Exploring adversity: Does perception of childhood trauma influence the development of Executive Functioning in adulthood?

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Abstract
(211 words)

The effects of early childhood trauma (ECT) have been studied rather thoroughly throughout the last decade. Many results have suggested ECT may lead to a myriad of emotional deficits, brain development, and even impairment in cognition. In the realm of cognition, many studies have observed specific deficits in Executive Functioning (EF). Some studies, however point out that there are potential mediators and moderators when it comes to the sensitive development of EF, and that this deficit is not always so clear. Previous research, has failed to examine the role of perception as a potential moderator in the development of executive functioning. The goal of the current project was to investigate how the perception of ECT may affect EF in adulthood. Preliminary results show that Perception of two traumas, Death and Major Upheaval/Other, are significantly correlated to performance on a subsection of the Stroop task. In addition, Major upheaval/other was correlated with Errors made on the Trails B test. Specifically, people who perceived their trauma as more traumatic performed better on the subsection of the Stroop task; while those who perceived their trauma as more traumatic made significantly more errors on the Trails B test. These results merit further investigation into the role of perception of trauma and its effects on EF.

Introduction

The effects of early childhood trauma (ECT) have been studied thoroughly throughout the last decade; notably much research has investigated childhood trauma in different contexts: physical abuse, sexual abuse, emotional abuse, neglect, parental loss, SES, and even divorce. From this research, we have gained some understanding of how ECT affects emotional regulation, and in some cases brain development and cognition; but the extent to how much cognition specifically may suffer because of ECT is not comprehensively understood. Previous research has suggested a link between a construct of cognition, executive functioning (EF), and ECT (Sarsour et al., 2010; Gould et al., 2012; Marshall et al., 2016). The role, however, of potential mediators and moderators of ECT have not been expansively studied. In the current study, we explored the relationship between the potential mediator of ECT, perception of trauma, and the development of EF; specifically, the paradigms of inhibitory control, cognitive flexibility, and working memory.

Brain development and early experience

Brain development occurs in stages, in a protracted process. It begins shortly after conception, and continues until about the third decade of life. It is well known that post-natal brain development is marked by an over-production of synapses; a process that is genetically driven. Following this initial over-production of synapses is an experience-dependent pruning phase; in which the brain becomes more organized and fine-tuned to fit an individuals' surrounding environment (Huttenlocher et al, 1982; LaMantia & Rakic, 1994; Pentanjek et al, 2008).

In addition, the brain develops in a hierarchical manner; beginning with rudimentary systems and ending with more complex systems. When more basic structures are formed, like the

brainstem, it is predominately carried out by genetic cues during the prenatal period (Bick & Nelson, 2015). While the more complex structures, like the prefrontal cortex, develop postnatally and rely predominately on experience. This leaves our more complex structures, here we focus on the prefrontal cortex, more susceptible to early environment; thus, more susceptible to early stress. Research has indicated that lack of stability, or caregiving needs being fulfilled in early childhood may threaten the brain's ability to develop to its' full potential; thus, threatening cognitive development itself (Bick & Nelson, 2015; Pechtel & Pizzagalli, 2010).

The Prefrontal Cortex and Executive Function

The Prefrontal cortex is sensitive to environment and is involved in a number of emotional, social and cognitive functions. Research has indicated that several environmental influences play a role in the development of the Prefrontal cortex including: early rearing conditions, SES, and even schooling type. The prefrontal cortex is also thought to be the main mediator of a cognitive construct called executive function (EF) (Barrasso-Catanzaro & Eslinger, 2016). EF consists of several core constructs: working memory, which is a form of short-term memory that has the capability of storing and manipulating information (Baddeley & Hitch, 1974); inhibitory control, which is the ability to inhibit a well-learned pre-disposed response when a more appropriate response is needed (Barkley, 2001); and cognitive flexibility, which is the ability to view and change perspectives to best fit view of the circumstances (Diamond, 2006). Given the right environment, executive functioning skills appear in early childhood and continue to develop well into adulthood.

Trauma, brain development, and EF

Given the hierarchical nature of brain development, it is evident that the prefrontal cortex is more susceptible to early childhood trauma. In fact, studies have shown that morphological

changes in the prefrontal cortex take place when exposed to early adverse environments (Bick & Nelson, 2015; Teicher et al., 2003; Cancel et al., 2015 Karlsson & Karlsson, 2010). It is no surprise then, that studies have also indicated that the presence of early life stress (ELS) or ECT have also been linked to deficits in EF, which is mediated by the prefrontal cortex (DePrince et al., 2009; Sarsour et al., 2010; Pechtel & Pizzagalli, 2010; Mothes et al., 2015; Marshall et al., 2016). However, studies such as the one by Gould et al., indicate that this link is not so clear; in fact, they found that trauma type, age of onset, and even duration were potential mediators in the development of EF. Studies such as these indicate a need for investigation into other potential mediators of ECT, so that we may better attenuate the suggested EF deficits associated.

Overview of current study

Previous research has failed to address the potential mediation of perception of trauma as it relates to the development of executive functioning. Thus, the goal of the current study was to address this gap, by examining the relationship between executive functioning and perception of early childhood trauma. To do this, 38 undergraduate adults were recruited using SONA to evaluate the development of executive functioning. It is expected that the more traumatic a person perceived their trauma to be, the more likely they were to have EF deficits; and that presence of trauma alone will have an effect on EF. This is important because this is the first step in understanding a potential mediator of trauma; this research can afford a better understanding of the ways in which trauma may be mediated to better attenuate the EF deficits associated.

Methods

Sample

The sample for the current project consisted of 38 undergraduate students, between the ages of 18 and 24 years. Table 1. Provides descriptive characteristics and history of trauma of the

sample. Participants were recruited through SONA and were all enrolled at the University of Cincinnati. The only qualification for the study was that participants were English fluent.

Measures

Executive function

The Trails Making Test (Trails A and B) were used to measure visual-spatial attention and cognitive flexibility. The test consisted of two-timed, paper-and-pencil tasks (Kortte, Horner, & Windham, 2002). For the Trails A test, participants must connect dots with numbers inside until they reach 25. Trails B involves the participant connecting dots similarly to the first task, with the added difficulty of switching between numbers and letters (e.g., 1-A-2-B…). Trails A was a measure of visual spatial attention, and Trails B measured cognitive flexibility. Both errors and time (in seconds) taken to complete the task were used in analyses.

The Stroop test was used as a measure of inhibitory control, and consisted of three 45-second timed tasks (Golden, 1978; Macleod, 1991). The first and second task were tests of nonexecutive cognitive skills, and the third measuring inhibitory control; where the participant must inhibit a instinctive verbal response. The first task required participants to read color words printed in black ink. The second task required the participant to name the color of symbols on a page, presented in randomized three-color sequences (red, green, blue). The final task required participants to name colors of color-words when the ink does not match the word (e.g., if the word *red* is printed in green the participant must say green and not red). Scoring was based on standardized Stroop scoring methods; amount of words completed in relation to age and grade provided a Stroop T-Score, which was used for analyses.

History of Trauma

The Childhood Trauma Questionnaire (CTQ) was used to measure history and perception of childhood trauma (Pennebaker & Susman, 2013). It contains six items, with two sub-questions scored on a 7-point scale. Participants were first asked superficial yes-or-no questions related to history of trauma (e.g., Prior to the age of 17, did you experience death of a very close friend or family member?); if the answer was yes to the question, participants were then asked on a 7-point scale how traumatic it was (1 = not at all traumatic, 4 = somewhat traumatic, 7= extremely traumatic). Participants were then asked the extent to how much they confided their trauma in others using a 7-point scale (1=not at all, 7= a great deal). It is notable that this questionnaire also provides participants with the opportunity to write in a trauma they may have experienced, if it is not listed. In scoring the CTQ, each trauma was given a 1 (if participant responded yes), and 0 (if participant responded no). Each trauma and perception score was analyzed independently, and analyzed for frequency; similarly, to the scoring methods of Pennebaker & Susman (2013).

Current state of mind

To control for participants' current mood and state-of-mind, the Center for Epidemiologic Studies Depression Scale (CES-D) and Emotional Regulation Questionnaire (ERQ) were administered as well. The CES-D is a 20-item self-report scale that measures depressive symptomology in nine different groups as defined by the APA (i.e., sadness, loss of interest, appetite, guilt…etc.). Participants respond to questions by checking a box indicating how they felt during the past week (responses were: Rarely or none of the time, Some or a little of the time, Occasionally or a moderate amount of time, Most or all the time) (Radloff, 1977; Eaton et al., 2004). The ERQ is a 10-item scale that measured participants' tendency to regulate their emotions through cognitive reappraisal or expressive suppression (Gross & John, 2003). Participants responded to each question on a 7-point Likert scale (1=strongly disagree,

7=strongly agree). Scoring for the ERQ warranted two separated scores: The Cognitive Reappraisal facet, and The Expressive Suppression facet. Each facet was totaled, and separate scores were used in analyses.

Procedures

Each of the Neuropsychological measure of Executive Function were administered by trained Research Assistants. Prior to participant arrival, all testing materials were marked with a unique subject code on the back to ensure participant anonymity.

Participants were asked to first complete the Trails test in the presence of a trained research assistant. Participants were timed during the duration of both tasks; if they created an error they were told 'no' and asked to correct their mistake. When participants completed the task, the research assistant would record their time (in seconds) and their error on the test.

Participants were then asked to complete the Stroop task. They were given a clip-board with each of the three paper tasks attached. Research assistants would have a clip board with the same task, so they could follow as the participant completes the task and mark where they finished. Participants were first read instructions for the task using the Research Assistants' copy as a reference; if the participant had no questions they were given their copy and told to begin the task. If the participant made a mistake, the Research Assistant would tell them 'no' and wait for them to correct the mistake. At the end of the 45-second period, the participant was told to 'stop' and the Research Assistant would record where they finished on their copy.

The final part of the experiment consisted of the three surveys (CES-D, ERQ, CTQ). The surveys were assembled into a 'package' prior to participant arrival, and were always in the same order: (CES-D, ERQ, CTQ). Participants were ensured that all answers were anonymous, and that if any questions made them uncomfortable they may skip them. Participants completed the

survey in private, to alleviate any feeling of nervousness in the presence of research staff. Participants were asked to leave the survey, and exit the testing room upon completion of the survey package. Once exiting the testing room, research assistants would answer any questions participants had and give them a list of mental health resources near the University of Cincinnati.

Statistical Analyses

Descriptive analyses were run to examine sample demographics and the number of individuals who reported experiencing the traumas listed within the CTQ. An Independent Samples T-test was run on each trauma to examine the influence of trauma on performance on EF test batteries. In addition, Independent Samples T-tests were run to examine the influence of presence of trauma on Depression and Emotional Regulation. Bivariate Pearson correlation analyses were run to examine the relationship between perception of trauma and performance on EF test batteries.

Results

Descriptive statistics

A total of 38 undergraduate students at the University of Cincinnati participated in the study. The demographics and history of trauma of the sample is summarized in Table 1. Participants whom reported an 'other' gave the following responses: "Family member diagnosed with cancer", "Coming out to family", "Familial drug/alcohol addiction", "Familial depression/suicide", "Being moved around frequently/military family", and "Strained relationship with close family". Average sample performance on neuropsychological test batteries are summarized in Table 2.

Table 1. Descriptive characteristics of sample

Study Variables	Total N (%)
Covariates	
Participant Gender	
Male	15 (39)
Female	23 (61)
Age (mean. SD)	19.74 (1.67)
History of trauma	
Loss of a loved one	17 (45)
Parental Divorce	7 (18)
Sexual Abuse	4 (11)
Physical Abuse	3 (8)
Extreme Illness	10 (26)
Major Upheaval / Other	15 (39)

Table 2. Mean and standard deviations of study executive function tasks

Construct	Task	N	Mean	SD
Cognitive Flexibility				
	Trails A (time, seconds)	38	29.58	10.737
	Trails A (errors)	38	.08	.359
	Trails B (time, seconds)	38	61.39	19.785
	Trails B (errors)	38	.95	1.593
Inhibitory Control				
	Stroop word reading	38	48.08	12.297
	Stroop rapid color naming	38	48.13	12.072
	Stroop word reading	38	53.45	11.493

Independent Samples T-Test

An independent-samples t-test was conducted to compare performance on EF test batteries between people who had and had not experienced trauma. There was a significant difference in errors made on the Trails B test and between presence of major upheaval/other trauma group (M = 1.73, SD = 2.120) and no Major Upheaval/Other trauma group (M = .45, SD = .858); (t (37) = -2.552, p = 000) (see figure 1.). In addition, there was a significant difference in performance on the Stroop color naming task between presence of major upheaval/other trauma group (M = 51.07, SD = 16.303) and no major upheaval/other trauma group (M = 46.14, SD =

8.323); (t (37) = -1.211, p = 017) (see figure 2.). Finally, there was a significant difference in CES-D total score between presence of major upheaval/other trauma group (M = 26.20, SD =9.244) and no major upheaval/other trauma group (M = 21.00, SD = 6.203); (t (37) = -2.052, p = 037) (see figure 3.).

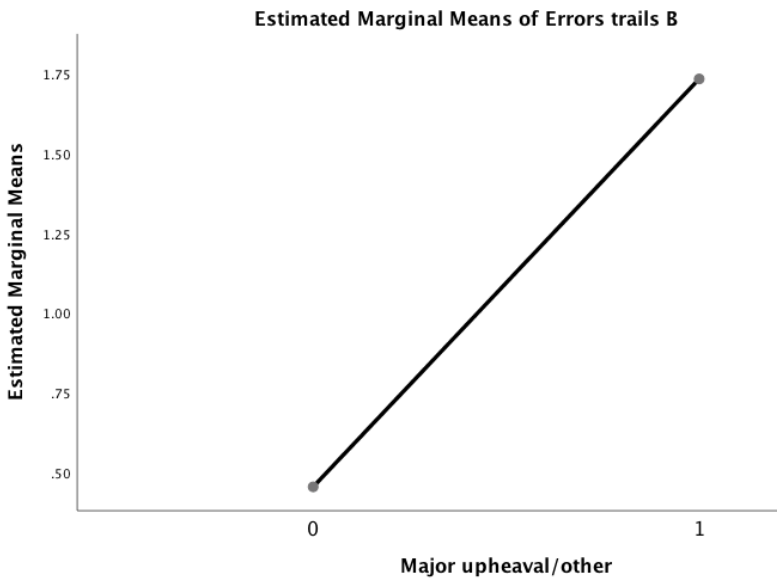

Figure 1. *Errors made on Trails B for individuals who have not (0) and have (1) experienced the trauma of Major Upheaval or other.*

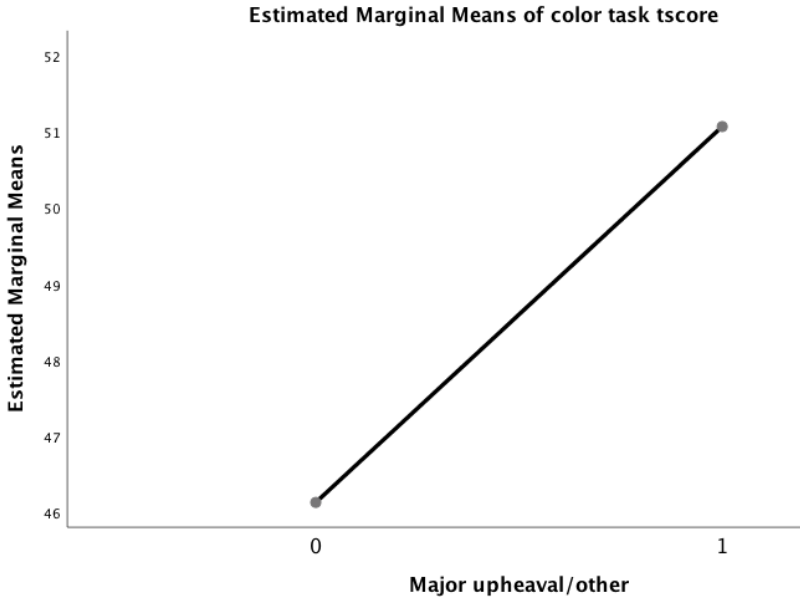

Figure 2. *Performance on Stroop color naming task for individuals who have not (0) and have (1) experienced the trauma of Major Upheaval or other.*

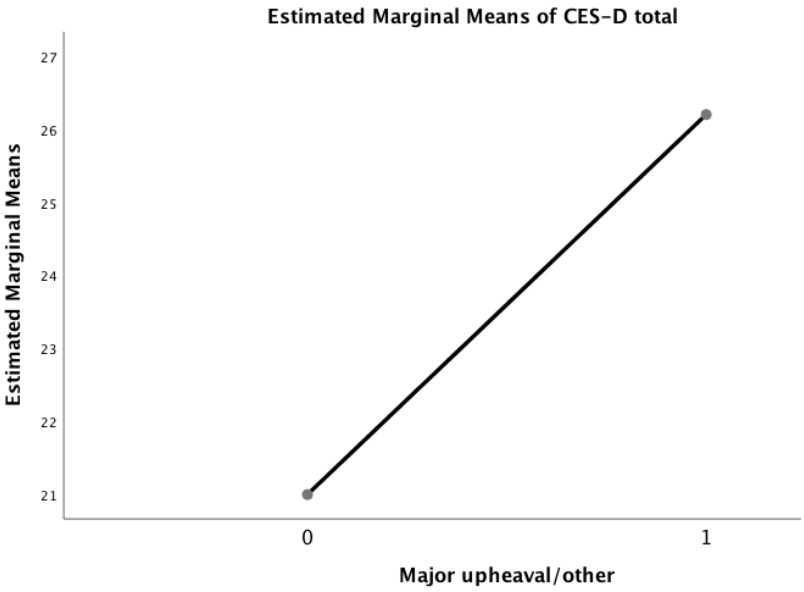

Figure 3. *CES-D response totals for individuals who have not (0) and have (1) experienced the trauma of Major Upheaval or other.*

Bivariate Pearson Correlation Coefficient test

A Bivariate Pearson correlation coefficient was computed to assess the relationship between perception of trauma and performance on neuropsychological test batteries. There was a weak, positive correlation between perception of loss of a loved one and performance on the Stroop word reading task (r = .366; p = .024). Figure 4 summarizes the results. There was a moderate, positive correlation between perception of Major upheaval/other and performance on the Stroop word reading task (r = .424; p = .009). Figure 5 summarizes the results. There was a moderate, positive correlation between perception of Major upheaval/other and Errors made on the Trails B test (r = .430; p = .008). Figure 6 summarizes the results.

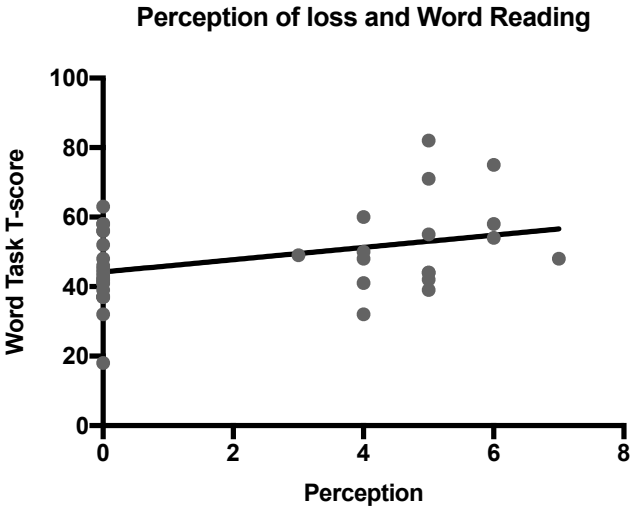

Figure 4. *Perception of loss trauma has a weak, positive correlation to performance on Stroop word reading task. p<.05**

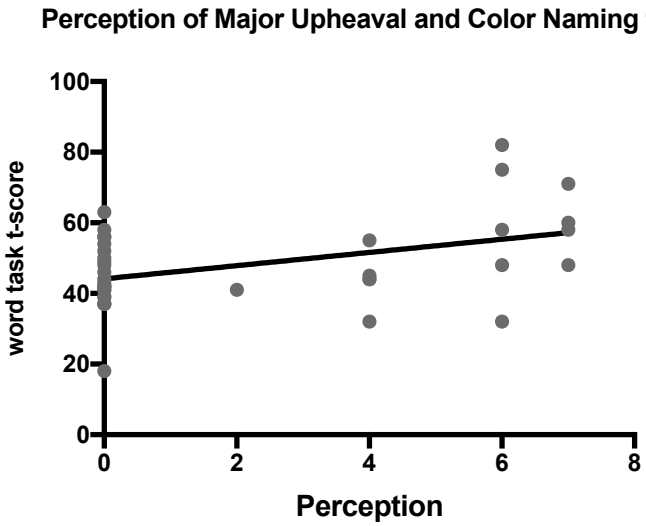

Figure 5. *Perception of Major upheaval/Other trauma has a weak, positive correlation to performance on Stroop color naming task. p<.05**

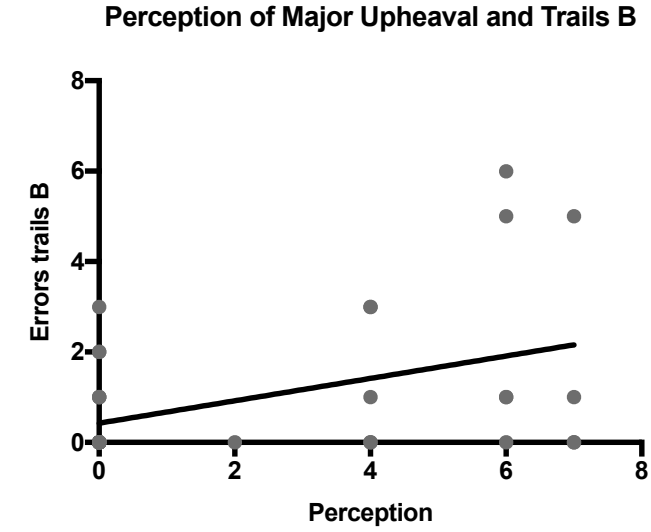

Figure 6*. Perception of Major Upheaval/Other trauma has a weak, positive correlation to errors made on Trails B test. p<.05**

Discussion

The purpose of this study was to evaluate the relationship between perception of early childhood trauma (ECT) and the development of executive functioning (EF). A sample of 38 undergraduate students at the University of Cincinnati between the ages of 18 and 24 was used to complete the study. Participants completed two neuropsychological test batteries that measured EF; specifically, in the realm of cognitive flexibility, working memory, and inhibitory control. Participants then completed a short survey package that contained the CES-D, a clinical measure of depression, the ERQ, a standardized measure of emotional regulation, and the CTQ, a measure of childhood trauma. To measure perception of trauma, the current study used responses to how the person felt about the trauma; obtained from the CTQ (i.e., participant describes trauma as 7, extremely traumatic; or 1, not at all traumatic). It was hypothesized that the more traumatic a person perceived their trauma to be, the more likely they were to have EF deficits.

Results

The current study has two interesting findings: the first is that although trauma does appear to affect EF, it is dependent on the trauma type itself. Individuals whom reported having experienced the trauma of major upheaval/other made significantly more errors on the Trails B test (see Figure 1.). In addition, that same group also had a significantly poorer performance on the Stroop color naming task (see Figure 2.) and had significantly higher scores on the CES-D (see Figure 3.). Results obtained from the two neuropsychological suggest that ECT does indeed affect EF, even into adulthood. The results obtained from the CES-D confirm the suspected emotional deficits also associated with ECT. Results from this study support the literature findings of DePrince et al. (2009) and Sarsour et al. (2010), and many more.

The second finding is that of those whom have experienced ECT, perception of trauma does appear to slightly influence EF. Perception of loss of a loved one had a weak, positive correlation with the Stroop word reading task; meaning those who perceived their trauma as more traumatic performed better on this task than those who perceived their trauma as less traumatic. Further, perception of major upheaval/Other had a moderate, positive correlation with performance on the Stroop color naming task; meaning those who perceived their trauma as more traumatic performed better on this task than those who perceived their trauma as less traumatic. By contrast, there was also a moderate, positive correlation with perception of major upheaval/other and errors made on the Trails B test; meaning that those who perceived their trauma as more traumatic made more errors on the Trails B test than those who perceived their trauma as less traumatic. These mixed findings, much like those found in the study by Gould et al. (2012), suggest a need to further investigate the role of perception as a mediator of ECT in the development of EF.

Limitations

An apparent limitation to this study was the small sample size, *n*=38. The small sample led to an uneven number of individuals who had and had not experienced certain traumas (see table 1); this may be a reason why those groups who were more even (Major Upheaval & Loss) showed significant correlations to performance on EF test batteries. In addition, this study only included college-aged students; primarily for ease of proximity. College aged students will have had more training at this stage in life, likely affecting results. The current study also failed to address the influence of previous access mental healthcare; specifically, no data was collected that would allow researchers to know if there was any influence of previous psychological help. Finally, since EF is a large network of cognition; more measures of EF should have been used in

the current study to better evaluate the effects of perception of ECT and ECT itself. While it is important to note these limitations, results of the currents study could still be used as foundational research for future studies investigating mediators of ECT on EF.

Future research

In future studies, researchers should use pre-college aged children to gain a better understanding of perception as a mediator of ECT on EF. This would allow for the sample to be more valid, since college-aged adults may have better EF in general. In addition, future research should use more measures of EF, since EF has many points of interest relative to cognition, and the current study only examined three main areas. Finally, it would be interesting to know if participants had seen a therapist/sought help for their trauma, to see if that may attenuate any EF deficits.

Conclusions

The results from this study are mixed, while trauma appears to have an effect on EF that effect seems to be solely dependent on the trauma type. Further, perception of trauma appears to play a role in EF; however, the results are mixed. Results showed in majority of cases that a more negative perception of ECT is correlated to better performance on EF test batteries. This raises question as to how our own perception of our circumstances may impact cognitive function. It could be that those who responded that their ECT was more traumatic were more aware of their own trauma, thus having a positive influence on EF; whereas those who reported their ECT as not at all traumatic, may be unaware their trauma and thus have a negative impact on EF. The results from this study indicate a need to further investigate the role of perception as a mediator of ECT that may mitigate the effects of EF.

References

Augusti, E., & Melinder, A. (2013). Maltreatment is associated with specific impairments in executive functions: A pilot study. Journal Of Traumatic Stress, 26(6), 780-783.

Baddeley, A. (1998). Working memory. Comptes rendus de l'Acade´ mie des sciences. Se´ rie III, Sciences de la vie, 321(2–3), 167–173.

Barkley, R.A. (2001). The executive functions and self-regulation: An evolutionary neuropsychological perspective. Neuropsychology Review, 11(1), 1–29

Barrasso-Catanzaro, C., & Eslinger, P. J. (2016). Neurobiological Bases of Executive Function and Social-Emotional Development: Typical and Atypical Brain Changes. Family Relations, 65(1), 108-119.

Bick, J., & Nelson, C. A. (2016). Early Adverse Experiences and the Developing Brain. Neuropsychopharmacology, 41(1), 177–196. http://doi.org/10.1038/npp.2015.252

Cancel, A., Comte, M., Truillet, R., Boukezzi, S., Rousseau, P., Zendjidjian, X. Y., & ... Fakra, E. (2015). Childhood neglect predicts disorganization in schizophrenia through grey matter decrease in dorsolateral prefrontal cortex. Acta Psychiatrica Scandinavica, 132(4), 244-256.

Deprince, A. P., Weinzierl, K. M., & Combs, M. D. (2009). Executive function performance and trauma exposure in a community sample of children. Child Abuse & Neglect, 33(6), 353-361.

Diamond, A. (2006). The early development of executive functions. In E. Bialystok & F.I.M. Craik (Eds.), Lifespan cognition: Mechanisms of change (pp. 70–95). New York, NY: Oxford University Press.

Gould, F., Clarke, J., Heim, C., Harvey, P. D., Majer, M., & Nemeroff, C. B. (2012). The effects of child abuse and neglect on cognitive functioning in adulthood. Journal of Psychiatric Research, 46(4), 500-506

Herbers, J. E., Cutuli, J. J., Monn, A. R., Narayan, A. J., & Masten, A. S. (2014). Trauma, adversity, and parent–child relationships among young children experiencing homelessness. Journal Of Abnormal Child Psychology, 42(7), 1167-1174.

Huttenlocher PR, de Courten C, Garey LJ, Van der Loos H (1982). Synaptogenesis in human visual cortex—evidence for synapse elimination during normal development. Neurosci Lett 33: 247–252.

Karlsson, L., & Karlsson, H. (2010). Trauma and the adolescent brain. Nordic Journal Of Psychiatry, 64(1), 3.

LaMantia AS, Rakic P (1994). Axon overproduction and elimination in the anterior commissure of the developing rhesus monkey. J Comp Neurol 340: 328–336.

Marshall, D. F., Passarotti, A. M., Ryan, K. A., Kamali, M., Saunders, E. H., Pester, B., & ... Langenecker, S. A. (2016). Deficient inhibitory control as an outcome of childhood trauma. Psychiatry Research, 2357-12.

Mothes, L., Kristensen, C. H., Grassi-Oliveira, R., Fonseca, R. P., de Lima Argimon, I. I., & Irigaray, T. Q. (2015). Childhood maltreatment and executive functions in adolescents. Child And Adolescent Mental Health, 20(1), 56-62.

Pechtel, P., & Pizzagalli, D. A. (2010). Effects of early life stress on cognitive and affective function: an integrated review of human literature. Psychopharmacology, 214(1), 55-70.

Petanjek Z, Judas M, Kostovic I, Uylings HB (2008). Lifespan alterations of basal dendritic trees of pyramidal neurons in the human prefrontal cortex: a layer-specific pattern. Cereb Cortex 18: 915–929