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AND EMOTION REGULATION, POSSIBLE MEDIATORS OF
EXTERNALIZING BEHAVIOR IN ADOLESCENTS IN RESIDENTIAL
TREATMENT**

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THE EFFECTIVENESS OF NEUROFEEDBACK ON DISSOCIATION AND EMOTION REGULATION,
POSSIBLE MEDIATORS OF EXTERNALIZING BEHAVIOR IN ADOLESCENTS IN RESIDENTIAL
TREATMENT

by

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Abstract

Residential treatment (RT) has shown a minimal effect in the treatment of aggression and delinquency in adolescents. Adverse childhood experiences predict these externalizing behaviors, and it is theorized that problems of self-regulation are involved. Neurofeedback has been used to facilitate self-regulation. Little research has examined how problems with self-regulation mediate the relationship between adverse childhood experiences and externalizing behaviors. Participants in the current study were male and female adolescents between ages 11 and 17 enrolled in a residential treatment facility. Participants were randomly assigned to either the treatment-as-usual or neurofeedback with treatment-as-usual condition. Multiple regression was utilized to examine a mediation model in which dissociative experiences and difficulties in emotion regulation would mediate the relationship between adverse childhood experiences and externalizing behavior. Although, the data did not support the multiple mediation model, effect sizes suggest promising results should the study be repeated using a larger sample size. Further, repeated measures ANOVA examined the effect of neurofeedback on dissociation and emotion regulation. Evidence for an overall decline was found supporting the effectiveness of residential treatment. Between-groups analyses were consistent with the power analysis suggesting that differences between the neurofeedback and treatment-as-usual groups would not be detected given the sample size. Limitations of the study are discussed.

Keywords: adverse childhood experiences, residential treatment, adolescents, dissociation, emotion regulation, externalizing behavior.

Introduction

Adolescents are placed in residential treatment (RT) for a wide range of referral reasons including affective disorders, behavioral problems and trauma-related disorders (Lyons, Terry, Martinovich, Peterson, & Bouska, 2001; Colson, Cornsweet, Murphy, & O'Malley, 1991; Gavidia-Payne, Littlefield, Hallgren, Jenkins, & Cocentry, 2003), among others. Many at-risk adolescents receive some benefit from the increased level of care RT provides. However, others do not. Further, while RT appears to reduce some mental health symptoms, other symptoms show no change or even worsen (Lyons et al., 2001).

Externalizing behaviors such as aggression and delinquency appear to receive a small benefit from RT (Knorth, Harder, Zandberg, & Kendrick, 2008). Research has focused on early childhood maltreatment as one of the important etiological factors in externalizing behavior (Connor, Doerfler, Toscano, Volungis, & Steingard, 2004). One way that early childhood maltreatment can have a lasting effect is by disrupting the ability to regulate emotion, oftentimes by the process of dissociation. The interruptions of self-regulation has also been indicated in externalizing behaviors. However, little research has examined problems of self-regulation as a mediator of the relationship between early childhood maltreatment and externalizing behaviors. Considering the interest in improving the efficiency of RT by reducing costs and improving outcomes (Leichtman, 2006), a better understanding of factors that mediate the relationship between risk factors and treatment outcome is needed to guide more effective treatment.

Neurofeedback is a promising intervention for a variety of mental health conditions, and theory and empirical research support its use for dissociation (Manchester, Allen, & Tachiki, 1998) and difficulties in emotion regulation (Johnston et al., 2010) in adult populations. Yet, little research has examined its effectiveness to enhance self-regulation for the adolescent population.

The current study contributes to the literature by testing a model that includes both dissociation and difficulties in emotion regulation as mediators of the relationship between adverse childhood experiences and externalizing behavior with adolescent participants in RT. In addition, the study examines the effects of neurofeedback on dissociation and difficulties in emotion regulation with the same participants.

Adolescents in Residential Treatment (RT)

Characteristics of adolescents in RT. Adolescents present to RT with a wide range of psychological distress, behavioral problems and psychiatric diagnoses including alcohol and marijuana abuse (Godley, Godley,

Dennis, Funk, & Passetti, 2002), emotional symptoms, behavior problems (Gavidia-Payne et al., 2003), delinquent behavior (Greenwood & Turner-Rand, 1993) eating disorders (Frisch, Herzog, & Franko, 2006), personality disorders, conduct problems, affective disorders, psychosis (Colson et al., 1991), internalizing, externalizing, aggression, (Connor et al., 2004) posttraumatic stress disorder, bipolar disorder, anxiety disorders, and self-mutilation behavior (Lyons et al. 2001). In one study, 92% percent of adolescents received at least one psychiatric diagnosis (developmental disorders accounted for the remaining 8%), 39% had two diagnoses, “32% had three diagnoses, 20% had four diagnoses and 1% had five diagnoses” (Connor et al., 2004, p. 502). In another study with an average of 4.74 out-of-home placements, 92% of the participants met criteria for conduct disorder (Shapiro, Welker, & Pierce, 1999).

Definitions of externalizing behavior, aggression, and delinquency. Some researchers have focused on aggression and delinquency in this population because of the long-term social and psychological problems with adjustment associated with these behaviors (Crick, Ostrav, & Werner, 2006). Research has shown that aggression and delinquency can be conceptualized as externalizing behavior (O’Keefe, Mennen, & Lane, 2006). Van der Ploeg (1997) defined aggression as “...injuring other persons, attacking or threatening them with mental and/or physical violence” (p. 263). Delinquency refers to minor crime, especially when committed by young people.

Challenges of externalizing behavior. Adolescent aggression in RT presents a unique challenge. Threatening and violent behaviors are often a major reason an adolescent requires a higher level of care. In addition, aggression can continue in RT settings (Knorth, Klomp, Van den Bergh, & Noom, 2007). Adolescents often have had histories of aggression towards adults (Armour & Schwab, 2005), and in RT, relational aggression can interfere with the therapist-client therapeutic relationship (Okamoto, 2004).

Delinquency also presents a set of unique challenges in RT. Researchers have been concerned that RT may have iatrogenic effects for adolescents with criminal histories (Garrett, 1985). The overlap between mental health and criminal behavior can complicate the treatment approach because mental health facilities may be inadequate for criminal behavior and correctional facilities may not address mental health issues (Underwood, Barretti, & Storms, 2004). Facilities that have attempted to compartmentalize mental health from delinquency treatment have been ineffective because criminal behavior and psychology are inseparable (Larkin, 2014). RT facilities that are designed to treat mental health conditions have been found to have elevated rates of delinquency (26%) and externalizing

behavior in general (35%; Connor et al., 2004). Fortunately, some researchers have found that integrating mental health and delinquency treatment is possible (Underwood et al., 2004).

Biological sex. Biological sex appears to be a factor related to aggression and delinquency during adolescence. Connor et al. (2004) found that female participants reported higher levels of verbal aggression, aggression towards self, aggression towards others, and perceived hostility than male participants (2004). Older female adolescents in RT were less likely to have social withdrawal problems but more likely to exhibit delinquency and externalizing behavior than male adolescents (Baker, Archer, & Curtis, 2005). However, females experienced more sexual abuse in their histories than male adolescents. Therefore, sex differences in aggression were at least partially explained by childhood sexual abuse (Connor et al., 2004). In addition, some researchers have hypothesized that due to socialized expectations of gender norms by administrators, more severe behavioral problems are required of females in order for them to be considered for RT.

Age. Age may also have an influence on adolescents' externalizing behavior. Evidence suggests that aggression slightly decreases as individuals develop from childhood to adolescence. Inversely, somatic complaints, widely considered an internalizing behavior, increases with age. Taken together, these trends suggest a shift from external to internal coping strategies as people age from childhood to adolescence (Baker et al., 2005). Externalizing behavior is therefore considered more normalized for younger children. Adolescents who show persistent externalizing behavior are then seen as more problematic.

Adverse childhood experiences (ACEs). Adolescents' adverse social factors place their psychological and behavioral problems into context. ACEs have been described as childhood experiences that include physical or emotional abuse and/or neglect, domestic violence, sexual abuse, separation or divorce of parents, substance abuse or a severe mental health condition of someone in the home, having an incarcerated household member, and/or not being raised by both biological parents (Felitti & Anda, 2009). Family characteristics such as parental legal history and family substance abuse are associated with adolescents' involvement in the juvenile justice system (Cropsey, Weaver, & Dupre, 2008). Seventy-five percent of adolescents in RT endorsed a high level of disrupted family relationships (Shapiro et al., 1999). In addition, homelessness, changes in the family structure such as divorce, and lack of supervision are factors that have an impact on adolescents' mental health (Kazdin, 1993). Given these social factors, adolescents' aggression and delinquency can be understood as reactions to their environments.

Often for these youth, adverse social situations have involved sexual and physical abuse as well as physical and emotional neglect. As mentioned above, female participants have demonstrated more aggression than male participants; however, in the same study, female adolescents (59%) were more likely than male adolescents (43%) to have a history of abuse by a parent or caregiver (Connor et al., 2004). These percentages are not uncommon for adolescents in RT. Boel-Studt (2017) found comparable rates in a combined group of male and female adolescents for emotional abuse (55.05%), neglect (48.70%), physical abuse (49.25%), sexual abuse (33.75%), and domestic abuse (26.25%) in RT. Other studies present even higher rates of abuse and neglect. Kisiel and Lyons (2001) found that nearly all (97%) of the participants in RT had a history of some type of abuse and many (84%) experienced moderate to severe abuse. They also found a high percentage (92%) of participants who had histories of neglect, severe neglect (42%), histories of sexual abuse (61%), and physical abuse (47%). The Kisiel and Lyons (2001) participants consisted of children and adolescents (ages 10 to 18) who were living in a RT center and were wards of the state of Illinois Department of Children and Family Services. Therefore, these individuals may better represent those adolescents at the higher end of the prevalence of abuse and neglect and may not be generalizable to all RT facilities. However, studies consistently show rates of abuse and neglect in adolescents in RT that are higher than in the general population (Connor et al., 2004).

Clearly, histories of trauma and abuse are prevalent in RT. However, a consistent metric is lacking in the research. Although little research has used the Adverse Childhood Experiences (ACE) scale in RT, the measure provides a useful framework for research to examine childhood abuse, neglect, and household dysfunction in such a setting (Larkin, 2014). Since the original ACE study found that an elevated score on adverse experiences in childhood strongly predicted lifelong health-risk behaviors, chronic problems and early death (Felitti et al., 1998), researchers have been using the ACE scale to better understand how these experiences impact long-term physical and mental health (Felitti & Anda, 2009). One of the major limitations of the original study was the lack of diversity. Participants were predominantly educated, Caucasian, middle-class, middle-aged, and financially stable enough to be able to afford adequate health insurance (van der Kolk, 2014). Research using the ACE scale in RT settings is needed because a consistent metric to assess for histories of abuse is lacking in RT and because such research would afford the opportunity to assess the validity and reliability of the ACE scale in diverse settings.

Residential Treatment (RT). Whittaker, Del Valle, and Holmes (2014) described “therapeutic residential care [as] playful use of a purposefully constructed, multi-dimensional living environment designed to enhance or

provide treatment, education, socialization, support, and protection to children and youth with identified mental health or behavioral needs in partnership with their families and in collaboration with a full spectrum of community based formal and informal helping resources” (p. 24). Although a wide range of services presents a challenge for researchers to determine the effectiveness of RT, a benefit is that programs can make adjustments to meet the needs of their clients. For instance, recent research has explored how factors such as adverse childhood experiences contribute to aggression and delinquency (Duke, Pettingell, McMorris, & Borowsky, 2010) and how common practices in RT such as physical restraints have retraumatized youth (Bryson et al., 2017). In response to this research, RT programs have effectively integrated trauma-informed care (Boel-Studt, 2017). RT facilities have shown their capacity to integrate innovative evidence-based interventions.

The Effectiveness of RT. Researchers conducted an evaluation of the overall effectiveness over 2 years of all RT facilities run by the Oregon Department of Mental Health on a broad range of mental health conditions and found mixed results. The evidence showed effectiveness for reducing risk-taking behaviors and depressive symptoms; and for improving the management of psychosis. However, the study did not find evidence for improved daily functioning in adolescents. Most concerning, the study found that RT worsened anxiety and hyperactivity (Lyons et al., 2001). In a review of 18 studies examining outcome at discharge and follow-up, Hair (2005), concluded that overall, adolescents with severe emotional and behavioral problems can sustain benefits gained from RT. The author, however, acknowledges several factors that contribute to variance in outcome. Overall, RT appears to be helpful for some adolescents for some of their problems.

Few existing studies have examined the effectiveness of RT on delinquency; however, the research available shows an overall pattern of a small, but consistent benefit. A meta-analysis of 111 studies revealed an overall effect size of 0.37 across outcome measures (i.e., recidivism, institutional adjustment, psychological adjustment, community adjustment, academic improvement, and vocational adjustment), type of offender, settings, and therapeutic modality. Effect sizes for more rigorous and less rigorous studies were 0.65 and 0.24, respectively (Garrett, 1985). Adolescents with delinquency improved beyond usual care when researchers added multidimensional treatment foster care (Chamberlain & Reid, 1998) or social skills training (Spence & Marziller, 1981). The addition of problem-solving skills training; however, was associated with adverse effects (Grant, 1988). Nevertheless, the consistent pattern of results suggests that RT has a small, but significant effect size for adolescents with delinquency.

Less is known about the effects of RT on aggressive behavior. Often aggressive behavior is categorized with conduct problems or externalizing behavior in the literature (Hair, 2005). When researchers added contingency awareness (Snyder & White, 1979), a trauma-informed therapeutic approach (Boel-Studt, 2017), and problem-solving skills training (Jarden, 1995) to residential treatment-as-usual, adolescents used less aggressive behavior. In their study on state-supported RT facilities, Lyons et al. (2001) found an overall decrease in aggression. More research is needed to understand the effects of RT on aggression, the associated factors, and whether integrated evidence-based treatments can enhance effectiveness.

Theoretical Perspectives

Several theories provide a framework to help understand the relationship between adverse childhood experiences and externalizing behaviors in adolescents in RT. Attachment theory (Bowlby, 1969), for instance, explains that children who experience inconsistent, neglectful and/or abusive caregiving will have difficulty with emotion regulation. Other theories, such as the neurodevelopmental view and other psychobiological theories acknowledge the long-standing impact that trauma has on physiological and neurological processes (Perry et al., 1995; Siegel, 1999; van der Kolk, 2014).

According to attachment theory, secure attachment develops over time through the interaction between the child and an attuned responsive caregiver. The caregiver offers a secure base where the child can consistently return from exploring the environment. When infants and toddlers are emotionally upset, they do not have the ability to regulate their difficult emotions, and they rely on the secure base to help them to do so. As children develop, they gradually learn how to internalize emotion regulation that was once facilitated by the caregiver (Bowlby, 1969). When a child-caregiver pair does not develop a secure attachment, the child can develop an anxious, avoidant or disorganized attachment style. According to the theory, these children fail to develop an internalized ability to regulate emotion and may remain in a heightened state, avoid situations that could activate negative emotion, or develop habits such as aggression and conduct problems in an attempt to externally regulate emotion (Ainsworth, Blehar, Waters, & Wall, 1978). Attachment theory would suggest that adolescents with adverse childhood experiences would have difficulty with internal emotion regulation and would, therefore, make external attempts to cope with negative emotion.

The neurodevelopmental view also provides a theoretical perspective to explain the relationship between adverse childhood experiences and difficulties with social and emotional functioning. Perry et al. (1995) explained

that the autonomic nervous system activates two adaptive responses in the face of trauma: hyperarousal and dissociation. The sympathetic and parasympathetic nervous systems are subsystems of the autonomic nervous system. The sympathetic and parasympathetic nervous systems activate hyperarousal and dissociation, respectively. Adaptively, these two systems regulate each other and function as a negative feedback loop. Children who are faced with threatening stimuli typically cry for help, a hyperarousal behavior. Ideally, a caregiver would then help the child to activate the parasympathetic system, which would generate a calming effect. However, in the context of adverse childhood experiences, parents are often involved in or part of the threatening stimuli, so behaviors stemming from hyperarousal of the child do not help to foster calming parental behaviors. Once the child has learned that hyperarousal is futile, dissociation—a state of disengaging with the external world—becomes the next available coping strategy. A child may dissociate by attending to the internal world by daydreaming and fantasizing, which can lead to depersonalization, derealization and fugue states, which are more severe forms of dissociation (Putnam, 1991). In a developmental context, when adverse experiences occur repeatedly, these adaptive states progress into maladaptive traits because the brain stores the memory of threatening stimuli in neural pathways. As hyperarousal and dissociation states increase in length of time, the likelihood of the central nervous system regulating these states to baseline decreases (Perry et al., 1995). Therefore, the neurodevelopmental view suggests that, as adverse childhood experiences increase, hyperarousal and dissociation increase. Dissociation involves psychological disengagement from the social environment while being physically present. Therefore, the neurodevelopmental view would also suggest that dissociated states would increase the chance of antisocial behaviors such as aggression and delinquency.

Attachment theory (Bowlby, 1969; Ainsworth et al., 1978) and the neurodevelopmental view (Perry et al., 1995) are based on the idea that learning from social interaction has lasting effects that impair emotion regulation. The neurodevelopmental view extends attachment theory by acknowledging the role of structural changes in the brain as a result of interaction with the environment during early development. The neurodevelopmental view also illuminates how traumatic response states such as hyperarousal and dissociation can progress into lasting traits. Using these theories, dissociation and difficulties in emotion regulation can be conceptualized as a mediator between early adverse experiences and problematic externalizing behaviors later in adolescence.

Out of the neurodevelopmental view and other psychobiological perspectives, several researchers have provided rationales for neurofeedback as an effective intervention for individuals suffering from the sequelae of

trauma and adverse experiences (Hamlin, 2011; Huang-Storms, Bodenheimer-Davis, Davis, & Dunn, 2006; Schauss et al., 2018; van der Kolk, 2014). A common theme from these rationales is that neurofeedback facilitates self-regulation that had been adaptively altered in traumatic and/or adverse experiences.

Neurofeedback (NF) is a type of biofeedback that utilizes electroencephalogram (EEG) to measure electrical brain activity in microvolts. NF is noninvasive and provides real-time visual stimulation based on principles of operant conditioning (i.e., positive reinforcement, negative punishment) to increase the likelihood that the participant utilizes optimal brainwave frequencies, as determined by individualized EEG assessments (Hamlin, 2011). Compared to other neuroscience-informed interventions (i.e., fMRI, transcranial magnetic stimulation) NF is a relatively affordable process, is engaging, and offers face validity to the participant.

Theoretical Application in RT

Researchers have conducted studies with adolescents in RT that have tested relationships among variables that attachment theory (Bowlby, 1969) and the neurodevelopmental view (Perry et al., 1995) propose. Some of these relationships such as the association between adverse childhood experiences and externalizing behaviors are well-established (Wisdom, 2014). Evidence also supports dissociation (Kisiel & Lyons, 2001; Egeland & Susman-Stillman, 1996) and difficulties in emotion regulation (Robertson, Daffern, & Bucks, 2012) as mediators between adverse childhood experiences and externalizing behaviors.

Adverse childhood experiences and externalizing behavior. Researchers have consistently found a relationship between adverse childhood experiences (ACEs) and externalizing behavior (Wisdom, 2014). Although supportive and caring relationships have moderated the impact of ACEs on substance abuse, this social support did not have the same protective influence on delinquency (Brown & Shillington, 2017). ACEs have predicted early onset and chronic offending (Baglivio, Wolff, Piquero, & Epps, 2015), conduct disorder (Greger, Myhre, Lydersen, & Jozefiak, 2015), oppositional defiant disorder (Beitchman et al., 1992; Boney-McCoy & Finkelhor, 1995), and illicit drug use (Dube et al., 2001). Studies have found ACEs related to externalizing behaviors that have caused a public health concern. For instance, ACEs are associated with increased risk for suicide (Dube et al., 2001; Greger et al. 2015), substance abuse (Boney-McCoy & Finkelhor, 1995), and tobacco use (Feoge, 1998).

Dissociation as a mediator. Dissociation may be a mechanism underlying the relationship between ACEs and externalizing behavior. The study of long-term dissociation following child maltreatment is over one hundred years old (Janet, 1889; van der Hart & Horst, 1989). Researchers have explained variance in dissociation with erratic

parenting styles (Kluft, 1984), childhood abuse, and the family environment (Nash, Hulsey, Sexton, Harralson, & Lambert, 1993). Dissociation is also related to an increase in externalizing behavior (Kisiel & Lyons, 2001). Further, when researchers controlled for dissociation, the main effect of sexual abuse on externalizing behavior was no longer significant (Kisiel & Lyons, 2001), suggesting that dissociation functions as a mediator between childhood sexual abuse and externalizing behavior. Examining transgenerational trauma, Egeland and Susman-Stillman (1996) found that among mothers who had been abused as children, participants were more likely to abuse their own children if they were currently experiencing high levels of dissociation. Therefore, mothers who had experienced abuse as children were less likely to abuse their own children if they were not experiencing high levels of dissociation.

Difficulties in emotion regulation as a mediator. Similarly, difficulty in emotion regulation appears to function as a mediator between ACEs and externalizing behavior. Studies in neuroscience have shown how early maltreatment and trauma have affected developing brain structures associated with emotion regulation. The amygdala and hippocampus play an important role in emotion regulation and have been shown to be affected by posttraumatic stress disorder in adolescents (Nooner et al., 2012). In addition, Barch, Belden, Tillman, Whalen, and Luby (2018) found that ACEs predicted decreased volume in the inferior frontal gyrus, a region also known to play an important role in emotion regulation. An inability to regulate difficult emotion can lead to aggressive and destructive behavior. For instance, Robertson et al. (2012) found that both over-regulation and under-regulation of angry emotion lead to aggressive behavior. In a further analysis from Barch et al.'s (2012) 11-year longitudinal study, researchers found that inferior frontal gyrus connectivity, an indicator of emotion regulation, predicted externalizing behavior, but not internalizing behavior. Given they had found an association between ACEs and inferior frontal gyrus volume, this study provides support for emotion regulation as a mediator, though more research is needed.

The Current Study

Based on the theory and empirical evidence described, the current study will include two phases of analysis. The first phase will test a conceptual model that includes dissociation and difficulties in emotion regulation as mediators of the relationship between ACEs and the externalizing behaviors of aggression and delinquency. The model hypothesizes that adverse childhood experiences are directly associated with externalizing behaviors. In

addition, the model hypothesizes that ACEs are indirectly associated with externalizing behaviors via dissociation and difficulties with emotion regulation.

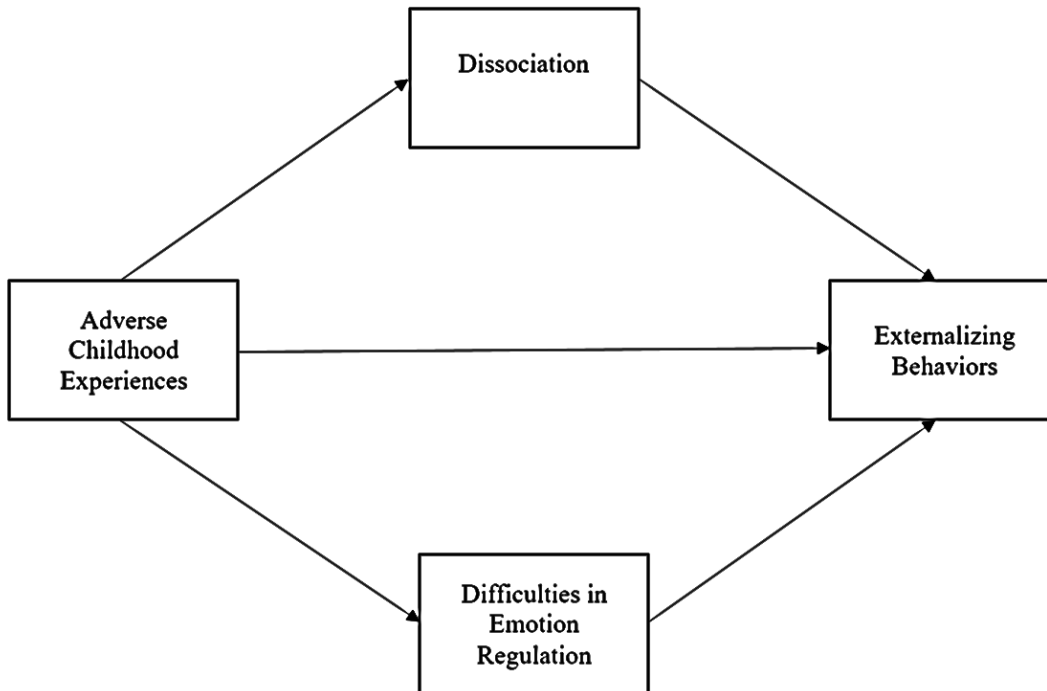


Figure 1.

The second phase will test the hypotheses that neurofeedback will reduce dissociative experiences and difficulties in emotion regulation in adolescents in RT. The study contributes to the literature by examining a model that includes both dissociation and difficulties in emotion regulation as mediators between adverse childhood experiences and externalizing behavior in adolescents in RT. The study also contributes to the literature by examining whether neurofeedback reduces dissociation and difficulties in emotion regulation in the same population.

Hypotheses

Hypothesis 1

Hypothesis 1 stated that dissociative experiences would mediate the relationship between ACEs and externalizing behaviors. The theory of dissociation and previous research using this multiple-mediation model with children (Hebert, Langevin, & Oussaid, 2018) provide a rationale for this hypothesis. Briefly, when people dissociate to cope for traumatic events, other self-regulatory processes may be impaired leaving them more

vulnerable to process current stressors, and thereby resorting to externalizing behaviors. The overarching mediation hypothesis contains several sub-hypotheses including: 1a) ACEs will predict dissociative experiences, 1b) ACEs will predict externalizing behavior, 1c) when controlling for ACEs, dissociative experiences will predict externalizing behavior, and 1d) the effect size of the prediction of ACEs on externalizing behavior (1b) will diminish or be eliminated when controlling for dissociation (1c).

Hypothesis 2

Hypothesis 2 stated that difficulties in emotion regulation would mediate the relationship between ACEs and externalizing behavior. Similar to Hypothesis 1, previous research supports the hypothesis that difficulties in emotion regulation would play a mediating role (Choi & Oh, 2014). The neurodevelopmental view (Perry et al., 1995) and attachment theory (Bowlby, 1969) suggest that events that have interfered with the internalization of self-soothing practices can result in difficulties with emotion regulation increasing the likelihood of externalizing current affect. Sub-hypotheses were: 1a) ACEs would predict difficulties in emotion regulation, 2b), ACEs would predict externalizing behavior (same as 1b), 2c, when controlling for ACEs, difficulties in emotion regulation would predict externalizing behavior, 2d) the effect size of the prediction of ACEs on externalizing behavior (2b) would diminish or be eliminated when controlling for difficulties in emotion regulation (2c).

Hypothesis 3

Hypothesis 3 stated that neurofeedback treatment would reduce dissociative experiences. This hypothesis predicted that the neurofeedback group would report greater declines in dissociative experiences than the treatment-as-usual group. The rationale is based on the theory of neurofeedback that suggests that real time feedback of brainwaves measured by electroencephalogram facilitates self-regulatory processes.

Hypothesis 4

Hypothesis 4 stated that neurofeedback treatment would reduce difficulties in emotion regulation measured by greater declines in the neurofeedback than in the treatment-as-usual group. The rationale is similar to that of hypothesis 3 that neurofeedback was expected to improved self-regulation, thereby reducing the level of difficulties in emotion regulation.

Methods

Participants and Procedures

Data of the current study was part of a larger study examining a wide range of psychological, social and biological variables. Residents could only enroll in the study at the beginning of their residential stay. The larger study's aim was to obtain 100 participants per year for two years; however, due to multiple obstacles in recruitment and admission, this was not accomplished. Facility staff made a determination as to whether participants were able to read and comprehend sufficiently to respond to assessment measures which were estimated to be no higher than 8th grade reading level. Staff also determined whether participants could adequately see and hear visual and auditory stimuli sufficiently enough to engage in neurofeedback.

Table 1

<i>Participant characteristics at baseline</i>		
Race	N	%
African American	7	16.3
White	28	65.1
Multi-racial	8	18.6
Biological sex		
Female	30	69.8
Male	13	30.2
Completed the study		
Yes	20	46.5
No	23	53.5
Group		
Neurofeedback	26	60.5
Treatment as usual	17	39.5

Participants were adolescent males and females between 11 and 17 years of age at a residential treatment (RT) facility in Memphis, TN. No participants were wards of the state. Over half (55.81%) of the participants had some type of prior criminal charge. Participants at the baseline assessment reported an average of 4.7 adverse childhood experiences in their lifetime. All of the participants had a *Diagnostic and Statistical Manual, Fifth Edition (DSM-5)* diagnosis and of the participants whose medication status was available (88.37%), nearly all (97.36%) were taking at least one psychiatric medication. Regarding these data, participants were similar to other, non-ward of state, RT inpatients.

Participants that completed the baseline assessment measures were predominantly white (65.1%) and female (69.8%; See Table 1). The majority of these participants did not complete the entire 9-week study for reasons such as

psychosis, exclusion criteria, premature discharge, safety concerns, allergic reaction to the neurofeedback conductor paste, campus-wide unrest, comprehension concerns, discharge against medical advice, and termination of participation by treatment facility staff and administration. The majority (60.5%) of participants, at pretreatment,

were randomly assigned to the neurofeedback group and the remaining 39.5% were assigned to the treatment-as-usual group.

Table 2

Participant characteristics at posttreatment, N = 20

Race	N	%
African American	2	10%
White	12	60%
Multi-racial	6	30%
Biological sex		
Female	17	85%
Male	3	15%
Group		
Neurofeedback	12	60%
Treatment-as-usual	8	40%

Forty-four participants in the current study completed the baseline assessment. Of these, 28 participants remained in the study and completed the midpoint assessment. Of the 28 midpoint participants, 21 participants completed the nine-week study and completed the posttreatment assessment (one participant was dropped due to missing data). Analyses of hypotheses 1 and 2 included data from participants who completed the baseline assessment and analyses of hypotheses 3 and 4 included participants who completed all, baseline, midpoint, and posttreatment assessments. Therefore, the sample size for the mediation analyses was $n = 44$ and the sample size for

the pretest-posttest repeated-measures analysis of variance was $n = 20$. Testing for assumptions for multiple regression, one case showed evidence of having influential bias. Therefore, this case was removed from the dataset, resulting in a sample size of $n = 43$ for the mediation analysis.

Written and verbal informed consent to participate was obtained by residents' legal guardians during admission to the treatment facility. In addition, written and verbal consent was obtained by the participants at the beginning of the study. Participants were randomly assigned to the treatment as usual comparison group or the experimental group. The experimental group received neurofeedback in addition to treatment as usual. Researchers assigned an ID code to participants in order to uniquely identify their data. The duration of the study for each participant was 9 weeks. Participants in the treatment-as-usual and neurofeedback groups completed all assessment measures at week 1 (baseline), week 5 (midpoint) and week 9 (posttreatment). Assessment included quantitative electroencephalogram (QEEG) which measured brain wave activity and informed neurofeedback protocols based on New Mind normative databases. The neurofeedback group received three 30-minute neurofeedback training sessions per week for 7 weeks (total of 21 sessions). Neurofeedback used individualized protocols based on QEEG readings.

Neurofeedback technicians completed fidelity checks at the end of each training session. The larger study was reviewed by the University of Memphis Institutional Review Board (IRB) and obtained approval. A separate IRB application was submitted for the current analysis and obtained approval.

Instruments

Adverse Childhood Experiences (ACE) Scale. The retrospective self-report ACE scale (Felitti and Anda, 2009) was designed to assess whether or not respondents experienced 10 types of adverse childhood experiences in their home, utilizing dichotomous response options (0 = no, 1 = yes). The items assess for psychological, physical, and sexual abuse; emotional and physical neglect; and household dysfunction including divorce, witnessed physical abuse against a maternal figure, alcohol abuse, mental illness/suicide attempts, and incarceration of a family member in the household. The ACE scale produces a score from 0 to 10. High scores indicate a greater number of types of adverse childhood experiences. A sample item is “Was a household member depressed or mentally ill or did a household member attempt suicide?” Test-retest reliability was excellent ($ICC = 0.95, p < .001$).

Difficulties in Emotion Regulation Scale – Short Form (DERS-SF). The DERS-SF (Kaufman et al., 2016) is an 18-item, Likert-type, self-report measure designed to assess clinically relevant emotion regulation deficits. The DERS-SF contains six subscales: Nonacceptance, Difficulties Engaging in Goal-Directed Behavior, Impulse Control Difficulties, Lack of Emotional Awareness, Limited Access to Emotion Regulation Strategies, and Lack of Emotional Clarity. Responses range from 1 (almost never) to 5 (almost always). Higher scores indicate greater difficulty in each domain of emotion regulation. The original Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) has similar acceptable psychometric properties as the short form (Kaufman et al., 2016). A sample item of the DERS is, “When I’m upset, I believe that I will remain that way for a long time.” Based on the current data, the Cronbach’s alpha estimates were excellent at baseline ($\alpha = 0.90, n = 43$), midpoint ($\alpha = 0.93, n = 28$), and posttreatment ($\alpha = 0.92, n = 20$).

Adolescent Dissociative Experiences Scale (ADES). The 30-item, self-report ADES (Armstrong, Putnam, Carlson, Libero, & Smith, 1997) was designed to assess the developmental progression of normal and clinical experiences of dissociation in adolescents. Higher scores indicate greater frequency of dissociative experiences (0 = never to 10 = always). The ADES includes four subscales related to domains of dissociation: Dissociative Amnesia, Absorption and Imaginative Involvement, Passive Influence, and Depersonalization and Derealization. A sample item is, “I find that I can’t tell whether I am just remembering something or if it is actually happening

to me.” In previous research, the Spearman-Brown split-half reliability estimate was 0.92 and Cronbach’s alpha coefficient for the total score was 0.93 (Armstrong et al., 1997). The current data showed similar estimates with excellent Cronbach’s alpha at baseline ($\alpha = 0.95, n = 43$), midpoint ($\alpha = 0.93, n = 28$), and at posttreatment ($\alpha = 0.92, n = 20$).

Youth Self-Report 11-18 (YSR/11-18). Externalizing behavior was assessed with the YSR/11-18, a mixed method self-report questionnaire (Achenbach & Rescorla, 2001) that measures overall functioning, mood, anxiety, and general symptomatology and is intended for adolescents ages 11 to 18. Factor analyses have found several domains within the YSR/11-18. For the purposes of the current study, the Aggression (19 items) and Delinquency (11 items) subscales as defined by O’Keefe, Mennen, & Lane (2006) were combined as a measure of externalizing behavior. Higher scores indicate greater externalizing behavior (0 = Not True, 1 = Somewhat or Sometimes True, 2 = Very True or Often True). A sample item is, “I destroy things belonging to others.” In previous research, reliability estimates for YSR 11-18 scores are acceptable as indicated by test-retest reliability (Pearson’s $r = .79$), internal consistency (Cronbach’s $\alpha = .83$), and inter-rater reliability with the Child Behavior Checklist ($r = .49$; Achenbach et al., 1995a; 1995b). In the current study, the Cronbach’s alpha of the items assessing externalizing behavior was good ($\alpha = 0.88, n = 43$).

Statistical Analysis

Mediation analysis.

Data preparation. As recommended by Schlomer, Bauman, & Card (2010), preliminary analyses calculated the percentage and found that for the variables of interest, no data were missing. A power analysis using G*Power 3.0.10 was conducted to estimate the sample size needed in order to detect a small effect size ($f = 0.07$). The total sample size, based on this power analysis, needed was computed as 115. The sample size was $n = 44$ and this was due to a number of barriers in recruitment, participant study completion, and to the suspension of the study due to COVID-19.

Five assumptions of multiple regressions were examined prior to the multiple regression analysis: Linearity, multicollinearity, homoscedasticity, normally distributed residuals, and no influential biasing cases. Assumptions were tested based on a multiple regression model where scores from externalizing behavior (EXT) represented the criterion variable, and age, biological sex, the Adverse Childhood Experiences (ACE) scale, the Adolescent Dissociative Experiences Scale (ADES), and the Difficulties in Emotion Regulation Scale (DERS) were

entered as predictor variables. Data met the assumptions of linearity, multicollinearity, and homoscedasticity. The data did not, however, meet the assumption of a normal distribution of the residuals. Analysis on influential biasing cases also revealed one case was overly influential in the regression model. This case was removed leaving a sample size of $n = 43$.

Mediation analysis using multiple regression. Baron and Kenney described a mediator as a third variable that “represents the generative mechanism through which the focal independent [predictor] variable is able to influence the dependent [outcome] variable of interest” (1986, p. 1173). Following their method, three conditions must be met for mediation to be possible and are determined in three steps. In step one, the predictor variable must significantly predict the outcome variable. In step two, the predictor variable must significantly predict the mediator. In step three, when the outcome variable is regressed on both the independent and mediator variable, the mediator must predict the outcome variable. If these three conditions are met and if the relationship between the predictor and outcome variables is diminished (partial mediation) or eliminated (full mediation) when including the mediator in a multiple regression analysis, then the evidence supports a mediation effect (Baron & Kenny, 1986).

Research Question 1 (RQ1). Does dissociation mediate the relationship between adverse childhood experiences (ACE) and externalizing behaviors? In the multiple regression analysis, the number of ACEs was the predictor variable, dissociation was the mediator variable, and externalizing behavior was the outcome variable. Data from baseline only was used to test RQ1 utilizing Baron and Kenny’s (1986) method. In step 1, testing hypothesis 1a, dissociation (mediator) was regressed on ACEs (predictor). In step 2, testing hypothesis 1b, externalizing behavior (outcome) was regressed on ACEs. In step 3, testing hypothesis 1c, externalizing behavior was regressed on both ACEs and dissociation. In the final mediation analysis, testing for hypothesis 1d, a Sobel test was used to determine if the reduction (or elimination) of the effect size of the prediction of ACEs on externalizing was statistically significant from step 2 to step 3 based on an alpha value of 0.05.

Due to research described above revealing the important differences in biological sex and age in the experience and response to ACEs, biological sex and age were used as control variables by entering them into the regression equation. Difficulties in emotion regulations was included in the regression equation to control for the second mediator of the model being tested.

Research Question 2 (RQ2). Do difficulties in emotion regulation mediate the relationship between adverse childhood experiences and externalizing behavior? Similarly, for RQ1, this analysis utilized Baron and Kenny’s

(1986) method for testing mediation using multiple regression. The data examined for RQ2 were the same as the data examining RQ1 with the exception that for RQ2 the mediator variable was difficulties in emotion regulation. The predictor variable was number of types of ACEs and the outcome variable was externalizing behaviors. Biological sex and age were used as control variables by entering them into the regression equation. Dissociation was included in the regression equation to control for the second mediator of the model being tested. The same steps were followed as for RQ1.

Effectiveness of neurofeedback: Analysis of variance at baseline, midpoint, and posttreatment.

Data preparation for dissociation analysis. Similar to the baseline data, no data were missing at the midpoint and posttreatment. Therefore, no missing data analyses were warranted.

The scant literature on the effectiveness of neurofeedback on dissociation either reported base rates (Manchester, Allen, & Tachiki, 1998) or focused on methodology of implementation (Brownback & Mason, 1999), but no effect sizes were found, so input parameters were estimated. A power analysis using G*Power 3.0.10 (Faul, Erdfelder, Lang, & Buchner, 2007) was conducted to estimate the sample size needed in order to detect a small effect size ($f = 0.12$). The total sample size needed was computed as 114. This sample size was not met and the implications will be discussed in the limitations section. However, a search of studies examining the effectiveness of neurofeedback using a treatment-as-usual control group revealed that the sample size is consistent other studies (Lackner et al., 2016; Dehghani-Arani, Rostami, & Nadali, 2013).

The data were examined to verify that they met four assumptions of repeated-measures ANOVA: Independence, normality of dependent variables, homogeneity of variance, and sphericity. In general, when assumptions are not met, the type I error rates increase. Independence was controlled in the sampling process by selecting participants independently and by randomly assigning them to either the neurofeedback or treatment-as-usual group using a randomization matrix. Based on normality tests, the data from the ADES were positively skewed. Therefore, a square root transformation was performed, which improved the normality of the frequency distribution with adequate skewness. The data met the assumptions of homogeneity of variance and sphericity.

Table 3

Skewness and Shapiro-Wilk of square root transformation of the ADES data

	Skewness statistic		<i>p</i> of Shapiro Wilk		
	original	sqrt	original	sqrt	
ADESbl	1.037	-0.107	ADESbl	0.167	0.965
ADESmid	1.7	0.245	ADESmid	0.004	0.907
ADESpst	2.003	0.648	ADESpst	0	0.409

Note: Skewness statistics < -1 and > 1 and significant *p* value (< 0.05) indicates overly skewed frequency distributions.

Repeated-measures analysis of variance (ANOVA). Repeated-measures 2x3 analysis of variance (ANOVA) with independent variables and a covariate tested for the effect of neurofeedback on dissociation compared to the treatment-as-usual condition across the three time-points (baseline, midpoint, and posttreatment; Dimitrov & Rumrill, 2003). In general, repeated measures ANOVA provides the advantage of being able to partition the total variation into between-treatment variation and within-treatment variation. Adding an independent variable allows researchers to ask if there are statistically significant differences in the dependent variable as defined by each group, the main effects. In addition, it allows for the examination of interaction effects between time and the independent variable.

In the 2x3 repeated-measures ANOVA with an independent variable design, two levels specified treatment condition, the independent variable (neurofeedback vs. treatment-as-usual group), and three levels specified the time point (baseline, midpoint, and posttreatment). Age was used as a covariate. The dependent variable was dissociation. The criteria value for significance was 0.10. The effect of the interaction between time and condition was also examined. These tests were calculated in SPSS.

Examining the impact of neurofeedback on difficulties in emotion regulation. Similar to dissociation, independent samples repeated measures analysis of variance (ANOVA) tested for the effect of neurofeedback on difficulties in emotion regulation. The same rationale, assumptions, and statistical procedures were used to address research question 4 as was used in research question 3 with the exception that difficulties in emotion regulation was the dependent variable. The data met the assumptions for independence, homogeneity of variance, and sphericity were met. Similar to the data from the ADES, data from the Difficulties in Emotion Regulation Scale (DERS) were positively skewed. A natural log transformation improved the normality of these data (See Table 4).

Table 4

Skewness and Shapiro-Wilk of square root transformation of the DERS data

	Skewness statistic			<i>p</i> of Shapiro Wilk	
	original	NL		original	NL
DERSbl	0.424	-0.371	DERSbl	0.389	0.557
DERSmid	1.176	0.603	DERSmid	0.043	0.285
DERSpost	0.885	0.200	DERSpost	0.062	0.556

Note: Skewness statistics < -1 and > 1 and significant *p* value (< 0.05) indicates overly skewed frequency distributions.

Results

Mediation Analysis

Variable characteristics. Age in years (11 to 17) did not significantly correlate with ACEs ($r = -0.05$, $p = 0.75$), ADES ($r = 0.00$, $p = 0.99$), DERS ($r = -0.12$, $p = 0.46$), or EB ($r = 0.26$, $p = 0.09$). Female participants reported a higher number of adverse childhood experiences (4.37) than their male counterparts (3.23); however, the mean difference (1.14) was not statistically significant ($t = 1.40$, $p = 0.17$). Based on biological sex, participants did not differ in dissociative experiences (Female mean = 1.17, male mean = 1.24, $t = -0.41$, $p = 0.69$), difficulties in emotion regulation (Female mean = 2.39, male mean = 2.47, $t = -0.29$, $p = 0.77$), or externalizing behavior (Female mean = 0.63, Male mean = 0.69, $t = -0.67$, $p = 0.51$).

Table 5

Correlations, means and standard deviations at baseline in the mediation analysis, N = 43

	Mean	SD	1	2	3	4	5
1. Age (in years)	15.29	1.49	N/A				
2. ACE scale	4.02	2.74	-0.05	N/A			
3. ADES	1.79	1.64	0.00	0.47**	<i>0.95</i>		
4. DERS	2.42	0.78	-0.12	0.46**	0.72**	<i>0.90</i>	
5. EXT	0.65	0.31	0.26	0.53**	0.53**	0.54**	<i>0.88</i>

Note: Italicized values on the diagonal for ADES, DERS, and EXT are Cronbach's alpha. Cronbach's alphas for ADES, DERS, and EXT were based on 30, 18, and 32 items, respectively. * $p < 0.05$, ** $p < 0.001$. ACE = Adverse Childhood Experiences. ADES = Adolescent Dissociative Experiences Scale. DERS = Difficulties in Emotion Regulation Scale. EXT = Externalizing Behaviors as measured on the Youth Self-Report.

Research question 1 (RQ1). RQ1 asked the question, do adolescent dissociative experiences mediate the relationship between adverse childhood experiences and externalizing behavior?

Multiple regression. A multiple regression model was constructed with externalizing behavior as the criterion variable, age and biological sex as controlled variables, Adverse Childhood Experiences (ACE) scale as the predictor, the Adolescent Dissociative Experiences Scale (ADES) scores and the Difficulty in Emotion Regulation Scale (DERS) scores as mediators, and Externalizing Behavior subscale (EXT) scores entered as the predicted variable. The overall model was a significant predictor of externalizing behavior ($R^2 = 0.508$, $F(5) = 7.632$, $p < 0.001$).

Table 6

Multiple regression coefficients of variables predicting externalizing behavior

Predictors	Unstandardized Coefficients		Standardized Coefficients	
	B	SE	β	p
Age in years	0.062	0.025	0.294	0.021**
Biological sex	0.055	0.084	0.082	0.518
ACE scale	0.045	0.018	0.356	0.015**
ADES	0.024	0.033	0.128	0.463
DERS	0.124	0.069	0.311	0.080*

Dependent variable = Externalizing Behavior, * $p < .10$, ** $p < .05$, ACE = Adverse Childhood Experience, ADES = Adolescent Dissociative Experiences Scale, DERS = Difficulties in Emotion Regulation Scale.

As shown in Table 6, Age in years and ACEs significantly predicted Externalizing Behavior and biological sex, the square root of Adolescent Dissociative Experiences Scale and the natural log of Difficulties in Emotion Regulation Scale were not significant predictors.

Hypothesis 1a. Hypothesis 1a stated that the Adverse Childhood Experiences (ACE) scale will predict the overall score on the Adolescent Dissociative Experiences Scale (ADES). In a regression model controlling for age, biological sex, and difficulties in emotion regulation (DERS), the ACE scale was not a significant predictor of the ADES ($\beta = 0.196$, $p = 0.13$).

Hypothesis 1b. Hypothesis 1b stated that the ACE scale will predict the score for Externalizing Behavior (EXT) from the Youth Self-Report. In a regression model controlling for age, biological sex, and difficulties in emotion regulation, the ACE scale significantly predicted the EXT subscale ($\beta = 0.381$, $p = 0.007$).

Hypothesis 1c. Hypothesis 1c stated that when controlling for ACEs, the ADES will significantly predict the EXT subscale. In a regression model controlling for ACEs, age, biological sex, and difficulties in emotion regulation, the ADES did not significantly predict EXT ($\beta = 0.128$, $p = 0.463$).

Hypothesis 1d. The effect size of the prediction of ACEs on externalizing behavior (1b) will diminish or be eliminated when controlling for dissociation (1c). The result from a Sobel test indicated that, when controlling for age, biological sex, and difficulties in emotion regulation, the strength of the relationship between adverse childhood experiences and externalizing behaviors ($\beta = 0.381$) did not significantly change when accounting for the variance from adolescent dissociative experiences ($\beta = 0.356$, $t = 0.66$, $p = 0.51$).

Summary. Overall, results from the current analysis did not provide significant statistical results to support the hypothesized path through adolescent dissociative experiences in a multiple mediation model controlling for age in years and biological sex of the relationship between adverse childhood experiences and externalizing behavior. However, the values of standardized regression coefficients were relatively high in magnitude, suggesting the lack of statistical significance was mainly caused by limited sample size.

Research question 2. Research question 2 posed the question: Do difficulties in emotion regulation mediate the relationship between adverse childhood experiences and externalizing behavior?

Hypothesis 2a. Hypothesis 2a stated that the Adverse Childhood Experiences (ACE) scale will predict the overall score on the Difficulties in Emotion Regulation Scale (DERS). In a regression model controlling for age, biological sex, and adolescent dissociative experiences, the ACE scale was not a significant predictor of the DERS ($\beta = 0.170, p = 0.192$).

Hypothesis 2b. Hypothesis 2b stated that the ACE scale will predict the score for Externalizing Behavior (EXT) from the Youth Self-Report. As reported above, in a regression model controlling for age, biological sex, and difficulties in emotion regulation, ACEs significantly predicted the EXT subscale ($\beta = 0.409, p = 0.006$).

Hypothesis 2c. When controlling for ACEs, the DERS will significantly predict the EXT subscale. In a regression model controlling for ACEs, age, biological sex, and adolescent dissociative experiences, the DERS significantly predicted EXT ($\beta = 0.311, p = 0.08$) at the 0.10 significance level.

Hypothesis 2d. The effect size of the prediction of ACEs on externalizing behavior (1b) will diminish or be eliminated when controlling for difficulties in emotion regulations (1c). The result from a Sobel test indicated that, when controlling for age, biological sex, and dissociative experiences, the strength of the relationship between adverse childhood experiences and externalizing behaviors ($\beta = 0.409$) did not significantly change when accounting for the variance from difficulties in emotion regulation ($\beta = 0.356, t = 1.03, p = 0.30$).

Summary. Overall, results from the current analysis did not provide evidence to support the hypothesized path through difficulties in emotion regulation in a multiple mediation model controlling for age in years and biological sex of the relationship between adverse childhood experiences and externalizing behavior. However, similar to the results of dissociation, the values of standardized regression coefficients were relatively high in magnitude, suggesting the lack of statistical significance was mainly caused by the limited sample size.

Repeated-Measures Analysis of Variance

A repeated-measure two-way analysis of variance (ANOVA) was utilized to compare the degrees of change in dissociative experiences and difficulties in emotion regulation between the treatment-as-usual group and the neurofeedback group across time from baseline, midpoint, to posttreatment of the intervention. Age was used as a covariate. Two hypotheses were tested: 1) adolescent dissociative experiences will decrease over time; and the decrease is significantly more for participants in the neurofeedback treatment group than in the treatment-as-usual group, and 2) difficulties in emotion regulation will decrease over time; and the decrease is significantly more for participants in the neurofeedback group than in the treatment-as-usual group. The original plan was to utilize a three-way ANOVA including biological sex as a third independent variable; however, due to the small sample size, some of the cells were too small. For instance, three male participants completed the study: One of them was assigned to the neurofeedback group and two were assigned to the treatment-as-usual condition. Therefore, biological sex was eliminated from the analysis model.

Research question 3: Will neurofeedback reduce dissociative experiences? Repeated-measures ANOVA was conducted with dissociative experiences (square root transformation of ADES data) as the dependent variable measured at three time points, group (treatment-as-usual vs. the neurofeedback group) as a between-subjects independent variable and age in years as a covariate.

Means and standard deviations of the square root of the average scores of the overall Adolescent Dissociative Experiences Scale scores at each time point for the treatment-as-usual group, neurofeedback, and combined are presented in Table 7.

Table 7

Mean and standard deviation scores of the Adolescent Dissociative Experiences Scale

	Baseline ₁	Midpoint ₂	Posttreatment ₃
TAU (N=8) _j	$\mu_{1j} = 1.48, s = .65$	$\mu_{2j} = 1.64, s = .74$	$\mu_{3j} = 1.45, s = .93$
NFG (N=12) _i	$\mu_{1i} = 1.28, s = .55$	$\mu_{2i} = 1.16, s = .75$	$\mu_{3i} = 1.10, s = .73$
Total (N=20)	$\mu_1 = 1.36, s = .58$	$\mu_2 = 1.35, s = .76$	$\mu_3 = 1.24, s = .81$

TAU = Treatment-as-usual, NFG = Neurofeedback group

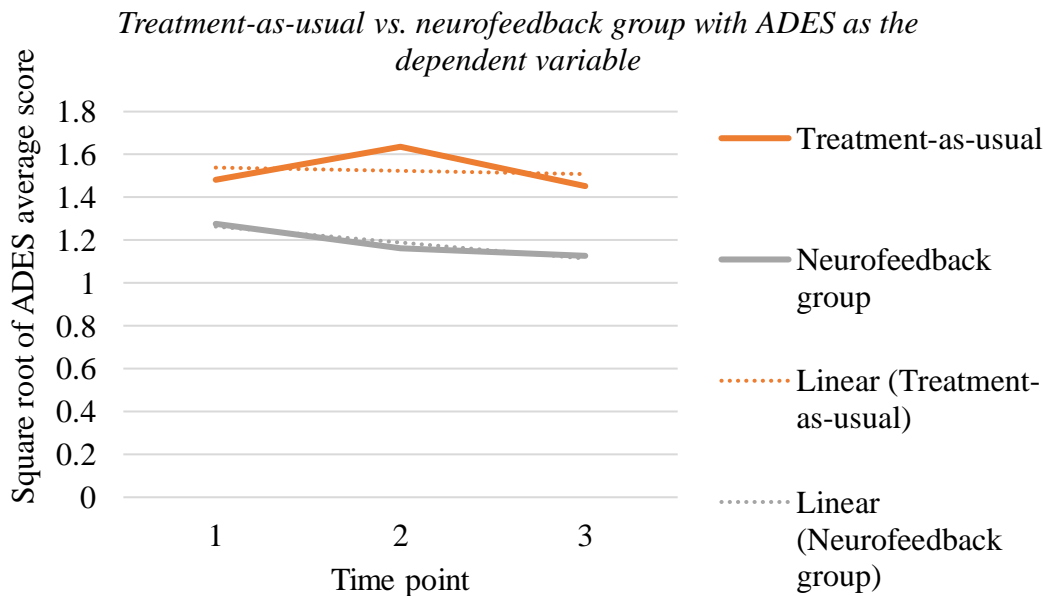
In general, ADES scores in the treatment-as-usual group increased from baseline to midpoint and decreased to slightly lower mean scores than baseline scores at the posttreatment assessment. For the neurofeedback group

(NFG), ADES scores followed a downward trend from baseline to midpoint to posttreatment. However, the interaction effect of time across the three time points and treatment condition was not statistically significant using the Wilks' Lambda test ($F(2, 16) = 1.47, p = 0.259$). In addition, in a test of between-subjects effects, the treatment condition variable did not significantly contribute to the variance ($F(1, 17) = 0.75, p = 0.40$).

Age in years was included in the model as a covariate to control for a portion of the variance of adolescent dissociative experiences. However, age in years did not significantly correlate with adolescent dissociative experiences at baseline ($r = 0.08, p = 0.74$), midpoint ($r = 0.16, p = 0.50$), or posttreatment ($r = 0.32, p = 0.17$). Further, the age in years examined by a test of within-subjects contrasts, did not significantly contribute to the explanation of the total variance ($F(1, 17) = .328, p = 0.57$).

Although tests of within-subjects contrasts found no significant change between baseline and midpoint ($F(1, 17) = 0.09, p = 0.77$), participants, as a whole, reported reduced dissociative experiences between midpoint and posttreatment ($F(1, 17) = 6.13, p < 0.05$). Similarly, no significant difference in the interaction of age and time was found between baseline and midpoint ($F(1, 17) = 0.11, p = 0.75$), though a significant difference was found in the interaction of time and age between midpoint and posttreatment ($F(1, 17) = 5.37, p < 0.05$).

Graph 1



Research Question 4: Will neurofeedback reduce difficulties in emotion regulation? A repeated-measures analysis of variance was calculated using SPSS with difficulties in emotion regulation (natural log of the

DERS data) as the dependent variable measured at three different time points, group (treatment-as-usual vs. the neurofeedback group) as a between-subjects independent variable and age in years as a covariate. Means and standard deviations of the natural log of the average scores of the overall Difficulties in Emotion Regulation Scale score at each time point for the treatment-as-usual, neurofeedback, and combined groups are presented in Table 8.

Table 8

Mean and standard deviation scores of the Difficulties in Emotion Regulation Scale

	Baseline ₁	Midpoint ₂	Posttreatment ₃
TAU (N=8) _j	$\mu_{1j}=.937, s=.243$	$\mu_{2j}=.830, s=.453$	$\mu_{3j}=.747, s=.398$
NFG (N=12) _i	$\mu_{1i}=.796, s=.385$	$\mu_{2i}=.696, s=.325$	$\mu_{3ib}=.588, s=.342$
Total (N=20)	$\mu_1=.852, s=.335$	$\mu_2=.750, s=.376$	$\mu_3=.652, s=.364$

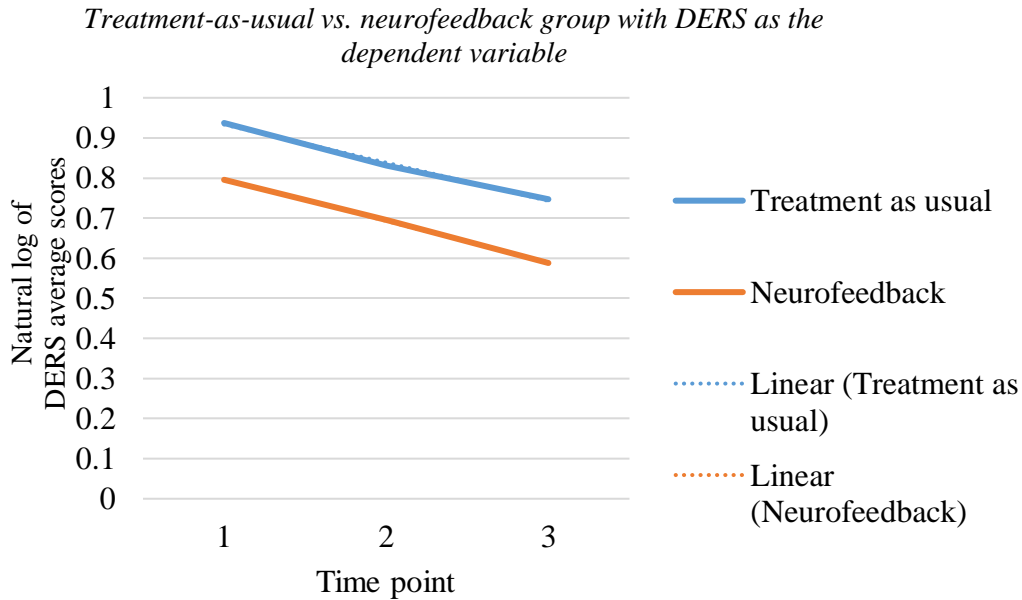
TAU = Treatment-as-usual, NFG = Neurofeedback group

In general, DERS scores presented a downward trend in both treatment-as-usual and neurofeedback groups. Graph 2 demonstrates a parallel relationship in DERS scores between the two groups. Consistent with the graph, a Wilks' Lambda test showed no significant interaction effect between time across the three time points and treatment condition ($F(2, 16) = 0.212, p = 0.811$). In addition, in a test of between-subjects effects, the treatment condition variable did not significantly contribute to the variance ($F(1, 17) = 0.73, p = 0.40$).

As in the model examining adolescent dissociative experiences, age in years was included in the model as a covariate to control for a portion of the variance of adolescent dissociative experiences. However, age in years did not significantly correlate with difficulties in emotion regulation at baseline ($r = -0.11, p = 0.64$), midpoint ($r = 0.07, p = 0.77$), or posttreatment ($r = 0.37, p = 0.11$). Further, the age in years examined by analysis of variance did not significantly explain the total variance ($F(1, 17) = .07, p = 0.80$).

A Wilks' Lambda test based on linearly independent pairwise comparisons among the estimated marginal means, showed that time across the three points collapsing across the two treatment conditions was statistically significant ($F(2, 16) = 3.95, p < 0.05$). This finding is evidence that the participants improved emotion regulation as a function of receiving treatment at a residential treatment facility.

Graph 2



Discussion

The current study investigated two overall research questions. First, the study examined a mediation regression model with adolescent dissociative experiences and difficulties in emotion regulation, as possible mediators of the relationship between adverse childhood experiences and externalizing behaviors. The second question asked whether a 7-week, 3 times-a-week, course of neurofeedback could have an impact on the two mediator variables in question, adolescent dissociative experiences and difficulties in emotion regulation.

One previous study was found with evidence supporting a multiple mediation model explaining how emotion regulation and dissociation mediate the relationship between cumulative childhood trauma and externalizing behavior (Hebert, Langein, & Oussaid, 2018). They found that emotion regulation and dissociation, both separately and combined, mediated the relationship in school-aged sexual abuse victims. Evidence supports emotion regulation (Choi & Oh, 2014) and dissociation (Kisiel & Lyons, 2001; Egeland & Susman-Stillman, 1996) as individual mediators of the relationship between adverse childhood experiences and externalizing behavior.

The current study is the first to date to examine the multiple mediation of these variables in a group of adolescents in residential treatment. Effect sizes suggest promising results should the study proceed. Although the four variables of interest were intercorrelated, analyses failed to provide statistically significant support for the multiple mediation model due to a very limited sample size. The conclusion that the current results were driven by a

lack of statistical power was supported by the results of the power analysis as well as the strong values of standardized regression coefficients, which are often considered as an indicator of effect size in regression. In the multiple regression analyses, the age (11 to 17) of the participants predicted externalizing behavior such that older participants tended to report greater levels of externalizing distress. This finding was not expected. Previous research suggested that as adolescents in RT develop, they tend to increasingly internalize their problems (Baker et al., 2005). Further research is needed to understand the relationship between age and externalizing behavior.

Consistent with previous research (Wisdom, 2014; Brown & Shillington, 2017), externalizing behavior was more likely when participants reported a greater number of types of adverse childhood experiences. This finding supports the theoretical models: attachment theory and the neurodevelopmental view. The implication is that when children are maltreated in early development, they themselves are more likely to use aggression or rule-breaking when frustrated in adolescence. Previous research has observed that female adolescents in residential treatment reported higher levels of externalizing behavior and that mediating variables such as sexual abuse and socialized expectations likely explain this discrepancy (Connor et al., 2004; Baker, Archer, & Curtis, 2005). However, in the current study, biological sex did not predict externalizing behavior. In previous studies, when adolescent girls reported higher levels of externalizing behavior than adolescent boys, the female participants also reported higher levels of past physical and sexual abuse (Connor et al., 2004). However, in this study, the difference in number of ACEs reported was not statistically different between male and female adolescents. Given the robust relationship between ACEs and externalizing behavior, the lack of difference in externalizing behavior is consistent. In addition, the culture and treatment approaches of residential treatment vary widely. For instance, some are more trauma-informed than others, and these differences can contribute to outcomes.

When adolescents had difficulty regulating their emotion when they were upset, they were more likely to become aggressive and less likely to follow rules. This finding is consistent with previous research (Choi & Oh, 2014) and supports attachment theory (Bowlby, 1969) and the neurodevelopmental view (Perry et al., 1995). Difficulty regulating emotion may mean that when an adolescent cannot self-soothe, they must persist with negative affective states leading to frustration and aggression. In addition, a lack of emotion regulation skills may lead to external attempts to feel better.

The second research question examined the effectiveness of a neurofeedback intervention on difficulties in emotion regulation and on adolescent dissociative experiences among the participants that completed the 9-week

study. Little research has examined the effectiveness and efficaciousness of neurofeedback on dissociation. In a one-arm study, Manchester, Alen, and Tachiki (1998) found that after 11 participants with a diagnosis of Dissociative Identity Disorder received 30 sessions of neurofeedback, they reported dissociative experiences in the normal range. More research has examined the effect of neurofeedback on emotion regulation (Linhartova, 2019), though no study to date explores this effect with adolescents in residential treatment. The current study found a significant decrease in dissociative experiences from the midpoint to posttreatment looking at participants as a whole; however, there was no significant difference between groups, meaning that the study did not find evidence that neurofeedback itself played a role in reducing dissociative symptoms. This lack of finding may be a type II error given the study's small sample size. Similarly, there was no significant difference between groups on the reduction in emotion regulation.

Limitations

The primary limitation of this study was its sample size. These data are considered preliminary data due to the suspension of the study due to COVID-19. The lack of findings from both the mediation and the pretest-posttest analyses were possibly type II errors as many of the findings were inconsistent with previous research. In addition, for the mediation analysis, all data analyzed were based on time 1. In future research, a time 2 and time 3 could be used to better inform hypothesis testing of a directional causal relationship. As in previous research on neurofeedback, the current study faced challenges with controlling for a potential placebo effect. The experiences of having a technician applying EEG to participants' scalp and sitting for 20 minutes receiving video stimuli were not controlled for in this study as could be done using a sham condition. Also, the ACE scale has generally been used as a measure intended for adults to recall their past adverse childhood experiences with the assumption that the periods of child and adolescent development are complete. However, the participants were necessarily adolescent, a part of the time period for which the scale measures. The data analyzed in the mediation analysis did not meet the assumption of a normal distribution of the residuals. However, this was unlikely a major limitation because failure to meet this assumption generally increases the risk of making a type I error rather than a type II error.

Future Research

In future research, simple mediation models may examine the role of dissociation and difficulties in emotion regulation in their relationship between adverse childhood experiences and externalizing behaviors. In addition, future research may examine the individual subscales of the Adolescent Dissociative Experiences Scale as Difficulties in Emotion Regulation Scale. Similarly, further analyses may examine the Aggression and Delinquency

(or Rule-Breaking) subscales of the Youth Self-Report rather than consolidating these items as externalizing behavior. Given the challenges of obtaining participants in residential treatment, future research may consider expanding to several facilities. This approach may also bolster confidence in generalizability of the findings. The current study examined adverse childhood experiences as the number types of general events. Future research may examine how specific types of experiences and how frequency, duration and intensity of the events related to dissociation, emotion regulation and externalizing behavior.

Conclusions

This study confirmed previous findings and theories suggesting that individuals with a greater number of types of adverse childhood experiences are more likely to experience higher levels of externalizing behavior. Further research is needed to better understand this relationship and what factors are involved. This study did not find evidence to support a multiple mediation model. However, due to the limitations of the study, the findings cannot reject the hypotheses with confidence. Likewise, analysis from the pretest-post design did not show that neurofeedback reduced dissociative experiences or improve emotion regulation, however, as preliminary data, these findings are inconclusive. Further research is needed to examine the effectiveness of neurofeedback on self-regulatory process in adolescents in residential treatment.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest.

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List of Tables

Table	Page
1. Participant characteristics at baseline	12
2. Participant characteristics at posttreatment	13
3. Skewness and Shapiro-Wilk of square root transformation of the ADES data	18
4. Skewness and Shapiro-Wilk of square root transformation of the DERS data	19
5. Correlations, means and standard deviations at baseline in the mediation analysis	20
6. Multiple regression coefficients of variables predicting externalizing behavior	21
7. Mean and standard deviation scores of the Adolescent Dissociative Experiences Scale	23
8. Mean and standard deviation scores of the Difficulties in Emotion Regulation Scale	25