RELATIONS BETWEEN TIC SEVERITY, EMOTION REGULATION, AND SOCIAL AND FAMILY FUNCTIONING IN YOUTH WITH TOURETTE SYNDROME

by

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ABSTRACT

Objective: This study aimed to examine associations between tic severity, emotion regulation (ER), and social and family functioning in children and adolescents with Tourette Syndrome (TS). The potential mediational and/or moderational role of ER was also examined. *Method:* Caregivers of youth with TS were administered proxy-report measures of tic severity, ER, social functioning, social impairment, and impact on family life. *Results:* Total tic severity and motor tic severity were associated with ER and all social and familial outcomes. Vocal tic severity was not associated with ER or social functioning, but was related to social impairment and impact on family life. ER mediated the relations between total tic severity and all social and familial outcomes, as well as between motor tic severity and all social and familial outcomes. ER did not moderate any of the tested associations. *Conclusion:* Tic severity is associated with ER and social and family functioning in youth with TS, with ER mediating the associations between total and motor tic severity and social functioning, social impairment, and impact on family life. Implementing interventions that target ER would likely be a beneficial adjunctive therapy provided to youth with TS, and may result in improved social and family functioning.

INDEX WORDS: Tourette Syndrome, Child and Adolescent, Tic Severity, Emotion Regulation, Social Functioning, Family Functioning, Impact on Family Life

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CHAPTER 1

RELATIONS BETWEEN TIC SEVERITY, EMOTION REGULATION, AND SOCIAL AND FAMILY FUNCTIONING IN YOUTH WITH TOURETTE SYNDROME

Tourette Syndrome (TS) is a neuropsychiatric disorder with childhood onset characterized by the presence of multiple motor and vocal tics for more than one year (American Psychiatric Association, 2013). Tics are defined as sudden and recurrent motor movements or vocalizations that wax and wane in frequency and severity. TS is recognized as a complex disorder; in addition to experiencing tics, children with TS often present with comorbid psychiatric conditions, including attention-deficit/hyperactivity disorder (ADHD), obsessive compulsive disorder (OCD), mood disorders, and anxiety disorders (Hirschtritt et al., 2015). Studies conducted in clinical populations and community samples have consistently found that about 90% of individuals with TS present with psychiatric and behavioral comorbidities (Cavanna et al., 2013), and approximately 30% of patients with TS have three additional disorders (Müller-Vahl et al., 2010). TS affects around 1% of school-aged individuals and is three to four times more common in males than females (Cavanna et al., 2013).

TS is strongly associated with impairment across many psychosocial domains of functioning (Conelea et al., 2011). Storch and colleagues (2007a) examined tic-related functional impairment in a clinical sample of youth with TS. Parents rated the degree to which tics interfered with their children's school, home, and social functioning. Results indicated that approximately 52% of children experienced significant tic-related impairment in at least one domain, and 38% of the sample had two or more significant tic-related problem areas. While multiple domains of tic-related impairment were represented, parents most frequently reported that their child's social functioning was negatively impacted by their tics. This finding is consistent with the extant literature, which suggests that social functioning is often negatively affected by TS (Güler, Berkem, Yazgan, & Kalaça, 2015; O'Hare, Helmes, Reece, Eapen, & McBain, 2016). Within the domain of social functioning, research shows that peers rate youth with TS less positively (Friedrich, Morgan, & Devine, 1996) and less socially acceptable (Boudjouk, Woods, Miltenberger, & Long, 2000) than children without TS. Similarly, Storch and colleagues (2007b) found that peer victimization, such as bullying and teasing, occurred at higher rates in those with TS compared to age-matched controls. Peer victimization was also found to be positively associated with loneliness, anxiety, and internalizing symptoms, indicating that victimization has a negative impact on overall adjustment. Further research produced similar findings to those highlighted above. Specifically, children with TS were significantly more withdrawn and less popular than their typical classmates (Stokes, Bawden, Backman, Dooley, & Camfield, 1991). Of note, Stokes and colleagues (1991) also found that children with TS displayed more aggressive behavior than their classmates. In sum, research suggests that youth with TS are viewed less favorably by their peers, are more likely to be the recipients of peer victimization, and are often more withdrawn, less popular, and experience higher levels of loneliness compared to children and adolescents without TS.

In addition to social functioning, TS often negatively impacts family functioning. In a study conducted by Wilkinson et al. (2001), results indicated that TS had significant adverse effects on the family in domains such as the quality of family relationships, family social life, and family finances. Other areas of impact on the family include high caregiver strain (Cooper & Livingston, 2003; Schoeder & Remer, 2007) and stress (Lee, Chen, Wang, & Chen, 2007;

Wilkinson, Marshall, & Curtwright, 2008). For example, Cooper and Livingston (2003) compared the level of impact on the family between a group of children with TS and a group of children with asthma. Findings showed that mothers of children with TS felt significantly greater burden than did mothers of children with asthma. Furthermore, mothers of children with TS reported that the source of most of their stress was related to managing their child's daily activities and their child's behavioral difficulties. Thus, having a child with TS seems to negatively impact family functioning, as well as result in caregiver burden.

A main contributing factor to these various social and familial difficulties in individuals with TS is tic severity (Wilkinson et al., 2001; O'Hare et al., 2016). In a study conducted by Woods, Fuqua, and Outman (1999), results revealed that as tic frequency and severity increase, negative social impact also increases. Additionally, Conelea and colleagues (2011) conducted a study on the impact of chronic tic disorders on youths' functioning in various domains, including physical, social, familial, academic, and psychological functioning. According to both caregiver and child report, tic severity was positively related to social interference. In regards to familial outcomes, greater tic severity has been found to be associated with an overall greater negative impact on the family (Wilkinson et al., 2001). Likewise, Woods, Himle, and Osmon (2005) found that greater tic severity is associated with greater impact on family relationships, the family's social life, and family finances.

One factor to consider when studying the impact of tics on social and familial functioning is the effect of comorbid disorders (Woods et al., 2005). Although tics are the distinguishing feature of TS, other psychiatric symptoms and disorders co-occur in approximately 90% of individuals with TS (Cavanna et al., 2013). Thus, comorbid conditions are part of the overall presentation for the vast majority of individuals with TS. It is possible that the comorbid symptoms or an interaction between the TS symptoms and comorbid symptoms, rather than just the TS symptoms themselves, are primarily responsible for functional impairment. In research, the creation of TS-only groups (without comorbid conditions) either requires specially designed enrollment procedures or the enrollment of large samples to yield enough participants who have TS without comorbid conditions. In a between-group study that examined the differential impact of TS alone versus TS with comorbid disorders, findings suggest that TS has negative effects on functioning independent of comorbid symptoms (e.g., O'Hare et al., 2016). Greater impairment, however, is typically found for those with TS plus comorbid symptoms in comparison to those with TS alone (e.g., Carter et al., 2000; Conelea et al., 2011; Wilkinson et al., 2001). Given that, in reality, most children and adolescents with TS also have comorbid disorders, the current study will examine social and familial outcomes without controlling for comorbid diagnosis or symptomology.

While there are established relations between tic severity and social and familial impairment, it is possible that other variables may significantly impact these associations. A factor that has been identified as a vital component in children's adaptive social functioning and psychological adjustment is emotional competence (Suveg & Zeman, 2004). One critical skill that underlies emotional competence is emotion regulation (ER). According to Thompson (1994), ER is 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." Included in this definition are several aspects of ER. First, ER involves adjusting emotional arousal to be congruent with the situation at hand. Also, ER includes both acquired, internal self-regulation strategies (e.g., deep breathing) as well as external influences that play a role in regulating one's emotions (e.g., caregivers using distraction to soothe a child during a medical procedure). Third, ER often affects the intensity and temporal features of different emotions. Specifically, various aspects of emotion management can reduce or enhance experienced emotion, slow down or speed up its onset or recovery, limit or augment its persistence over time, and decrease or increase emotion range or lability. Lastly, ER is utilized to help achieve one's goals for a particular situation.

To date, very few studies have examined ER in individuals with TS. Thus, it is unclear whether ER may function as a mediator or moderator of the effects of tic severity on social and family functioning in children and adolescents with this disorder. It is possible that ER mediates the relation between tic severity and social and family functioning, as the neural mechanisms that are responsible for tics are also associated with the emotional difficulties (e.g., outbursts, low frustration tolerance) often seen in those with TS (Stern, Blair, & Peterson, 2008). TS is associated with abnormalities in the striatal GABAergic system that result in excessive striatal dopamine and disinhibition of prefrontal motor circuits, which causes an increase in tic production (Caligiore, Mannella, Arbib, & Baldassarre, 2017). Similarly, ER relies on sub-regions of the prefrontal cortex that decrease activation of the amygdala and allow individuals to more easily implement ER strategies (Ochsner, Silvers, & Buhle, 2012). Thus, both tics and ER rely on the same prefrontal circuitry.

Furthermore, the orbitofrontal cortex (OFC) is a portion of the prefrontal cortex that is largely involved in ER processes (Golkar et al., 2012) and has been implicated as a brain region that is responsible for severe emotion dysregulation in individuals with TS (Stern et al., 2008). Specifically, a sub-set of those with TS report experiencing a high rate of explosive outbursts and self-injurious behavior, which are likely due to abnormalities in the OFC (Stern et al., 2008). In a study of 218 individuals (ages 5-75 years) with TS, 20% of participants experienced sudden, dramatic, repetitive, explosive outbursts of verbal and/or physical aggression (Chen et al., 2013). Although explosive outbursts are short-term displays of emotion, many researchers believe that these explosive outbursts are linked to ER more broadly and that these repetitive outbursts are potentially part of wider difficulties with impulse control (Drury, Wilkinson, Robertson, & Channon, 2016). Additionally, 29% of a large sample of children and adults with TS engaged in self-injurious behaviors, such as head-banging, persistent skin picking, or scratching (Mathews et al., 2004). Predictors for severe self-injurious behaviors included explosive outbursts and risk-taking, suggesting that self-injurious behaviors are linked to ER in individuals with TS (Stern et al., 2008). Taken together, although few studies have been conducted on the neurobiological effects of TS on ER specifically, especially among children and adolescents, preliminary evidence suggests that dysfunction in prefrontal circuitry in individuals with TS contributes to the ER difficulties seen this population.

Graziano, McNamara, Geffken, & Reid (2011) conducted a study that provides further evidence in support of a mediational role of ER in the relation between tic severity and social and familial outcomes. This study, which examined the association between ADHD symptom severity and parenting stress, revealed a mediational role of emotional lability, among other factors (Graziano et al., 2011). Specifically, in a sample of 80 children and adolescents with ADHD, multiple mediation analyses indicated that the association between ADHD symptoms and parenting stress was explained by children’s emotional lability, perceived comorbid aggression levels, and executive functioning difficulties. Given the high comorbidity between TS and ADHD, similar relations between symptom severity, ER, and social and familial outcomes may be observed in youth with TS.

On the other hand, it is possible that ER moderates the relation between tic severity and social and familial outcomes. Prior research has preliminarily identified ER as a moderator of the relation between symptom severity and children's social functioning in youth with anxiety, a disorder that also commonly co-occurs with TS. In a study conducted by Jacob, Suveg, and Whitehead (2014), analyses revealed that the relation between anxiety severity and social problems was exacerbated for youth who were high in lability/negativity and low in ER coping. Thus, it is possible that the relation between tic severity and social and familial outcomes is enhanced in TS-affected youth who have poor ER skills, and reduced in youth with TS who have strong ER skills, suggesting a moderational role of ER. As ER has yet to be studied in children and adolescents with TS, as well as there being evidence to support both mediation and moderation models, both pathways will be examined in the current study.

The Current Study

The current study aims to address gaps in the TS literature by furthering our understanding of the relations between tic severity, ER, social functioning, social impairment, and impact on family life in youth with TS. If ER emerges as a factor that helps to explain the relations between tic severity and poor social and familial outcomes, results from this study could be used to help guide the development of interventions to support the functioning of children with TS and their families. Based on a review of the literature on pediatric TS, it was hypothesized that tic severity will be negatively associated with ER, social functioning, and impact on family life (higher scores indicate less negative impact), and positively associated with social impairment. ER is also expected to be positively associated with social and family functioning. Additionally, given that it is theoretically plausible that ER can function as either a mediator or moderator based on the extant literature, both models will be tested with no specific hypotheses offered.

CHAPTER 2

METHOD

Participants

Participants included 77 caregivers of children and adolescents with a diagnosis of TS. All participants were the caregivers of children and adolescents attending Camp Twitch and Shout, a week-long summer camp in the Southeastern United States for youth with TS. Inclusion criteria for this study include: (1) having a child who is between the age of 8 and 18, and (b) being fluent in English. All caregivers of children who attended camp (*N* = 141) were requested to complete various inventories prior to camp to aid the directors in planning for campers' special needs. Of those, 84 completed some or all of the inventories, with 82 caregivers consenting for their data to be used in the current study. Of these 82 consenting participants, 77 completed all study measures. This yielded a final participation rate of 54.6% of all caregivers of campers, and 91.7% of all caregivers who completed some or all inventories.

The present sample represents predominately female (*n* = 61; 79.2%) caregivers between the ages of 31 and 62 (*M* = 44.17; *SD* = 6.65). A majority of the participants were biological parents of the children and adolescents attending camp (*n* = 69; 89.6%), while others were adoptive parents and legal guardians. Most participants were Caucasian (*n* = 72; 93.5%), followed by African American, Hispanic, and Biracial.

Demographic information about the caregivers' children was also collected. Participants' children were mostly male (*n* = 48; 62.3%), ranging in age from 8 to 17 years (*M* = 13.1; *SD* = 2.29). A majority of campers were Caucasian (*n* = 70; 90.9%), followed by African American, Hispanic, Asian, and Biracial. Approximately 18% of campers had been diagnosed with one comorbid condition (e.g., ADHD, OCD, depression, anxiety), 19.5% of campers had been diagnosed with 2 comorbidities, and approximately 56% of campers had been diagnosed with 3 or more comorbid conditions. Only 6.5% of campers had TS without comorbidities. See Table 1 for further details.

Procedure

All study procedures were approved by the Institutional Review Board of the participating institution. To recruit participants for this study, investigators contacted all potentially eligible caregivers (*N* = 141) approximately 1 to 2 months before camp via email using contact information provided by Camp Twitch and Shout. Details regarding the study aims were provided in the initial contact email, and parents were asked to click on a secure Qualtrics hyperlink to access the full informed consent document and questionnaires. Caregivers consented or declined to participate in research prior to responding to the questionnaires. Those who declined were still asked to complete the questionnaires in order to help camp staff best prepare for the needs of each individual camper. In addition to the recruitment email, trained research assistants contacted families by telephone to invite them to participate in the study and answer any questions that they had about the research procedures and goals. Caregivers did not receive compensation for their participation. Caregivers who declined to participate in the study (*n* = 2) were asked to complete a brief anonymous demographic questionnaire to allow the researchers to examine sociodemographic differences between those who participated and those who did not. However, due to the low rate of declines among caregivers who provided any information, differences between participants and decliners were not examined.

Measures

Participants completed a brief demographic questionnaire to provide basic information about themselves (i.e., age, gender, ethnicity, relationship to the child or adolescent, relationship status, and family income) and their children (i.e., age, gender, ethnicity, and comorbid diagnoses).

Tic severity

Tic Severity Scale Report – Parent Report (TSSR-P; Allen et al., 2005; Scahill, Leckman, Schultz, Katsovich, & Peterson, 2003). Caregivers completed the TSSR-P, which is a caregiver proxy-report measure of children's motor and vocal tic severity over the past week. Items are rated on a 4-point scale ranging from *No symptoms at all this past week* to *Tics were very frequent and very forceful*. The TSSR-P yields two subscales: Motor Tic Severity and Vocal Tic Severity; a Total Tic Severity composite was also calculated by summing the motor and vocal tic severity ratings. In a previous study, the TSSR-P Total Tic Severity scale showed good internal consistency, with a Cronbach's alpha of .88 (Eaton et al., 2016). In the present study, internal consistency on the TSSR-P was excellent for Total Tic Severity ($\alpha = .92$) and Motor Tic Severity ($\alpha = .90$), and good for Vocal Tic Severity ($\alpha = .87$).

Child and adolescent emotion regulation

Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997). Caregivers completed the ERC, which assesses caregivers' perceptions of their child's typical methods of managing emotional experiences on a 4-point scale ranging from *Never* to *Always*. The ERC yields two subscales: (1) Lability/Negativity and (2) Emotion Regulation. In the current study, only the Emotion Regulation subscale, which measures appropriate emotional expression, empathy, and emotional self-awareness, was used. The ERC has previously been used in a sample of children and adolescents with ADHD who ranged in age from 4.5 to 18 years of age (Graziano et al., 2011). Furthermore, Cronbach's alpha for the Emotion Regulation subscale has been shown to be good (α = .83), and discriminant validity of the ERC has been established (Shields & Cicchetti, 1997). In the current sample, internal consistency of the Emotion Regulation subscale of the ERC was acceptable (α = .73).

Social functioning

The Pediatric Quality of Life Inventory – Parent Report (PedsQL; Varni, Seid, & Kurtin, 2001). Caregivers completed the PedsQL, which assesses caregivers' perceptions of their child's or adolescent's health-related quality of life. The PedsQL has 4 subscales, including physical functioning, emotional functioning, social functioning, and school functioning. In the current study, only the 5-item social functioning subscale was utilized. Depending on the age of their child, caregivers either completed the PedsQL Parent Report for Children (for ages 8-12) or the PedsQL Parent Report for Teens (for ages 13-18); both versions contain the same questions, but with different wording (e.g., "getting along with other children" versus "getting along with other teens). Items are rated using a 5-point scale ranging from *Never* to *Almost always*. The 5-point scale translates into values of 0, 25, 50, 75, and 100 per item, with the total social functioning score representing the average of all items. The reliability of the social functioning subscale of the PedsQL typically ranges from acceptable to excellent, exceeding the standard of .70, and strong validity has been demonstrated (Varni et al., 2001). In the current study, internal consistency of the PedsQL social functioning subscale was good for both the Parent Report for Children (α = .84) and the Parent Report for Teens (α = .80).

Social impairment

Child Tourette Syndrome Impairment Scale – Parent Report (CTIM-P; Storch et al., 2007a). Caregivers completed the CTIM-P, which is a measure that includes school, home, and social activities that may be impaired by a child's tic symptoms. In the current study, only the social activities subscale was used. Caregivers are asked to "Please rate how much your child's Tourette syndrome (vocal and motor tics) has caused difficulties for him or her in the following areas over the past month" on a 4-point scale ranging from *Not at all* to *Very much*. Internal consistency of the CTIM-P has been found to be excellent (α = .94), and convergent and divergent validity has been established (Storch et al., 2007a). In the current sample, internal consistency of the CTIM-P social activities subscale was excellent (α = .93).

Impact on family life

Parent Response to Child Illness (PRCI; Austin et al., 2008). Caregivers completed the PRCI, which assesses caregivers' responses and perceptions related to having a child with TS. The PRCI has 5 subscales: (1) Child Support, (2) Family Life/Leisure, (3) Condition Management, (4) Child Autonomy, and (5) Child Discipline. In the current study, only the Family Life/Leisure subscale was utilized. Items are rated on a 5-point scale ranging from *Strongly disagree* to *Strongly agree*, reflecting the negative impact that TS has on the activities of the family, with higher scores indicating less impact. High internal consistency reliability and validity of the Family Life/Leisure subscale of the PRCI is supported by previous research (Austin et al., 2008). Internal consistency of the Family Life/Leisure subscale in the current sample was good (α =.88).

Statistical Analyses

All statistical analyses were conducted using IBM Statistical Package for the Social Sciences, Version 22.0 (SPSS).

Descriptive and Correlational Analyses

Descriptive statistics including means, standard deviations (*SD*), and ranges were calculated for all sociodemographic (i.e., caregiver age, gender, ethnicity, relationship to the child or adolescent, and annual family income; child or adolescent age, gender, ethnicity, and comorbid diagnoses) and study variables (i.e., total tic severity, motor tic severity, vocal tic severity, ER, social functioning, social impairment, and impact on family life) to characterize the sample. Preliminary analyses using Spearman's rank-order correlations were conducted to determine if there were any significant associations between sociodemographic variables and study variables. Additionally, Spearman's correlations or partial correlations controlling for specific demographic variables, as determined by the preliminary analyses, were conducted to investigate the associations among all main study variables. Due to the non-normal distribution of six of the seven study variables, as described below, Spearman's correlations were used. Spearman's correlations are recommended when data do not meet the normality requirement for using Pearson product-moment correlations (Hauke & Kossowski, 2011).

Mediation and Moderation Analyses

Nine separate mediation analyses, as well as 9 separate moderation analyses, were conducted to examine the extent to which ER mediates and/or moderates the relations between tic severity (total, motor, vocal) and social functioning, social impairment, and impact on family life. To conduct these analyses, approaches that are best supported by the current literature were used. Specifically, the PROCESS procedures for SPSS outlined by Hayes (2013) were utilized. The SPSS macro for PROCESS is available online at http://www.afhayes.com/introduction-to-mediation-moderation-and-conditional-process-analysis.html.

Mediation Analyses. To examine the proposed mediation analyses, indirect effects of the models were tested by producing a bootstrapped estimation of the indirect effect based on 5,000 iterations and a 95% confidence interval for this estimate. In the event that zero does not lie within the 95% confidence interval for the bootstrapped results for indirect effects, we can conclude that the indirect effect is significantly different from zero and that mediation is demonstrated (Preacher & Hayes, 2004). Especially with small sample sizes, recent research supports the use of the bootstrapped samples and associated confidence intervals to determine significance (Preacher & Hayes, 2004). Given that the proposed study used cross-sectional data, the mediational analyses do not support determining causal relations.

Moderation Analyses. Moderation analyses examined the simple effects at high (+1 *SD*) and low (-1 *SD*) levels of ER (Holmbeck, 2002) following procedures of Hayes (2013) using the PROCESS macro for SPSS. Due to the non-normal distributions of the data for each of the variables except social functioning (raw data ranges: kurtosis = 0.29 – 4.60, skewness = -2.24 – 5.03), log transformations were conducted. This resulted in normal distributions for total, motor, and vocal tic severity, but did not result in improvements to the distributions beyond the raw data for ER, social impairment, and impact on family life (raw data ranges: kurtosis = 0.29 – -0.62, skewness = -2.24 – 3.89). Data analyses were conducted in two ways in order to thoroughly test for moderation, with raw data for all variables as well as with the log transformed data for total, motor, and vocal tic severity.

Power Analyses

Sample sizes necessary to detect significant statistical effects were determined a priori. G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) was used to calculate the sample size necessary to detect effects with power = .80, α = .05, and medium effect size for correlational analyses = 0.30 (Cohen, 1988). It was determined that 82 caregivers are required to detect effects for Spearman's rank-order correlations. For mediation analyses with power = .80, α = .05, and medium effect size for mediation = 0.15 (Cohen, 1988), 55 caregivers are required to detect significant effects. For moderation analyses with power = .80, α = .05, and medium effect size for moderation = 0.15 (Cohen, 1988), 77 caregivers are required to detect significant effects.

CHAPTER 3

RESULTS

Descriptive Data, Preliminary Analyses, and Correlational Results

Means and standard deviations for all study variables are indicated in Table 2. Preliminary correlational analyses were conducted to determine if there were any significant associations between sociodemographic variables and study variables. Results indicated that child or adolescent age was significantly and positively correlated with impact on family life ($\rho = .27$, $p = .02$), and was included as a covariate in the analyses that included impact on family life.

Spearman’s rank-order correlations and partial correlations, as appropriate, were conducted to investigate the associations between all main study variables. Both total tic severity and motor tic severity were negatively associated with ER, social functioning and impact on family life, and positively associated with social impairment. Vocal tic severity was not associated with ER or social functioning, but was positively associated with social impairment and negatively associated with impact on family life. Of note, when examining impact on family life in the current study, higher scores indicate less negative impact. Correlations between all study variables are presented in Table 2.

Mediation Analyses

We tested whether ER mediated the relations between tic severity (total, motor, vocal) and social functioning, social impairment, and impact on family life.

Total Tic Severity

ER mediated the relation between total tic severity and social functioning, with a point estimate of -0.13 (*SE* = 0.07, 95% CI -0.27 – -0.02). The effect of total tic severity on social functioning was significant without the inclusion of ER (*SE* = 0.14, $p < .05$), but became non-significant when ER was included in the model (*SE* = 0.13, $p = .10$), indicating full mediation. The total model accounted for 23.12% of the variance in social functioning ($p < .001$).

ER mediated the relation between total tic severity and social impairment, with a point estimate of .05 (*SE* = 0.03, 95% CI 0.01 – 0.11). The effect of total tic severity on social impairment was significant without the inclusion of ER (*SE* = 0.06, $p < .001$), but became less significant when ER was included in the model (*SE* = 0.06, $p < .01$), indicating partial mediation. The total model accounted for 26.22% of the variance in social impairment ($p < .001$).

Lastly, ER mediated the relation between total tic severity and impact on family life, with a point estimate of -.003 (*SE* = 0.002, 95% CI -0.01 – -0.0002). The effect of total tic severity on impact on family life was significant without the inclusion of ER (*SE* = 0.005, $p = .002$), but became less significant when ER was included in the model (*SE* = 0.005, $p = .01$), indicating partial mediation. The total model accounted for 20.76% of the variance in impact on family life ($p < .001$). Although age was significantly correlated with impact on family life, it did not serve as a significant covariate in this model ($p = .08$). Figures 1, 2, and 3 illustrate the effects of each of these mediation models.

Motor Tic Severity

ER mediated the relation between motor tic severity and social functioning, with a point estimate of -.24 (*SE* = 0.10, 95% CI -0.47 – -0.08). The effect of motor tic severity on social functioning was significant without the inclusion of ER (*SE* = 0.22, $p < .01$), but became less significant when ER was included in the model (*SE* = 0.21, $p < .05$), indicating partial mediation. The total model accounted for 25.05% of the variance in social functioning ($p < .001$).

ER also mediated the relation between motor tic severity and social impairment, with a point estimate of .09 (*SE* = 0.05, 95% CI 0.02 – 0.21). The effect of motor tic severity on social impairment was significant without the inclusion of ER (*SE* = 0.10, *p* < .001), but became less significant when ER was included in the model (*SE* = 0.10, *p* < .01), indicating partial mediation. The total model accounted for 25.74% of the variance in social impairment (*p* < .001).

Lastly, ER mediated the relation between motor tic severity and impact on family life, with a point estimate of -.01 (*SE* = 0.004, 95% CI -0.02 – -0.0005). The effect of motor tic severity on impact on family life was significant without the inclusion of ER (*SE* = 0.01, *p* < .01), but became less significant when ER was included in the model (*SE* = 0.01, *p* < .05), indicating partial mediation. The total model accounted for 19.41% of the variance in impact on family life (*p* < .01). Although age was significantly correlated with impact on family life, it did not serve as a significant covariate in this model (*p* = .10). Figures 4, 5, and 6 illustrate the effects of each of these mediation models.

Vocal Tic Severity

ER did not mediate the relation between vocal tic severity and social functioning (*SE* = 0.13, 95% CI -0.44 – 0.06), social impairment (*SE* = 0.06, 95% CI -0.03 – 0.20), or impact on family life (*SE* = 0.004, 95% CI -0.01 – 0.001), as evidenced by the insignificant indirect effects in these models. Figures 7, 8, and 9 illustrate these findings.

Moderation Analyses

We also tested whether ER moderated the relations between tic severity (total, motor, vocal) and social functioning, social impairment, and impact on family life. None of the models supported a moderation effect, as evidenced by nonsignificant interaction terms. Thus, support was not found for ER moderating the relations between tic severity and social and familial functioning. The nonsignificant interaction terms for the moderation analyses using both raw and transformed data are presented in Tables 3 and 4.

CHAPTER 4

DISCUSSION

The aim of the current study was to examine the associations between tic severity and ER, as well as how these factors relate to social and family functioning in children and adolescents with TS. As hypothesized, greater total tic severity was associated with poorer ER and social functioning, and with greater impact on family life and social impairment. These findings are consistent with the extant literature indicating that tic severity is related to indices of negative social and familial outcomes. Specifically, several prior studies revealed that greater tic severity is associated with outcomes such as peer victimization, bullying, and a lower quality of family relationships (e.g., O'Hare et al., 2016; Wilkinson et al., 2001; Woods et al., 2005). Expanding on the existing literature, results of the current study also indicate that tic severity is related to ER, such that more severe tics are associated with worse ER. Further, poorer ER was associated with greater social impairment and impact on family life, as well as worse social functioning. Prior to the current study, ER had not been directly studied in this population; only measures of emotional difficulties that may relate to problems with ER, such as explosive outbursts and self-injurious behaviors, had been utilized.

In addition to total tic severity, this study investigated how the separate domains of motor and vocal tic severity related to ER and social and family functioning. Although engaging in both motor and vocal tics at some time during the illness is necessary for a diagnosis of TS, the two categories of tics are qualitatively different and may have differing associations with important aspects of emotional, social, and family functioning. As was found for total tic severity, greater motor tic severity was associated with poorer ER and social functioning, as well as greater social impairment and impact on family life. However, while greater vocal tic severity was also associated with greater social impairment and impact on family life, it was not significantly associated with ER or social functioning. Due to the scarcity of literature investigating ER in youth with TS, further research needs to be conducted to examine why motor tics were significantly associated with ER, and vocal tics were not. In regards to the differing associations between motor and vocal tic severity and social functioning, it is possible that motor tics have a more profound impact on peers. While many vocal tics are relatively inconspicuous (e.g., throat clearing, whistling, humming, gulping, coughing), most motor tics are atypical relative to normal behavior and are easily observable by others (e.g., excessive eye blinking, head jerks, leg kicking, hitting oneself, skipping). Thus, compared to vocal tics, it is likely that motor tics result in more negative perceptions and rejection from peers. For example, peers may be more willing to befriend a child who clears her throat more than usual, as opposed to one who frequently jerks his or her head or shoulders.

An additional goal of this investigation was to examine whether ER might mediate or moderate the relations between tic severity and social and familial outcomes. Results showed that ER served as a mediator of the relations between total tic severity and social functioning, social impairment, and impact on family life. Examination of the components of total tic severity also revealed a mediational role of ER in the analyses including motor tic severity, but not in those that included vocal tic severity. More specifically, as with total tic severity, ER mediated the relations between motor tic severity and social functioning, social impairment, and impact on family life, while ER did not mediate the relations between vocal tic severity and these social and familial domains. It is possible that the smaller correlations between vocal tic severity versus motor tic severity and the other variables in this investigation differentially influenced the results of the mediation analyses. In contrast to finding support for mediation, ER was not found to be a moderator of the relations between total, motor, or vocal tic severity and social and family functioning. Neurobiological mechanisms may help explain why support for mediation, as opposed to moderation, was found. Prior research indicates that the neural mechanisms that contribute to TS symptoms also appear to be the same ones that underlie ER (Stern et al., 2007). The prefrontal cortex is disinhibited in children and adolescents with TS, and is also the brain region that is responsible for ER processes (Caligiore et al., 2017; Ochsner et al., 2012). More specifically, TS is associated with excess striatal dopamine, which results in disinhibition of prefrontal motor circuits, and in turn, an increase in tic production (Caligiore et al., 2017). Likewise, ER relies on sub-regions of the prefrontal cortex that decrease activation of the amygdala and allow individuals to more easily and successfully implement ER strategies.

In regards to clinical implications, current results suggest that implementing ER interventions, such as teaching appropriate emotional expression and adaptive ways of thinking about emotion (Southam-Gerow, 2013), deep breathing exercises, muscle relaxation, and mindfulness techniques, may result in better social and family functioning for youth with TS. Currently, Comprehensive Behavioral Intervention for TICS (CBIT) is an established, evidence-based treatment that has been shown to effectively reduce tic severity (Woods et al., 2008). Although the efficacy of ER treatments has yet to be documented in the TS literature, training in ER skills may serve as an important adjunctive component to CBIT to help improve the social and family functioning of youth with TS. Furthermore, enhanced ER skills may potentially result in additional TS symptom reduction. Previous research suggests that an increase in certain emotions, such as stress, anxiety, frustration, and tension, may be associated with an increase in tic symptoms (Conelea & Woods, 2008). Thus, being able to better regulate these negative emotions may result in less severe and frequent tics.

While this study provides novel and important contributions to existing literature, it is not without limitations. Although the number of participants in this study is large relative to many investigations of youth with TS, larger sample sizes would support broader generalization, as well as increase statistical power. A related limitation is a low level of participant diversity. The current sample was predominately Caucasian and had a high annual family income. Thus, it is not clear how these results apply to minority and lower SES families and children with TS. This study also relied on proxy-report measures from one caregiver and did not include ratings from other reporters (e.g., from the child or adolescent, camp counselor, and/or an additional caregiver) or in vivo behavioral measures. Future researchers should consider including multiple reporters, as well as observational methods (e.g., tic frequency and severity, social interactions) and other forms of data collection. An interesting future direction for research in this area is the possibility of incorporating neuroimaging as a means to further investigate the interplay among the shared neurobiological pathways responsible for TS symptoms and ER. Utilizing neuroimaging to examine brain circuitry would likely reveal novel information regarding the association between TS symptom severity and ER difficulties. Lastly, the study design was cross-sectional; thus, the use of mediation analyses should not be used to infer causation, but instead shows indirect effects. Longitudinal research is needed to test causal relations between tic severity, ER, and social and family functioning.

In conclusion, the results of the current study provide further insight into the associations between tic severity, ER, and social and family functioning in children and adolescents with TS. ER helped to explain the relations between total and motor tic severity and social functioning, social impairment, and impact on family life. Interventions that target ER may include teaching appropriate emotional expression and adaptive ways of thinking about emotion, deep breathing exercises, muscle relaxation, and mindfulness techniques. Clinically, results suggest that providers working in this area should be assessing and addressing ER difficulties in children and adolescents with TS, as poor ER seems to be an important factor leading to negative social and familial outcomes in this population.

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Table 1. *Participant Demographic Information*

Caregivers[a]	Age (Range = 31-62; *M* = 44.17; *SD* = 6.65)
	N (%)
Gender	
Male	16 (20.8%)
Female	61 (79.2%)
Ethnicity	
Caucasian	72 (93.5%)
African American	3 (3.9%)
Hispanic	1 (1.3%)
Biracial	1 (1.3%)
Relationship to Child	
Biological Parent	69 (89.6%)
Adoptive Parent	6 (7.8%)
Legal Guardian	2 (2.6%)
Annual Family Income	
$9,999 or less	2 (2.6%)
$10,000 to $24,999	6 (7.8%)
$25,000 to $49,999	9 (11.7%)
$50,000 to $74,999	12 (15.6%)
$75,000 to $99,999	11 (14.3%)
$100,000 or greater	26 (33.8%)
Prefer not to say	11 (14.3%)
Child/Adolescent	Age (Range = 8-17; *M* = 13.1; *SD* = 2.29)
	N (%)
Gender	
Male	48 (62.3%)
Female	29 (37.7%)
Ethnicity	
Caucasian	70 (90.9%)
African American	2 (2.6%)
Hispanic	1 (1.3%)
Asian	2 (2.6%)
Biracial	2 (2.6%)
Comorbid Diagnoses	
ADHD	58 (75.3%)
OCD	46 (59.7%)
Depression	20 (26.0%)
Anxiety	55 (71.4%)
Other	14 (18.2%)

Note: [a]N = 77 caregivers

Table 2. *Correlation Matrix for Main Study Variables*

Variables	1	2	3	4	5	6	7
1. Total Tic Severity	-	.88**	.84**	-.23*	-.24*	.43**	-.35**
M^{a} = 25.79, SD^{b} = 17.73, Range = 0 – 93.00							
2. Motor Tic Severity		-	.52**	-.28*	-.33**	.41**	-.34**
M = 15.03, SD = 10.76, Range = 0 – 52.00							
3. Vocal Tic Severity			-	-.09	-.12	.36**	-.29*
M = 10.77, SD = 9.12, Range = 0 – 41.00							
4. Emotion Regulation				-	.43**	-.33**	.30**
M = 29.08, SD = 3.83, Range = 19.00 – 36.00							
5. Social Functioning					-	-.62**	.54***
M = 63.64, SD = 21.65, Range = 0 – 100.00							
6. Social Impairment						-	-.63***
M = 24.75, SD = 10.13, Range = 15.00 – 56.00							
7. Impact on Family Life							-
M = 3.94, SD = 0.89, Range = 1.80 – 5.00							

Note: Correlations with Impact on Family Life are partial correlations controlling for child or adolescent age. All other correlations are Spearman's rank-order correlations.
^{a}M = Mean; ^{b}SD = Standard Deviation
*$p < .05$, **$p < .01$, $^{***}p < .001$

Table 3. *Interaction Term Statistics for Moderation Analyses Using Raw Data*

	Social Functioning			Social Impairment			Impact on Family Life		
	R^2 Change	*F*	*p*	R^2 Change	*F*	*p*	R^2 Change	*F*	*p*
Total Tic Severity	.01	0.56	.46	.01	1.25	.27	.001	0.04	.84
Motor Tic Severity	.002	0.20	.65	.01	0.56	.46	.002	0.18	.68
Vocal Tic Severity	.01	1.22	.27	.03	2.90	.09	.001	0.10	.75

Note: Child or adolescent age was included as a covariate in the models that included Impact on Family Life.

Table 4. *Interaction Term Statistics for Moderation Analyses Using Transformed Data*

	Social Functioning			Social Impairment			Impact on Family Life		
	R^2 Change	*F*	*p*	R^2 Change	*F*	*p*	R^2 Change	*F*	*p*
Total Tic Severity	.01	0.77	.38	.02	2.33	.13	.001	0.05	.82
Motor Tic Severity	.01	1.45	.23	.01	1.28	.26	.001	0.06	.81
Vocal Tic Severity	.005	0.46	.50	.04	3.96	.051	.0000	0.0000	.99

Note: Child or adolescent age was included as a covariate in the models that included Impact on Family Life.

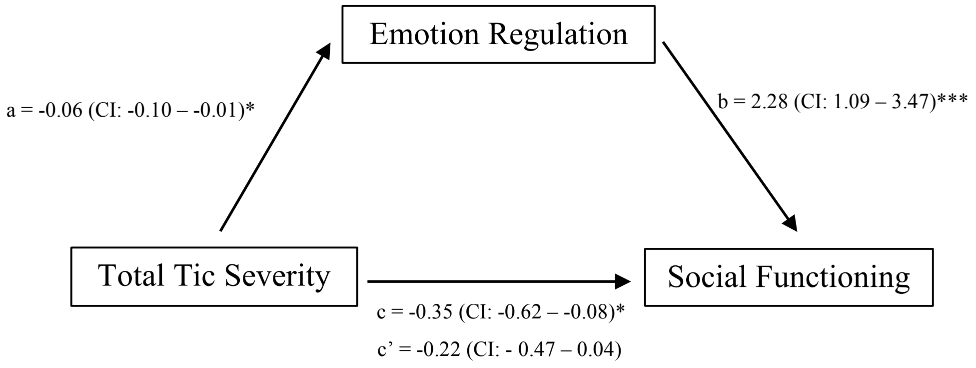

Figure 1. Mediation model: Emotion regulation mediates the relation between total tic severity and social functioning. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. **p* < .05, ****p* < .001

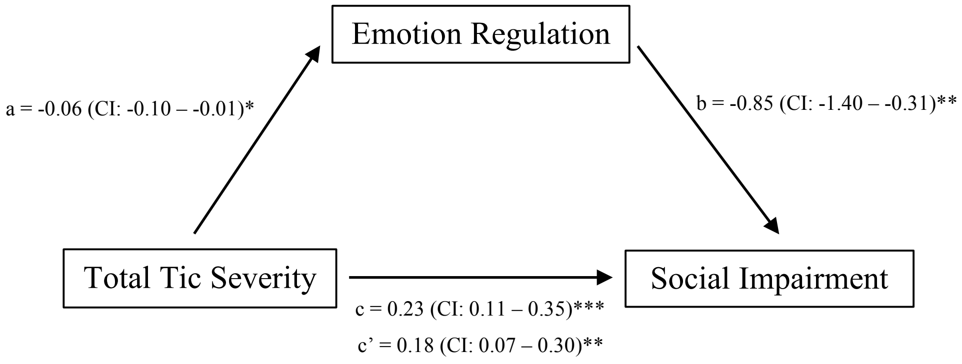

Figure 2. Mediation model: Emotion regulation mediates the relation between total tic severity and social impairment. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. *$p < .05$, **$p < .01$, ***$p < .001$

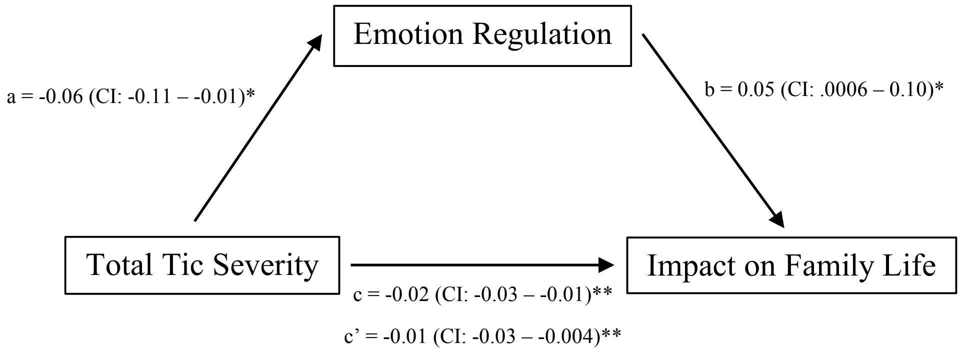

Figure 3. Mediation model: Emotion regulation mediates the relation between total tic severity and impact on family life. Child or adolescent age was included as a covariate in this model. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. **p* < .05, ***p* < .01

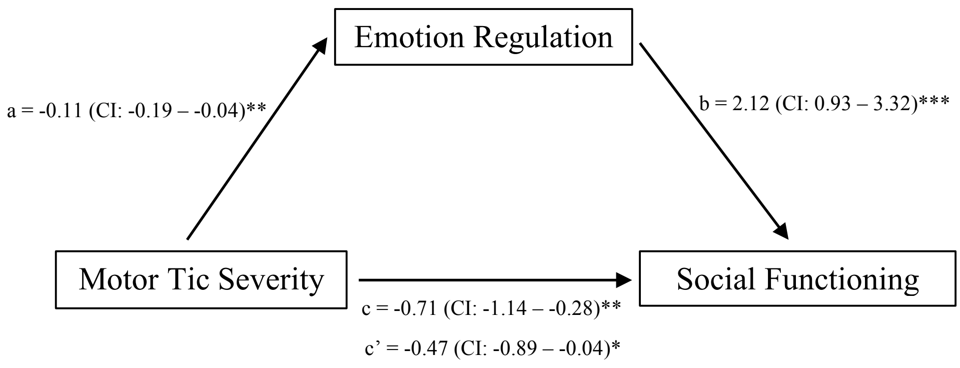

Figure 4. Mediation model: Emotion regulation mediates the relation between motor tic severity and social functioning. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. *$p < .05$, **$p < .01$, ***$p < .001$

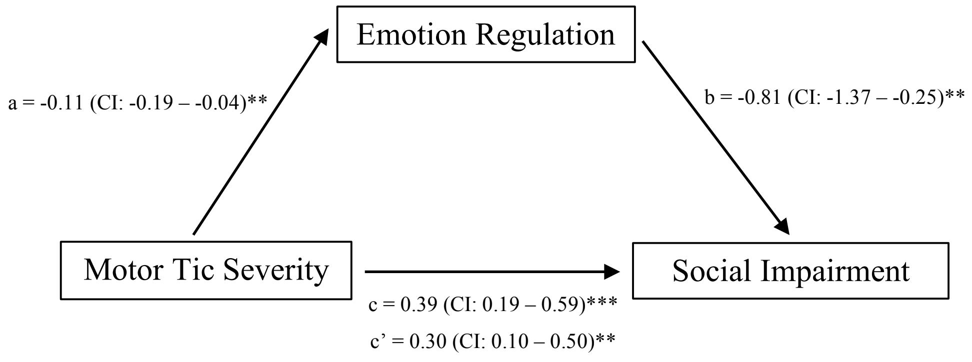

Figure 5. Mediation model: Emotion regulation mediates the relation between motor tic severity and social impairment. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. $^{**}p < .01$, $^{***}p < .001$

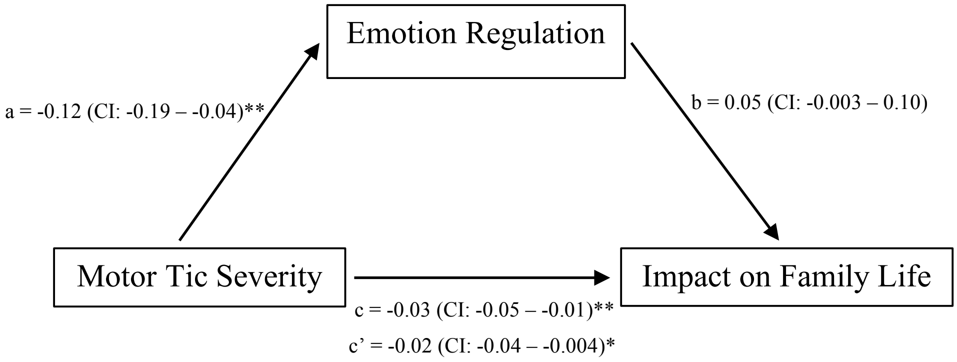

Figure 6. Mediation model: Emotion regulation mediates the relation between motor tic severity and impact on family life. Child or adolescent age was included as a covariate in this model. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. **p* < .05, ***p* < .01

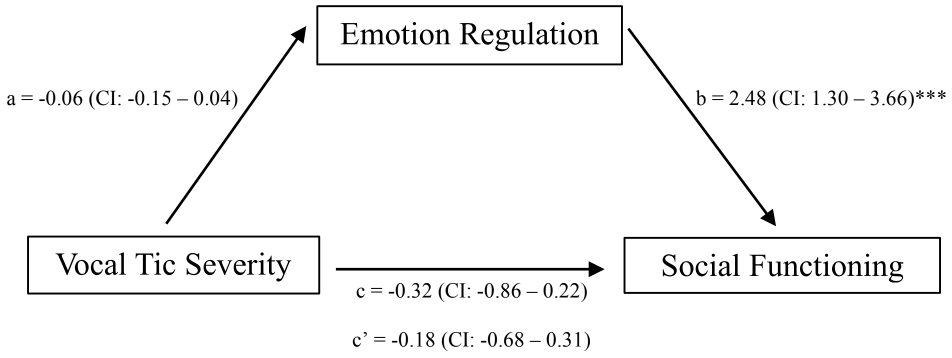

Figure 7. Mediation model: Emotion regulation does not mediate the relation between vocal tic severity and social functioning. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. ****p* < .001

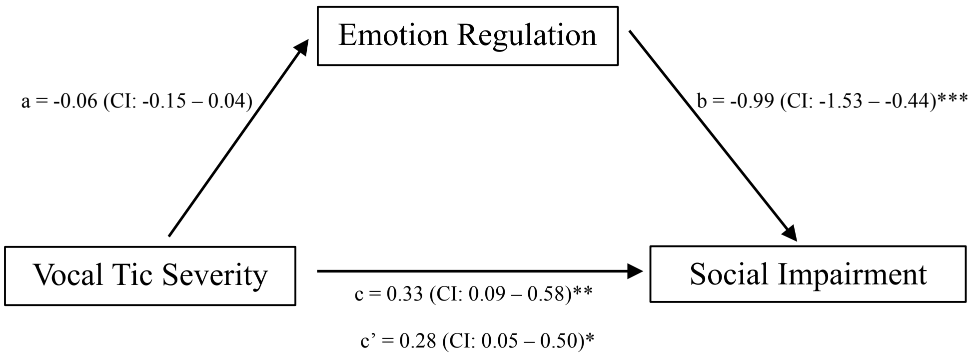

Figure 8. Mediation model: Emotion regulation does not mediate the relation between vocal tic severity and social impairment. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. **p* < .05, ***p* < .01, ****p* < .001

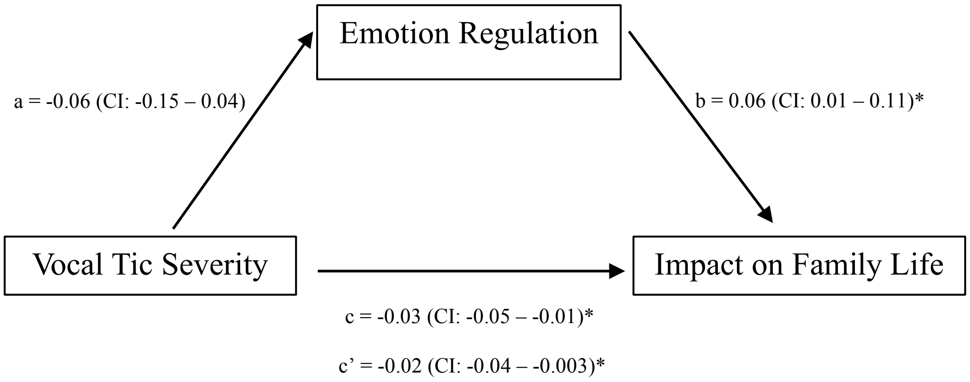

Figure 9. Mediation model: Emotion regulation does not mediate the relation between vocal tic severity and impact on family life. Child or adolescent age was included as a covariate in this model. Path values indicate unstandardized regression coefficients. c represents the total effect, and c’ represents the direct effect. **p* < .05