




Emotion Dysregulation Mediates the Relationship Between Sensory Processing and Behavior Problems in Young Children with Autism Spectrum Disorder: A Preliminary Study

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Abstract

Emotion dysregulation is one of the challenges that children with autism spectrum disorder (ASD) and their families face. It is unclear whether emotion dysregulation plays a mediating role in the relationship between sensory processing patterns and problem behaviors among these children. This study examined the relations between emotion dysregulation, behavioral problems, and sensory processing patterns among fifty-seven young children with ASD. Behavioral problems and sensory processing patterns were moderately to strongly correlated with emotion dysregulation. The relationship between sensory processing patterns and behavioral problems was significant with emotion dysregulation as a mediator. These findings help identify the relationship between emotion dysregulation, sensory processing patterns, and behavioral problems to facilitate the planning of intervention strategies for young children with ASD.

Keywords Emotion regulation · Autism · Young children · Sensory processing · Behavior · Mediator

Introduction

Emotion regulation involves intrinsic and extrinsic processes that allow us to modify emotional responses to meet our needs or the context (Thompson, 1991). Gratz and Roemer (2004) reported that emotion regulation is the process of being aware, acknowledging and understanding emotions, and using appropriate emotion regulation strategies, and behaviors to meet one's goals. The lack of abilities in each part of the process would result in emotion dysregulation. In early childhood, children develop language abilities and verbalize their emotions. Expression of emotions may contribute to the fundamental shift from emotion co-regulation to self-regulation (Vandekerckhove et al., 2008; Zeman et al.,

2006). As young children become more familiar with rules and cultural norms in this developing period, they try to regulate emotions to satisfy social interaction norms (Holidynski & Friedlmeier, 2006). Therefore, emotion regulation is an essential functional ability to develop quality social interactions that impact their lives (English et al., 2012; Rydell et al., 2007). On the contrary, emotion dysregulation contributes to social, academic, and behavioral problems (Graziano et al., 2007; Rydell et al., 2007). Understanding emotion regulation in early childhood and paying more attention to young children are crucial for designing appropriate early intervention programs.

Children with autism spectrum disorder (ASD) are commonly known to experience emotion dysregulation (Jahromi et al., 2012; Nuske et al., 2017; Samson et al., 2015). ASD is a neurodevelopment disorder with an increasing prevalence in Taiwan (Ministry of Health and Welfare, [MOWH] 2020). ASD is diagnosed with the presence of two core symptoms: problems with social interaction and communication, and repetitive behaviors or restricted interests. Diagnosis is made using the standardized criteria proposed by the Diagnostic and Statistical Manual of Mental Disorder (fifth edition) (DSM-5, American Psychiatric Association [APA], 2013). Children with ASD have problems understanding non-verbal communication, which leads to their inability to understand

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their own and others' emotions. They also have difficulties with sharing and adapting emotions and behaviors to fit in the social context (APA, 2013). In addition to the descriptions of difficulties with understanding emotions in DSM-5, researchers have suggested that emotion dysregulation in children with ASD is higher than in typically developing peers (Cai et al., 2018; Jahromi et al., 2012; Mazefsky et al., 2013; Samson et al., 2014). The core features of ASD have been found to contribute to emotion dysregulation (Mazefsky et al., 2013; Samson et al., 2014). Emotion dysregulation is associated with sensory abnormalities (Ashburner et al., 2008; Samson et al., 2014), behavior problems, depression and anxiety (Maskey et al., 2013), and language abilities (Zantinge et al., 2017). However, most of the studies have focused on adolescents or adults with ASD. Only some studies have focused on emotion regulation in young children with ASD. Studies have shown that young children with autism use fewer adaptive emotion regulation strategies than typically developing peers (Jahromi et al., 2012; Nuske et al., 2017; Zantinge et al., 2017). Young children with ASD developed emotion regulation strategies relying on familiar others (Nuske et al., 2017). They are more likely to use maladaptive strategies such as venting and avoidance strategies (Zantinge et al., 2017). Focusing on emotion dysregulation in young children with ASD is essential to help design specific intervention programs.

Behavioral problems are a critical issue in children with ASD. Behavior problems, such as tantrums, self-injuries, aggression toward others, and anxiety, are common in children with ASD. Empirical studies have shown that children with ASD have more internalizing behavioral problems, such as anxiety, withdrawnness, and sensory problems, than their peers (Maskey et al., 2013). They also present more externalizing behavioral problems, such as aggressiveness, hyperactivity, and inattentiveness (Hartley et al., 2008; Maskey et al., 2013; Ooi et al., 2011). Parenting stress (Chiang et al., 2019; Osborne & Reed, 2009), quality of life (Chuang et al., 2014), and academic and social functioning (Zaidman-Zait, 2021) are linked to children's behavioral difficulties. Although emotion dysregulation appears to be the underlying mechanism causing problematic behaviors in children with ASD (Samson et al., 2014, 2015), to date, only three studies have investigated this association in young children with ASD (Berkovits et al., 2017; Gulsrud et al., 2010; Reyes et al., 2020). A longitudinal study found that higher levels of early emotion dysregulation were related with an increase in internalized and externalized behavioral problems (Berkovits et al. 2017). Reyes et al. (2020) reported that emotion dysregulation was strongly and positively associated with more significant behavioral problems in young children with ASD. By contrast, Gulsrud et al. (2010) found no association between emotion dysregulation and behavioral problems in young children with ASD. There is limited

evidence to conclude that emotion dysregulation is related to behavioral problems in young children with ASD.

In addition to the aforementioned behavioral problems, atypical sensory processing patterns have also been well reported in children with ASD (Reynolds et al., 2012; Tomchek & Dunn, 2007). Previous studies have reported higher frequencies of sensory processing problems in children with autism than in typically developing peers (Ashburner et al., 2008; Lin, 2020; Nieto et al., 2017; Tomchek & Dunn, 2007). One diagnostic criterion proposed by the DSM-5 for ASD is unusual sensory processing, identified as “hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment” (APA, 2013). Sensory processing is defined as registering, integrating, and interpreting sensory stimulation from the environment and its behavioral responses (Dunn, 2014; Miller et al., 2007). According to Dunn (2014), sensory processing is a known interaction between neurological thresholds and the reaction behavior to receiving sensory stimuli. There are four sensory processing patterns: sensory seeking (seeker), sensory avoiding (avoider), sensory sensitivity (sensor), and low registration (bystander). Dunn (2014) reported that the seeker is the person who has a high threshold of sensory information and seeks sensory stimulation input to maintain arousal level. Children with avoider patterns try not to meet their low neurological threshold and avoid situations with excessive sensory information. The sensor is the person who is sensitive to sensory information because of low neurological threshold and excessively reacts to sensory stimuli. Lastly, the bystander is the person who has high neurological threshold and often does not notice the sensory information. Children with autism have higher frequencies of sensor and avoider patterns, such as being over-reactive to sensations (such as sounds, smells, lights, tastes, or touch) and becoming easily overwhelmed or avoidant (Simpson et al., 2019). Unusual sensory processing has been widely documented as a significant predictor of behavioral problems in children with ASD (O'Donnell et al., 2012; Schoen et al., 2009; Tseng et al., 2011). Dysfunction of the sensory processing in children with autism may impact their social functioning and participation (Suarez, 2012; Thye et al., 2018; Ismael et al., 2018), eating habits, and participation in daily activities (Ismael et al., 2018; Lin, 2020).

Emotion regulation and sensory processing are underlying mechanisms for individual behaviors in response to environmental stimuli. For example, when children enjoy pleasant music, they may dance because of the initiation of joyful emotions. As a result of their sensory processing, they may shout when they accidentally hit something. Furthermore, excessive sensory information can cause uncomfortable feelings and negative emotional reactions. However, there is scarce evidence regarding the association between emotion dysregulation and sensory processing

patterns in the current literature. Mazefsky et al. (2013) reported that sensory processing dysfunction, especially sensor and bystander, may lead to emotion dysregulation in children with ASD. To the best of our knowledge, only a few studies have focused on school-aged children with ASD and shown significant associations between emotion dysregulation, under-responsiveness or sensation seeking, and auditory filtering (Ashburner et al., 2008; Samson et al., 2014). To date, no study has been conducted to understand the association between emotion dysregulation and sensory processing patterns in young children with ASD. Because the development of emotion regulation begins in infancy, healthcare providers and researchers need to understand whether the association between emotion regulation and sensory processing patterns occurs at a younger age, for instance, among preschoolers. Therefore, more evidence is needed to understand the association between emotion dysregulation, sensory processing, and behavioral problems in young children with ASD.

One way to understand these associations is to examine whether emotion regulation is the mediator between sensory processing and problem behaviors. Brindle et al. (2015) reported that the inability to regulate emotions and acknowledge and accept negative emotions might mediate the relationship between sensory-processing sensitivity and anxiety symptoms. In children with ASD, Fernandez-Prieto et al. (2020) reported that executive functions through emotion regulation and control were a mediating factor underlying the sensory processing of and behavior consequences from environmental stimuli among young children and school-aged children with ASD. However, the association and roles of emotion dysregulation, sensory processing patterns, and problem behavior in early childhood have not been studied. Consequently, healthcare providers may have inaccurate expectations regarding the treatment of emotion dysregulation in young children with ASD. For example, healthcare providers should recognize how problem behaviors are linked to emotion dysregulation; thus, appropriate emotion regulation strategies may treat behavior problems among children with ASD.

This study aimed to investigate the relationship between emotion dysregulation, behavioral problems, and sensory processing patterns among young children with ASD. Additionally, we wanted to examine whether emotion dysregulation mediates the relationship between sensory processing patterns and behavioral problems. We hypothesized that emotion dysregulation, behavioral problems, and sensory processing patterns are highly correlated in children with ASD from four to six years old. Emotion dysregulation and regulation were the mediating factors in the relationship between sensory processing patterns and behavioral problems.

Table 1 Characteristics and scores in emotion regulation, behavior problems, and sensory processing patterns of participants with ASD

Variable	Mean (SD)/ n (%)	Range
Age (month)	58.6 (9.3)	33–73
Gender		
Male	52 (91.2%)	
Female	5 (8.8%)	
CARS-2	34.8 (4.6)	30–49
Cognitive ability (percentile rank)	39.5 (32.1)	0.1–98
Language ability (percentile rank)	46.2 (39.0)	0.1–99
ERC- Emotion regulation	23.6 (4.0)	13–33
ERC- Lability/negativity	29.7 (7.3)	18–49
CBCL		
Total problems	66.1 (12.3)	37–94
Internalizing problems	66.5 (9.8)	41–89
Externalizing problems	61.3 (13.1)	35–95
SSP-2 sensory quadrants		
Seeker	18.3 (5.7)	9–32
Avoider	28.6 (7.0)	14–42
Sensor	29.4 (6.9)	17–45
Bystander	21.8 (7.5)	0–39

ASD autism spectrum disorder, CARS2 childhood autism rating scale-second edition, ERC Emotion Regulation Checklist, CBCL Child Behavior Checklist, SSP-2 Short Sensory Profile-2

Method

Participants

This study was exploratory, using a cross-sectional design of 57 young children with ASD (mean age = 58.6 ± 9.3 months; 52 boys = 91.2%) selected from clinics, hospitals, and early intervention centers in northern and southern Taiwan. All children were diagnosed by a certified pediatric psychiatrist using the standard criteria for the DSM-5 (APA, 2013). The diagnosis was confirmed using the Childhood Autism Rating Scale, second edition (CARS-2). All children with ASD had a CARS-2 score of 30 or above (Table 1). The male to female ratio was 10.4:1.

Instruments

Childhood Autism Rating Scale-Second Edition (CARS-2)

The CARS-2 (Schopler et al., 2010) is a rating scale that assesses the severity of autistic symptoms. This is the most widely used and validated autistic assessment and covers all spectrum, including Asperger's Syndrome (Gharamaleki, et al., 2021). The CARS-2 has 15 items ranging from 1 (age appropriate) to 4 (severely abnormal) on a seven-point Likert scale, with the possibility of selecting half-point scores for each item. A higher CARS-2 score indicates severe autism

symptoms. According to the cutoff point, a score greater than 30 indicates autism, whereby 30–36.5 indicates mild to moderate autism, and greater than 37 indicates severe autism. The internal consistency ($\alpha = 0.93$), sensitivity value (0.88), and specificity value (0.86) of CARS-2 are good (Schopler et al., 2010). The internal consistency of the CARS-2 was $\alpha = 0.83$ for this study.

Emotion Regulation Checklist (ERC)

The ERC is a parent-reported questionnaire that measures the emotion regulation ability of children (Shields & Cicchetti, 1997). Parents rate their children's emotion regulation (ERC-ER subscale; 10 items), and lability and negativity (ERC-L/N subscale; 14 items) using a four-point Likert scale (where 1 is never and 4 is almost always). The ERC-ER subscale examines children's capacity to perceive, express, and regulate emotion in both negative and positive situations (sample item: "responds positively to neutral or friendly approaches by peers"). A higher score in ERC-ER indicates better emotion regulation ability. The ERC-L/N subscale assesses children's emotion dysregulation, inflexibility, and lability (sample item: "is prone to angry outbursts"). Higher scores in ERC-L/N indicate higher emotion dysregulation or emotion regulation difficulty. In this study, emotion dysregulation (ERC-L/N) was the main factor of concern. The ERC-ER was presented as emotion regulation. The internal consistency is good for both the ERC-ER ($\alpha = 0.96$) and ERC-L/N ($\alpha = 0.83$) (Shields & Cicchetti, 1997). For use in this study, we translated the ERC into a Chinese. Back-translation was completed by a bilingual individual who participated independently in the translation process. Three bilingual experts compared the original English version and the back-translation version. Discrepancies were resolved through group consensus. Finally, a bilingual expert in Taiwan reviewed the English and Chinese versions of the ERC to verify the accuracy of the translations. The internal consistency of the ERC-L/N and ERC-ER were $\alpha = 0.88$ and $\alpha = 0.64$ for the present sample, respectively.

Child Behavior Checklist (CBCL) The CBCL is a parent-reported questionnaire measuring the behavior of children 1.5–5 years old (Achenbach & Rescorla, 2000; Chen et al., 2009). It contains 100 items on a three-point Likert scale, ranging from 0 (not true) to 2 (very true or often true). This study used two behavior summary subscales—separated into internalizing problems and externalizing problems. The internalizing problems subscale includes anxious or depressed, withdrawn-depressed, and somatic complaints scores. The externalizing problems subscale includes rule-breaking and aggressive behavior. Higher scores in the internalizing and externalizing problems subscales indicate more severe behavioral problems. A t-score cutoff point above 65

indicates that children might have significant behavioral problems. The Cronbach alpha coefficient ($\alpha = 0.90$) and test-retest reliability (0.72) are both good for the CBCL (Chen et al., 2009).

Short Sensory Profile-2 (SSP-2) The SSP-2 is a parent-reported questionnaire measuring sensory processing patterns in children 3–14 years old (Dunn, 2014). This is the most commonly used questionnaire to assess a child's sensory processing pattern. The SSP-2 contains 34 items on a five-point Likert scale, ranging from 1 (almost never) to 5 (almost always). Items can be used to calculate four-quadrant scores, including the seeker pattern (the person is seeking and more engaged in sensory experiences), the avoider (the person prefers environments with limited sensory input), the sensor (the person reacts to sensation more quickly and more intensely and easily becomes overwhelmed), and the bystander (the person misses more sensory cues than others). Higher scores in each quadrant indicate higher sensory patterns than the norms. The definite difference indicates that the mean score is 2 SD more than each quadrant's standard sample. A probable definite difference indicates scores of more than 1 SD and less than 2 SD. In the present study, we used raw score of SSP-2 for analyses. The SSP-2 was translated to Chinese by the investigator. Back-translation was completed by a bilingual individual who participated independently in the translation process. An English-speaking expert and three bilingual individuals compared the original English version and the back-translation. Discrepancies were resolved through group consensus. Finally, a bilingual expert in Taiwan reviewed the English and Chinese versions of the SSP-2 to verify its accuracy. The reliability of the SSP-2 was $\alpha = 0.949$ for 109 preschool children (58 autistic children and 51 children with typical development [TD]). The internal consistency and concurrent validity of the SSP-2 are good. The internal consistency for this study was $\alpha = 0.86$.

Procedures

We provided recruitment posters and flyers to the early intervention center and pediatric rehabilitation clinicians. The researcher and several occupational therapists provided the information to parents. Those interested in participating received detailed information regarding the complete procedure from the research team. After fully understanding the study, a parent provided written informed consent if they agreed to participate. Then, the parents were required to complete the ERC, CBCL, and SSP-2 and provide information on children's age and gender. Parents also consented that researchers could obtain the intelligence quotient score and language ability score from medical charts. The cognitive assessments used were Bayley-II, Wechsler Preschool

Table 2 Correlations between emotion regulation, behavior problems, sensory processing, and children characteristics

Variables	1	2	3	4	5	6	7
1 ERC-ER	–						
2 ERC-L/N	–0.423**	–					
3 CBCL-Total	–0.504**	0.829***	–				
4 SSP-2-Seeker	–0.356**	0.607***	0.654***	–			
5 SSP-2-Avoider	–0.429**	0.773***	0.770***	0.570***	–		
6 SSP-2-Sensor	–0.505**	0.587***	0.678***	0.617***	0.718***	–	
7 SSP-2-Bystander	–0.136	0.477***	0.494***	0.536***	0.479***	0.444**	–

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. ERC: Emotion regulation checklist; ER: Emotion regulation; L/N: lability/negativity; CBCL: Child Behavior Checklist; SSP2: Short Sensory profile 2

& Primary Scale of Intelligence (WPPSI-IV), or the Test of Nonverbal Intelligence third edition (TONI-3). The language ability assessments used were the Communication and Language Screening Test for Birth to Three Chinese-Speaking Infant-Toddlers (CLST) or Preschool Language Scale (PLS), or Peabody Picture Vocabulary Test-Revised (PPVT-R). These were all well-validated assessments and widely used in the clinical assessments in Taiwan. Parents filled out the questionnaires in the rehabilitation room. Meanwhile, the occupational therapists or psychologists known to the children administered the CARS-2 in another rehabilitation room.

Data Analysis

Descriptive statistics were used to describe the demographic characteristics of the participants. We used Pearson correlation to test the correlation between the ERC and CBCL and the ERC and SSP. To understand the mediating role of emotion dysregulation and emotion regulation, we performed a linear regression to identify whether sensory processing patterns predicted behavioral problems. Mediation analysis using the Hayes' PROCESS macro for SPSS was conducted to examine whether the association between sensory processing and behavioral problems in young children with autism was mediated by emotion dysregulation (IBM, Chicago, IL, USA) (Hayes, 2018). The bootstrapping procedure was used with bias-corrected bootstrapping resamples (1,000 samples), and 95% confidence intervals (CIs) were conducted (Preacher & Hayes, 2008). A mediation effect (indirect effect) can be considered significant when zero does not fall into the CIs. A Sobel test was also conducted for mediation (Hayes, 2012). ERC-L/N was used as emotion dysregulation, and the CBCL total behavioral problem score were used as behavioral problems. All hypotheses assumed a 0.05 significance level and a two-sided alternative hypothesis.

Results

The mean scores of emotion regulation, behavioral problems, and sensory processing patterns are presented in Table 1. Average scores for emotion regulation and lability/negativity were 23.6 (SD = 4.0) and 29.7 (SD = 7.3), respectively. The children's internalizing problem T scores ranged from 41 to 89 ($m = 66.5$, $SD = 9.8$), externalizing problem T scores ranged from 35 to 95 ($m = 61.3$, $SD = 13.1$), and total problems T scores ranged from 37 to 94 ($M = 66.1$, $SD = 12.3$). According to the cutoff point of 65, the percentages of participants in the borderline or clinical ranges for internalizing, externalizing, and total problems scores were 64.9%, 36.8%, and 57.9%, respectively.

The mean scores of the four sensory quadrants were 18.3 (seeker), 28.6 (avoider), 29.4 (sensor), and 21.8 (bystander). The mean scores of the seeker quadrant were similar to those of most people from a large normative sample of the sensory quadrants. The mean scores of the other three sensory quadrants were higher than those of most people, indicating that the behavioral responses of autistic children in everyday life are linked to their sensory processing challenges. The percentages of those who scored higher than most people in the three quadrants were 78.9% (avoider), 75.4% (sensor), and 75.4% (bystander). All children with ASD had at least one atypical sensory processing quadrant. The most common atypical patterns were avoider, followed by sensor, bystander and seeker.

The relationships between emotion dysregulation, behavioral problems, and sensory processing patterns are presented in Table 2. The ERC-L/N was strongly and positively correlated with the CBCL total score ($r = 0.829$, $p < 0.001$). Moreover, all of the correlations showed significantly positive slopes across the sensory processing patterns (seeker, $r = 0.607$, $p < 0.001$; avoider, $r = 0.773$, $p < 0.001$; sensor, $r = 0.587$, $p < 0.001$; bystander, $r = 0.477$, $p < 0.001$) and the ERC-L/N. The results showed that the ERC-ER was significantly negatively correlated with the seeker ($r = -0.356$, $p = 0.007$), avoider ($r = -0.429$, $p = 0.001$), and sensor ($r = -0.505$, $p < 0.001$) patterns. Total behavioral problems

Table 3 Results of testing for mediation by emotion dysregulation on relationship between sensory processing patterns and total behavior problems

Sensory processing patterns	Effect of sensory pattern on mediator (a path)	CBCL Total behavior problems (c path)	Direct effect (c')	Indirect effect (ab)	Complete model	Sobel's test Type of mediation
Seeker	0.670 (0.137)***	0.654 (0.219)***	0.179(0.214)	0.475*	R ² =0.705, F(2, 54)=64.495***	z=4.892*** Full
Avoider	0.773 (0.089)***	0.770 (0.152)***	0.321 (0.200)	0.449*	R ² =0.729, F(2, 54)=72.580***	z=2.894** Full
Sensor	0.587 (0.115)***	0.678 (0.177)**	0.291 (0.153)*	0.386*	R ² =0.743, F(2, 54)=70.037***	z=3.391*** Partial
Bystander	0.478 (0.115) **	0.547 (0.186) ***	0.196 (0.136) *	0.351*	R ² =0.717, F(2, 54)=68.425***	z=3.257** Partial

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Unique effect of mediator (b path) was $\beta = 0.829$, $SE = 0.128$, $p < 0.001$. All coefficients reported for paths are standardized slopes with the corresponding standard error of the slope in parentheses

Table 4 Results of testing for mediation by emotion regulation on relationship between sensory processing patterns and total behavior problems

Sensory processing patterns	Effect of sensory pattern on mediator (a path)	CBCL Total behavior problems (c path)	Direct effect (c')	Indirect effect (ab)	Complete model	Sobel's test Type of mediation
Seeker	-0.356 (0.088)**	0.654 (0.219)***	0.544 (0.219)***	0.110*	R ² =0.512, F(2, 54)=28.305***	z=3.886*** Partial
Avoider	-0.429 (0.070)***	0.770 (0.152)***	0.679 (0.161)***	0.091*	R ² =0.630, F(2, 54)=46.002***	z=5.614*** Partial
Sensor	-0.505 (0.068)***	0.568 (0.201)***	0.677 (0.177)***	0.109	R ² =0.459, F(2, 54)=26.387***	z=1.376 No mediation

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Unique effect of mediator (b path) was $\beta = -0.504$, $SE = 0.036$, $p < 0.001$. All coefficients reported for paths are standardized slopes with the corresponding standard error of the slope in parentheses

were related to all of the sensory processing patterns (seeker, $r = 0.654$, $p < 0.001$; avoider, $r = 0.770$, $p < 0.001$; sensor, $r = 0.678$, $p < 0.001$; bystander, $r = 0.494$, $p < 0.001$).

The mediation effect of emotion dysregulation on the relationship between the sensory processing patterns and total behavioral problems is shown in Table 3. The sensory processing patterns with a significant indirect effect via emotion dysregulation were the seeker (Bootstrapping 95% CI [0.329, 0.6396]) and avoider (Bootstrapping 95% CI [0.298, 0.609]). There was a full mediating effect on the relationship between the seeker pattern and total behavioral problems, as well as the avoider pattern and total behavioral problems. Based on analyses using Sobel's test (Hayes, 2012), the mediation effect was significant. The results showed that young children with ASD with greater emotion dysregulation have increased behavioral problems if high seeking and avoiding behaviors appear.

Additionally, emotion dysregulation was partially mediating the relationship between the sensor pattern and total behavioral problems. A Bootstrapping CI revealed a significant indirect effect (Bootstrapping 95% CI [0.248, 0.525]). Higher levels of emotion dysregulation accounted for greater behavioral problems and higher levels of

sensory avoiding behaviors. Similarly, a partial mediating effect on the relationship between the bystander pattern and total behavioral problems was observed, indicating that greater behavioral problems in children who react to sensory stimuli faster and more intensely than others are due to a higher level of emotion dysregulation.

The mediation effect of emotion regulation on the relationship between the sensory processing patterns and total behavioral problems is shown in Table 4. Emotion regulation was partially mediating the relationship between the seeker pattern and total behavioral problems. The Bootstrapping CI revealed a significant indirect effect (Bootstrapping 95% CI [0.015, 0.230]) and significant direct effect (Bootstrapping 95% CI [0.730, 1.607]). Similarly, a partial mediating effect on the relationship between the avoider pattern and total behavioral problems was observed (indirect effect Bootstrapping 95% CI [0.004, 0.200]; direct effect Bootstrapping 95% CI [0.873, 1.521]). On the other hand, there was no significant mediating effect of emotion regulation on the relationship between the sensor pattern and total behavioral problems.

Discussion

This study investigated the relationship between emotion dysregulation, behavioral problems, and sensory processing patterns in young children with ASD. The results of this study confirmed that behavioral problems are strongly and positively correlated to emotion dysregulation and negatively correlated to emotion regulation. All of the sensory processing patterns were significantly and moderately to strongly correlated with emotion dysregulation. Moreover, all of the sensory processing patterns were significantly correlated with behavioral problems. This study further found that emotion dysregulation mediated the relationship between behavioral problems and sensory processing patterns (seeker, avoider, sensor, and bystander).

A prior longitudinal study found a substantial link between the emotion dysregulation and internalizing and externalizing behavioral problems in young children with ASD (Berkovits et al., 2017). Autistic children who had higher emotion dysregulation earlier had more internalizing and externalizing problems (Berkovits et al., 2017). Similar findings have been reported in TD children. The literature has shown that emotion dysregulation worsens externalizing and internalizing behavioral problems (Eisenberg et al., 2001). In this study, over 60% of the young children with ASD scored higher than the cutoff point in at least one of the domains scoring behavioral problems. The findings from this study correspond with those of other studies indicating a higher rate of behavioral problems in young children with ASD. Therefore, the present study results demonstrated an association between emotion regulation and behavioral problems in young children with ASD.

In terms of sensory processing patterns, the seeker, avoider, sensor, and bystander patterns had a moderate to strong correlation with emotion dysregulation. To our knowledge, this is the first study to investigate the association between emotion dysregulation and sensory processing patterns in young children with ASD. Partially consistent with the results concerning school-age children, the impairment of emotion regulation was associated with the seeker and sensor patterns (Ashburner et al., 2008; Samson et al., 2014). We have reported results for all sensory patterns. However, only the seeker and avoider patterns were fully mediated by emotion dysregulation. In addition, emotion regulation was partially mediating the relationship between some of the sensory processing patterns (seeker and avoider) and behavioral problems. These results are consistent with the findings of a previous study (Fernandez-Prieto et al., 2020). The active behavior response in the seeker and avoider sensory patterns is more related to emotion dysregulation. In Dunn's

model (Dunn, 1997), children who had a low neurological threshold for sensory stimuli and tried to avoid activities appeared withdrawn, ill, or had emotional outbursts. Consistent with previous findings, preschool children with ASD were observed to have higher reactivity to sensory stimuli (Lin, 2020). Since sensory processing occurs daily in any context, sensory processing patterns were reported in children with ASD participating in daily life activities (Ismael et al., 2018; Lin, 2020). Clinical health care providers, teachers and parents should observe behavioral responses in children with ASD to understand their sensory processing patterns. When a child with ASD and emotion dysregulation engages in daily activities, doctors and parents need to address the issue of avoidance by respecting that they may feel uncomfortable with the typical levels of sensory stimuli, acknowledging the children's needs, and introducing them to strategies to make them feel comfortable (Dunn, 1997).

Interestingly, our results showed that both behavioral problems and sensory processing patterns were significantly associated with emotion dysregulation and emotion regulation. Additionally, consistent with previous studies, we found that sensory processing patterns were associated with total problem behaviors (O'Donnell et al., 2012; Schoen et al., 2009; Tseng et al., 2011). However, there was no mediating relationship between the sensor or bystander pattern and behavioral problems through emotion regulation. The sensor and bystander patterns had passive behaviors to sensory stimuli. In a previous study, a small to fair correlations ($r = -0.13$ to -0.43) between sensory processing and internalizing and externalizing behaviors was reported in preschool children with ASD (Tseng et al., 2011). This indicates that other factors may be involved. Similar to a previous study, we found that sensory processing patterns impacted behavioral problems through the mediating effect of emotion dysregulation. Fernandez-Prieto et al. (2020) reported that emotion regulation was associated with sensory processing and behavior in children and adolescents with ASD and that sensory processing was associated with problem behaviors. Emotion regulation was the mediator for sensory processing and problem behaviors.

Moreover, our results showed the relationship of each sensory processing pattern and determined its mediating effect. Our results indicated an indirect effect, accounting for 59.3% of the association, between the avoider pattern and behavioral problems. Dunn (1997) reported that avoidance might cause negative emotions and reactions. Notably, the greater emotion dysregulation accounted for the higher chance of presenting behavioral problems in children with ASD with higher avoider scores in the sensory processing pattern. Future studies need to build an extended process model of emotion regulation, behavioral problems, and sensory processing patterns in young children with ASD.

A better understanding of the factors related to children's emotion dysregulation by healthcare providers may help to address sensory processing dysfunction as a contributing factor. In school and at home, teachers and parents might understand the behavioral problems in daily life of children with ASD better. Therefore, modifying the environmental stimuli and teaching children how to regulate emotions triggered by the sensory stimuli may be a potential method for reducing inappropriate behaviors in young children with ASD.

This study has several limitations. First, it is a cross-sectional and observational study. The results of our study can only present the relationships between factors and cannot provide further evidence on causality. Causality between these factors cannot be supported by the present study's design, and future studies are needed to provide robust evidence on causal relationships. Longitudinal studies are thus needed to corroborate our findings. Second, the present study only included young children with ASD and did not include TD children for comparisons. Therefore, we could not compare the results to those of the TD population and understand the differences between the two populations. Third, all of the measures used were parent-reported questionnaires. Therefore, the present study may have social desirability, common method variance, and recall error biases. Additionally, ERC is commonly and widely used for assessing emotion dysregulation, but there have been some concerns about the validity of using it with a population with ASD (Weiss et al., 2014) and a non-ASD population (Adrian et al., 2011; Mazefsky et al., 2021). The original ERC (Shields & Cicchetti, 1997) was a conference poster with a small sample size, with an internal consistency of $\alpha=0.96$ in ERC-LN and $\alpha=0.83$ in ERC-ER. The psychometric characteristics of the population with ASD are not well established (Weiss et al., 2014; Mazefsky et al., 2021). Studies of the population with ASD using the ERC as a measurement have reported a good internal consistency for the ERC-LN and ERC-ER (Berkovitch et al., 2017; Jahromi et al., 2012). Future studies may want to use objective measurements to corroborate the findings of this study and explore psychometrics scales that are ASD specific. Fourth, due to the small sample size, demographic characteristics, such as autism severity, language ability, cognitive ability, and sex difference, were not inputted into the mediation model for controlling. Previous studies have mentioned that cognitive ability (Nuske et al., 2020), language ability (Zantinge et al., 2017), and autism symptom severity (Mazefsky et al., 2013; Samson et al., 2014) were associated with emotion dysregulation. In addition, the sample size for female participants was not sufficient for the statistical analysis. Previous studies have shown a significant difference in the association with emotion regulation between genders (Mazefsky et al., 2013), reporting that the female population with ASD

had poor emotion dysregulation (Northrup et al., 2021). A larger sample size and more female participants are needed for future studies. Despite the limitations, this is the first study focusing on sensory processing patterns, behavioral problems, and emotion dysregulation and the mediating role in young children with ASD.

Conclusion

This study contributes the first preliminary view of the relationship between emotion dysregulation, behavioral problems, and sensory processing patterns in young children with ASD. The findings showed that behavioral problems and sensory processing patterns are associated with emotion dysregulation in young children with ASD. The results also highlighted the significant mediating role of emotion dysregulation. Emotion dysregulation plays a significant role as a mediator in the relationship between total behavioral problems and all of the sensory processing patterns, especially the seeker and avoider that were full mediated. Understanding the child's sensory profile could strengthen and individualize interventions based on child characteristics. These findings suggest that clinical interventions should consider sensory processing patterns and emotion dysregulation interventions to diminish behavioral problems in young children with ASD.

Author contributions YSS and LYL contributed to the study conception and design. Material preparation was completed by YSS. Data collection was completed by YSS and LYL. Analysis was performed by YSS and CYL. The introduction and literature review was written by YSS. Results and discussion were written by YSS and LYL. SYC and LYL commented on previous versions of the manuscript. YSS, CYL, SYC, and LYL read and approved the final manuscript.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare.

References

- Achenbach, T. M., & Rescorla, L. A. (2000). *Manual for the ASEBA preschool forms & profiles*. University of Vermont, Research Center for Children, Youth, & Families.
- Adrian, M., Zeman, J., & Veits, G. (2011). Methodological implications of the affect revolution: a 35-year review of emotion regulation assessment in children. *Journal of Experimental Child Psychology*, 113, 1–15.

- Psychology*, 110, 171–197. <https://doi.org/10.1016/j.jecp.2011.03.009>.
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Pub.
- Ashburner, J., Ziviani, J., & Rodger, S. (2008). Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy*, 62(5), 564–573. <https://doi.org/10.5014/ajot.62.5.564>.
- Berkovits, L., Eisenhower, A., & Blacher, J. (2017). Emotion regulation in young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 47(1), 68–79. <https://doi.org/10.1007/s10803-016-2922-2>.
- Brindle, K., Moulding, R., Bakker, K., & Nedeljkovic, M. (2015). Is the relationship between sensory-processing sensitivity and negative affect mediated by emotional regulation? *Australian Journal of Psychology*, 67(4), 214–221. <https://doi.org/10.1111/ajpy.12084>.
- Cai, R. Y., Richdale, A. L., Uljarević, M., Dissanayake, C., & Samson, A. C. (2018). Emotion regulation in autism spectrum disorder: where we are and where we need to go. *Autism Research*, 11(7), 962–978. <https://doi.org/10.1002/aur.1968>.
- Chiang, W. C., Tseng, M. H., Fu, C. P., Chuang, I. C., Lu, L., & Shieh, J. Y. (2019). Exploring sensory processing dysfunction, parenting stress, and problem behaviors in children with autism spectrum disorder. *American Journal of Occupational Therapy*, 73(1), 7301205130p1–7301205130p10. <https://doi.org/10.5014/ajot.2019.027607>.
- Chuang, I. C., Tseng, M. H., Lu, L., Shieh, J. Y., & Cermak, S. A. (2014). Predictors of the health-related quality of life in preschool children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 8(9), 1062–1070. <https://doi.org/10.1016/j.rasd.2014.05.015>.
- Chen, I. C., Huang, H. L., & Chung, G. C. (2009). *Chinese edition of the Achenbach System of empirically based Assessment (ASEBA)*. Psychological Publishing.
- Conner, C. M., White, S. W., Scahill, L., & Mazefsky, C. A. (2020). The role of emotion regulation and core autism symptoms in the experience of anxiety in autism. *Autism*, 24(4), 931–940.
- Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: a conceptual model. *Infants and Young Children*, 9, 23–35.
- Dunn, W. (2014). *Sensory Profile 2: user's manual*. Psych Corp.
- Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., & Guthrie, I. K. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development*, 72(4), 1112–1134. <https://doi.org/10.1111/1467-8624.00337>.
- English, T., John, O. P., Srivastava, S., & Gross, J. J. (2012). Emotion regulation and peer-rated social functioning: a four-year longitudinal study. *Journal of Research in Personality*, 46(6), 780–784. <https://doi.org/10.1016/j.jrp.2012.09.006>.
- Fenning, R. M., Baker, J. K., & Moffitt, J. (2018). Intrinsic and extrinsic predictors of emotion regulation in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 48(11), 3858–3870. <https://doi.org/10.1007/s10803-018-3647-1>.
- Fernandez-Prieto, M., Moreira, C., Cruz, S., Campos, V., Martínez-Regueiro, R., Taboada, M., & Sampaio, A. (2020). Executive functioning: a mediator between sensory processing and behaviour in autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 51(6), 2091–2103. <https://doi.org/10.1007/s10803-020-04648-4>.
- Gharamaleki, F. F., Bahrami, B., & Masumi, J. (2021). Autism screening tests: a narrative review. *Journal of Public Health Research*, 11(1), 2308. <https://doi.org/10.4081/jphr.2021.2308>.
- Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, 26, 41–54. <https://doi.org/10.1023/B:JOBA.0000007455.08539.94>.
- Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation and children's early academic success. *Journal of school psychology*, 45(1), 3–19. <https://doi.org/10.1016/j.jsp.2006.09.002>.
- Gross, J. J. (2015). Emotion regulation: current status and future prospects. *Psychological Inquiry*, 26(1), 1–26.
- Gulsrud, A. C., Jahromi, L. B., & Kasari, C. (2010). The co-regulation of emotions between mothers and their children with autism. *Journal of Autism and Developmental Disorders*, 40(2), 227–237. <https://doi.org/10.1007/s10803-009-0861-x>.
- Hartley, S. L., Sikora, D. M., & McCoy, R. (2008). Prevalence and risk factors of maladaptive behaviour in young children with autistic disorder. *Journal of Intellectual Disability Research*, 52(10), 819–829. <https://doi.org/10.1111/j.1365-2788.2008.01065.x>.
- Hayes, A. F. (2012). *PROCESS: a versatile computational tool for observed variable mediation, moderation, and conditional process modeling*. [White paper].
- Holodynski, M., & Friedlmeier, W. (2006). *Development of emotions and ER*. Springer Science & Business Media.
- Ismael, N., Lawson, L. M., & Hartwell, J. (2018). Relationship between sensory processing and participation in daily occupations for children with autism spectrum disorder: a systematic review of studies that used Dunn's sensory processing framework. *American Journal of Occupational Therapy*, 72(3), 7203205030p1–7203205030p9. <https://doi.org/10.5014/ajot.2018.024075>.
- Jahromi, L. B., Meek, S. E., & Ober-Reynolds, S. (2012). Emotion regulation in the context of frustration in children with high functioning autism and their typical peers. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 53(12), 1250–1258. <https://doi.org/10.1111/j.1469-7610.2012.02560.x>.
- Li, B., Bos, M. G., Stockmann, L., & Rieffe, C. (2020). Emotional functioning and the development of internalizing and externalizing problems in young boys with and without autism spectrum disorder. *Autism*, 24(1), 200–210. <https://doi.org/10.1177/1362361319874644>.
- Lin, L. Y. (2020). Activity participation and sensory processing patterns of preschool-age children with autism spectrum disorder. *American Journal of Occupational Therapy*, 74(6), 7406345010. <https://doi.org/10.5014/ajot.2020.039297>. p7406345011-7406345010p7406345017.
- Maskey, M., Warnell, F., Parr, J. R., Le Couteur, A., & McConachie, H. (2013). Emotional and behavioural problems in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 43(4), 851–859. <https://doi.org/10.1007/s10803-012-1622-9>.
- Mazefsky, C. A., Herrington, J., Siegel, M., Scarpa, A., Maddox, B. B., Scahill, L., & White, S. W. (2013). The role of emotion regulation in autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, 52(7), 679–688. <https://doi.org/10.1016/j.jaac.2013.05.006>.
- Mazefsky, C. A., Conner, C. M., Breitenfeldt, K., Leezenbaum, N., Chen, Q., Bylsma, L. M., & Pilkonis, P. (2021). Evidence base update for questionnaires of emotion regulation and reactivity for children and adolescents. *Journal of Clinical Child and Adolescent Psychology*, 50(6), 683–707. <https://doi.org/10.1080/15374416.2021.1955372>.
- Miller, L. J., Anzalone, M. E., Lane, S. J., Cermak, S. A., & Osten, E. T. (2007). Concept evolution in sensory integration: a proposed

- nosology for diagnosis. *American Journal of Occupational Therapy*, 61(2), 135–140.
- Ministry of Health and Welfare (2020). *Statistics of General Health and Welfare 2018*. <https://www.mohw.gov.tw/lp-4614-2.html>
- Nader-Grosbois, N., & Mazzone, S. (2014). Emotion regulation, personality and social adjustment in children with autism spectrum disorders. *Psychology*, 5(15), 1750. <https://doi.org/10.4236/psych.2014.515182>.
- Nieto, C., López, B., & Gandía, H. (2017). Relationships between atypical sensory processing patterns, maladaptive behaviour and maternal stress in Spanish children with autism spectrum disorder. *Journal of Intellectual Disability Research*, 61(12), 1140–1150. <https://doi.org/10.1111/jir.12435>.
- Nuske, H. J., Pellecchia, M., Kane, C., Seidman, M., Maddox, B. B., Freeman, L. M., Rump, K., Reisinger, E. M., Xie, M., & Mandell, D. S. (2020). Self-regulation is bi-directionally associated with cognitive development in children with autism. *Journal of Applied Developmental Psychology*, 68, 101139. <https://doi.org/10.1016/j.appdev.2020.101139>.
- Nuske, H. J., Hedley, D., Woollacott, A., Thomson, P., Macari, S., & Dissanayake, C. (2017). Developmental delays in emotion regulation strategies in preschoolers with autism. *Autism Research*, 10(11), 1808–1822. <https://doi.org/10.1002/aur.1827>.
- Northrup, J. B., Patterson, M. T., & MazeFSky, C. A. (2021). Predictors of severity and change in emotion dysregulation among children and adolescents with ASD. *Journal of Clinical Child and Adolescent Psychology*, 50(6), 708–729. <https://doi.org/10.1080/15374416.2021.1955369>.
- O'Donnell, S., Deitz, J., Kartin, D., Nalty, T., & Dawson, G. (2012). Sensory processing, problem behavior, adaptive behavior, and cognition in preschool children with autism spectrum disorders. *American Journal of Occupational Therapy*, 66(5), 586–594. <https://doi.org/10.5014/ajot.2012.004168>.
- Ooi, Y. P., Tan, Z. J., Lim, C. X., Goh, T. J., & Sung, M. (2011). Prevalence of behavioural and emotional problems in children with high-functioning autism spectrum disorders. *Australian and New Zealand Journal of Psychiatry*, 45(5), 370–375. <https://doi.org/10.3109/00048674.2010.534071>.
- Osborne, L. A., & Reed, P. (2009). The relationship between parenting stress and behavior problems of children with autistic spectrum disorders. *Exceptional Children*, 76(1), 54–73. <https://doi.org/10.1177/001440290907600103>.
- Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, 40, 879–891. <https://doi.org/10.3758/BRM.40.3.879>.
- Reyes, N. M., Factor, R., & Scarpa, A. (2020). Emotion regulation, emotionality, and expression of emotions: a link between social skills, behavior, and emotion problems in children with ASD and their peers. *Research in Developmental Disabilities*, 106, 103770. <https://doi.org/10.1016/j.ridd.2020.103770>.
- Reynolds, S., Lane, S. J., & Thacker, L. (2012). Sensory processing, physiological stress, and sleep behaviors in children with and without autism spectrum disorders. *OTJR: Occupation Participation and Health*, 32(1), 246–257. <https://doi.org/10.3928/15394492-20110513-02>.
- Rydell, A. M., Thorell, L. B., & Bohlin, G. (2007). Emotion regulation in relation to social functioning: an investigation of child self-reports. *European Journal of Developmental Psychology*, 4(3), 293–313. <https://doi.org/10.1080/17405620600783526>.
- Samson, A. C., Phillips, J. M., Parker, K. J., Shah, S., Gross, J. J., & Hardan, A. Y. (2014). Emotion dysregulation and the core features of autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 44(7), 1766–1772. <https://doi.org/10.1007/s10803-013-2022-5>.
- Samson, A. C., Hardan, A. Y., Lee, I. A., Phillips, J. M., & Gross, J. J. (2015). Maladaptive behavior in autism spectrum disorder: the role of emotion experience and emotion regulation. *Journal of Autism and Developmental Disorders*, 45(11), 3424–3432. <https://doi.org/10.1007/s10803-015-2388-7>.
- Scarpa, A., & Reyes, N. M. (2011). Improving emotion regulation with CBT in young children with high functioning autism spectrum disorders: a pilot study. *Behavioural and Cognitive Psychotherapy*, 39, 495–500. <https://doi.org/10.1017/S1352465811000063>.
- Schoen, S. A., Miller, L. J., Brett-Green, B. A., & Nielsen, D. M. (2009). Physiological and behavioral differences in sensory processing: a comparison of children with autism spectrum disorder and sensory modulation disorder. *Frontiers in Integrative Neuroscience*, 3, 29. <https://doi.org/10.3389/neuro.07.029.2009>.
- Schopler, E., Van Bourgondien, M. E., Wellman, G. J., & Love, S. R. (2010). *Childhood Autism Rating Scale* (2nd ed.). Western Psychological Services.
- Shields, A., & Cicchetti, D. (1997). Emotion regulation among school-age children: the development and validation of a new criterion Q-sort scale. *Developmental Psychology*, 33(6), 906–916.
- Simpson, K., Adams, D., Alston-Knox, C., Heussler, H. S., & Keen, D. (2019). Exploring the sensory profiles of children on the autism spectrum using the short sensory Profile-2 (SSP-2). *Journal of Autism and Developmental Disorders*, 49(5), 2069–2079. <https://doi.org/10.1007/s10803-019-03889-2>.
- Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin*, 87, 245–251.
- Suarez, M. A. (2012). Sensory processing in children with autism spectrum disorders and impact on functioning. *Pediatric clinics of North America*, 59(1), 203–xiii. <https://doi.org/10.1016/j.pcl.2011.10.012>.
- Thompson, R. A. (1991). Emotional regulation and emotional development. *Educational Psychology Review*, 3(4), 269–307. <https://doi.org/10.1007/BF01319934>.
- Thye, M. D., Bednarz, H. M., Herringshaw, A. J., Sartin, E. B., & Kana, R. K. (2018). The impact of atypical sensory processing on social impairments in autism spectrum disorder. *Developmental Cognitive Neuroscience*, 29, 151–167. <https://doi.org/10.1016/j.dcn.2017.04.010>.
- Tomchek, S. D., & Dunn, W. (2007). Sensory processing in children with and without autism: a comparative study using the short sensory Profile. *American Journal of Occupational Therapy*, 61(2), 190–200. <https://doi.org/10.5014/ajot.61.2.190>.
- Tseng, M. H., Fu, C. P., Cermak, S. A., Lu, L., & Shieh, J. Y. (2011). Emotional and behavior problems in preschool children with autism: relationship with sensory processing dysfunction. *Research in Autism Spectrum Disorders*, 5(4), 1441–1450. <https://doi.org/10.1016/j.rasd.2011.02.004>.
- Vandekerckhove, M., Jung, S., & Kronast, S. (2008). *Regulating emotions: culture, social necessity, and biological inheritance*. Blackwell Pub.
- Weiss, J. A., Thomson, K., & Chan, L. (2014). A systematic literature review of emotion regulation measurement in individuals with autism spectrum disorder. *Autism Research*, 7(6), 629–648. <https://doi.org/10.1002/aur.1426>.
- Zantinge, G., van Rijn, S., Stockmann, L., & Swaab, H. (2017). Physiological arousal and ER strategies in young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 47(9), 2648–2657. <https://doi.org/10.1007/s10803-017-3181-6>.
- Zeman, J., Cassano, M., Perry-Parrish, C., & Stegall, S. (2006). Emotion regulation in children and adolescents. *Journal of Developmental & Behavioral Pediatrics*, 27(2), 155–168. <https://doi.org/10.1097/00004703-200604000-00014>.

Zaidman-Zait, A., Mirenda, P., Szatmari, P., Duku, E., Smith, I. M., Zwaigenbaum, L., Vaillancourt, T., Kerns, C., Volden, J., Waddell, C., Bennett, T., Georgiades, S., Ungar, W. J., & Elsabbagh, M. (2021). Profiles and predictors of academic and social school functioning among children with autism spectrum disorder. *Journal of Clinical Child and Adolescent Psychology*, *50*(5), 656–668. <https://doi.org/10.1080/15374416.2020.1750021>.

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