provide much needed criterion validity for using these measures with this population. Future research could consult the type/domain matrix defined by Table 2 to find measures that assess ER from various methodologies.

As with other literature reviews, the current review has a number of limitations. Given that three additional studies were found after the initial search through Mazefsky et al. [2013], it is possible that other studies were not ascertained by our search terms, despite using the same as was used in a prior comprehensive systematic review. To address this limitation, future research may also consider additional search terms beyond those used in Adrian et al. [2011], and include literature reviews, translations of research in languages other than English, book chapters, and other publications that may not present empirical data. As well, to further increase confidence in the selection process, more than one reviewer could screen the initial search results. This review also assessed ER from a specific theoretical framework, and other ER theories would lead to a different organizing matrix. The modal model of ER is not the only model that could be used to organize a broad set of ER strategies. For example, Mazefsky et al. (2014) recently employed a theoretical framework developed by Connor-Smith et al. [2000], in which emotional responses are categorized first, as either voluntary versus involuntary and second, by engagement or disengagement [i.e. aimed directly or indirectly at the stressor or emotional response, respectively; Connor-Smith et al., 2000]. Many of the same ER strategies are found in both the modal model and the theoretical framework by Connor-Smith et al. [2000]. One useful aspect of using the modal model is that its emphasis on ER as a multidimensional individual-contextual process has helped to shape effective ER interventions for individuals without ASD [Ehrenreich-May et al., 2013; Moses & Barlow, 2006; Trosper et al., 2009] and has the potential to inform the overall conceptualization and treatment of ER in individuals with ASD (Weiss, in press). The current review contributes to the field by providing novel information as to how a framework of ER maps on to the actual measures used to assess its constructs.

A continued focus on multimethod and multicomponent studies will serve to improve our understanding of ER and may translate into better ways of improving outcomes for individuals with ASD. For instance, one study of cognitive behavior therapy for ER in young children with ASD has emerged in the literature, with promising preliminary results [Scarpa & Reyes, 2011]. More sophisticated research of ER may help to develop measures that more accurately operationalize its processes, informing targeted ER treatments that may assist in decreasing the challenging behaviors and emotional problems that are common for individuals with ASD [Mazefsky & White, 2014]. It is important that clinical research be able to access the multiple ways that the field has measured ER processes in ASD, in order to improve our understanding of this fundamental contributor to mental health.

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Note: An asterisk (*) indicates that the article was one of the 32 reviewed.

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Appendix

Definitions of Emotion Regulation Domains [Gross & Thompson, 2007]

Situation Selection: Acting to make it more (or less) likely to end up in an expected situation, which can give rise to desirable (or undesirable) emotions. It requires an understanding of likely features of remote situations, and of expected emotional responses to these features.

Situation Modification: Altering situations to address emotional responses. This includes parents' emotional responses to their children's emotions and how they help children cope with situations (scaffolding).

Attentional Deployment: Focusing or distancing attention on the emotional aspects of a situation. Types: emotional awareness, attention bias, rumination, and distraction.

Cognitive Change: Modifying emotional reactions by the thoughts about the situation and capacity to cope with it. Types: reappraisal, downward social comparison.

Response Modulation: Regulating and expressing experienced emotions physiologically and behaviorally.