



# The Effectiveness of a Gamified Relaxation Intervention for Traumatized Youths in Residential Care

Catarina Rosada

Master Science Thesis

Supervised by:

1. Prof. Dr. Ron Scholte
2. Dr. Maaïke Cima

30-06-2018

**Radboud University**



## Abstract

Childhood trauma can lead to decreased executive functions and increase the risk of experiencing severe psychological problems. Within residential care, most youths have a history of traumatic life experiences, but applying trauma-focused treatment remains difficult. In the present study, we conducted a randomized controlled trial (RCT) to test the effectiveness of a gamified mindfulness-based relaxation intervention (*Muse*) on youths' post-traumatic stress symptoms and executive functions. Twenty-eight youths were randomly assigned to play *Muse* or receive treatment as usual (TAU). Self- and mentor-reported post-traumatic stress symptoms as well as mentor-reported executive functions were measured both at baseline and post-treatment. Results showed a decrease on self-reported post-traumatic stress symptoms for the *Muse*-condition, compared to the control condition. No differences between the conditions were found regarding mentor-reported post-traumatic stress symptoms and executive functions. Our findings provide preliminary evidence for the effectiveness of *Muse* in a high-risk youth population and lead to the discussion of suggestions for future research.

Exposure to complex traumatic experiences during childhood and early adolescence is a major concern within residential care, affecting up to 90% of institutionalized youths (Connor, Doerfler, Toscano, Volungis, & Steingard, 2004). Most of these traumatic events, including physical, emotional, and sexual abuse, are interpersonal in nature and occur in the primary caregiving environment (van der Kolk, 2010). Although trauma seems to contribute to the development of many disorders, treatment within residential care primarily focuses on reducing externalizing problems. On the one hand, externalizing problems are more noticeable and often not recognized as being a consequence of trauma and maltreatment (Collin-Vézina, Coleman, Milne, Sell, & Daigneault, 2011; Connor et al., 2004). On the other hand, applying traditional trauma-focused treatment within residential care remains difficult, because treatment characteristics do not conform to youths' needs (van Binsbergen, 2003; van der Kolk, 2010). In the present study, we try to address the lack of trauma-focused treatments in residential care by testing the effectiveness of *Muse*, a mindfulness-based relaxation game, as an intervention for traumatized youths. Our study is the first to test this novel innovative intervention that includes principles of traditional trauma-focused treatment but is better tailored to meet the needs of high-risk youths in residential care.

One possible source of the externalizing problems treated within residential care regards trauma and maltreatment (Cook et al., 2017; van der Kolk, 2010). Kearny, Wechsler, Kaur, and Lemos-Miller (2010) developed a psychobiological model of maltreatment in order

to explain the suggested relationship between trauma and behavioral problems. They stated that trauma causes systematic biological changes, including disruptions in the growth, maturation, and plasticity of the prefrontal cortex. These changes result in problems concerning emotional and behavioral self-regulation that can cause psychological problems including anxiety, aggression, impulsivity, and depression. Cook and colleagues (2017) supported this model and suggested that middle childhood and early adolescence regards a sensitive period of the prefrontal cortex's development. Traumatic experience may disrupt this development and thereby cause problems regarding affect regulation and the ability to monitor and plan behavior, which can be summarized under the umbrella term of executive functions. Executive functions thus seem to play a crucial role in the relationship between traumatic experiences and resulting psychological problems. Further research showed that children and adolescents exposed to complex trauma possess poorer executive functioning skills compared to controls not exposed to trauma (Mothes et al., 2015; Nadeau & Nolin, 2013). In addition, executive functions were found to partially mediate the influence of traumatic experiences on post-traumatic stress symptoms, with poorer executive functions being related to higher levels of post-traumatic stress symptoms in youths (op den Kelder, Ensink, Overbeek, Maric, & Lindauer, 2017).

Due to this relationship between traumatic experiences, post-traumatic stress symptoms, and executive functions, our aim was to test the effectiveness of Muse on both post-traumatic stress symptoms and executive functions. To our knowledge, this is the first study to simultaneously assess the effect of an intervention on both concepts in a sample of high-risk children and adolescents.

Even when trauma is recognized as a possible source of behavioral problems, it still remains difficult to treat post-traumatic stress symptoms in residential care. There are two evidence-based treatments for complex trauma in children and adolescents: trauma-focused cognitive behavioral therapy (TF-CBT; Cohen, Deblinger, & Mannarino, 2018) and eye movement desensitization and reprocessing (EMDR; Shapiro & Maxfield, 2002). Although both methods proved to be effective in decreasing post-traumatic stress symptoms (Leenarts, Diehle, Doreleijers, Jansma, & Lindauer, 2013), these treatments include several limitations. First, they require youth to speak about their traumatic experiences, which might result in exposure to experiences that may be re-traumatizing and lead to self-destructive behaviors in emotionally unstable youth (Green & Myrick, 2014). Second, as a consequence of interpersonal trauma, most youth experience difficulty in relying on others and in trusting caretakers. This further complicates trauma-focused treatment (van der Kolk, 2010). Third,

CBT especially relies on imparting knowledge via psycho-education in a didactic style, a practice which is found to be boring by most youth in residential care (Harder, Knorth, & Kalverboer, 2012; van Binsbergen, 2003). The theoretical approach of CBT may explain the typically low treatment motivation within residential care, whilst youths' willingness to participate was shown to be one of the strongest predictors of a treatment's effectiveness (Karver, Handelsman, Fields, & Bickman, 2006). Finally, about 20-25% of youth within residential care suffer from intellectual disabilities (van Nieuwenhuizen, 2010). They have limited cognitive, emotional, and social capabilities, and are at particular risk for traumatic experiences, and to develop post-traumatic stress symptoms. Even though promising case descriptions suggest that especially EMDR is effective in treating traumatized youths with intellectual disabilities, there is a lack of controlled studies that test the effectiveness of EMDR and TF-CBT (Mevisse-Renckens, 2017; Sturmey & Didden, 2014).

One alternative treatment approach gaining increasing popularity concerns the use of games as mental health interventions. Games provide an advantage over traditional approaches by allowing individuals to immediately practice newly accomplished skills (Granic, Lobels, & Engels, 2014). This may be especially important for youth with intellectual disabilities, as they require simplified learning methods and a greater emphasis on daily-life generalization than is offered within traditional programs (Didden, 2006). Furthermore, games uniquely serve to increase youths' intrinsic motivation by providing immediate and concrete feedback (Granic et al., 2014). A recent systematic review and meta-analysis showed that serious games are potentially effective in improving disorder-related symptoms and thus seem to provide a viable alternative to traditional approaches (Lau, Smit, Fleming, & Riper, 2017). However, the number of randomized controlled trials (RCT) is still limited and therefore no definite statements can yet be proposed. Additional RCTs are needed to test the effectiveness of serious games on specific mental health disorders. Within residential care, a videogame intervention was shown to be effective in decreasing psychopathological problems and was positively evaluated by participants, as user satisfaction was high and attrition rates were low. (Schuurmans, Nijhof, Engels, & Granic, 2017; Schuurmans, Nijhof, Vermaes, Engels, & Granic, 2015). Games thus seem to present a viable alternative to traditional treatment approaches for youth within residential care, but additional controlled research on games is needed to determine their effectiveness.

The present study advances the field of research on serious games by testing the effectiveness of Muse among traumatized youths within residential care. Muse is a gamified intervention that utilizes neurofeedback and is based on the principles of mindfulness-based

relaxation (developed by InteraXon, Toronto, Canada). Mindfulness can be defined as the ability to focus on the present moment and to experience each moment with an open, non-judgmental attitude (Ortiz & Sibinga, 2017). Earlier research showed evidence of promising effects of mindfulness-based interventions on youths' post-traumatic symptoms, stress, and their overall quality of life (Jee et al., 2015; Ortiz & Sibinga, 2017). Furthermore, executive functions seem to be related to mindfulness, and a mindfulness-based intervention entailed positive effects on executive functions, including emotional regulation, attentional control, and responses to stress (Riggs, Black, & Ritt-Olson, 2015; Tang, Yang, Leve, & Harold, 2012). Muse itself consists of meditation exercises that teach participants to focus on their breathing, which is comparable to deep-breathing techniques used in CBT (Weisz & Kazdin, 2010). Prior to each session participants can choose one of five different nature environments. During the sessions participants hear sounds from the chosen environment while real-time neuro-feedback on brain activity is provided by reflecting the degree of activity in the intensity of the environment. For example, participants hear a calm wind when they are calm and focused on their breathing, whereas the wind becomes more intense as participants' minds begin to wander. Feedback on individuals' brain activity is based on electroencephalogram (EEG) recordings that are provided by a brain-sensing headband that is worn during the sessions. To increase players' motivation, points and awards are granted when individuals succeed in reaching and remaining in a calm state.

The aim of the present study was to test the effectiveness of Muse as an intervention for post-traumatic stress symptoms among youth in residential care by conducting a RCT. We expected participants who played Muse in addition to their treatment as usual (TAU) to show reduced post-traumatic symptoms and increased executive functions compared to the control condition receiving TAU alone.

## **Method**

### **Study Design and Procedure**

The present study was designed as a RCT with two parallel conditions (Muse vs. TAU). We conducted the study at two residential care institutions and began by initially screening all youths for post-traumatic stress symptoms using the Children's Revised Impact of Event Scale (CRIES-13; Perrin, Meiser-Stedman, & Smith, 2005). Adolescents with clinically elevated levels of post-traumatic stress symptoms (with a score of 30 or higher) were invited to individual meetings with the conducting researchers. During the meetings, youths received all relevant information about the study and about their rights as participants

(e.g., the possibility to quit at any time and confidential treatment of all information) verbally and in written form. The latter further included the written consent, which participants were asked to complete at the beginning of the study. For participants under the age of 16, we also informed the legal guardians and requested their written consent. After receiving written consent from the legal guardians, we randomly assigned participants to the experimental or control condition using a computer-generated list of random numbers.

For both conditions, assessment of post-traumatic stress symptoms and executive functions occurred prior to the intervention period (week 1) and immediately following the intervention period (week 8). We measured executive functions with mentor-reports and post-traumatic stress symptoms with both self- and mentor-reports. Self-reports were administered in interview form to ensure youth's correct comprehension of all questions. The interviews required approximately 15 minutes. All participants received 25 euros in gift cards and a stress ball for their participation. Ethical approval for the study was obtained from the Commissie Mensgebonden Onderzoek (CMO, Arnhem-Nijmegen).

### **Intervention**

**Experimental condition (Muse).** Participants in the experimental condition received the mindfulness-based relaxation intervention Muse in addition to their TAU. This intervention consisted of twelve meetings held by one of the researchers in offices located on the campus of the residential care institutions. During each meeting participants were asked to perform at least two relaxation exercises, with each followed by a 3-minute Muse relaxation session. Participants could choose among five available nature environments (beach, ambient music, desert, rainforest, and city park) and 22 different exercises. A calibration occurred before each session, during which the headband recorded youths' brain activity at rest in order to provide an up-to-date reference point for the following session. The researcher then provided instructions for the chosen exercise according to a standardized protocol. After the sessions, the researcher discussed the results with the participants. In total each meeting required approximately 30 minutes.

**Control Condition (TAU).** Participants in the control condition received TAU, thus the treatment their clinicians decided to deliver due to their conditions. They were offered the opportunity to try Muse at the end of the study.

### **Measurements**

**Post-traumatic Symptoms.** We examined self- and mentor-reported post-traumatic stress symptoms using the Dutch version of the Child and the Parent Report of Post-Traumatic Symptoms (CROPS, PROPS; Greenwald et al., 2002). Both questionnaires reflect

a broad definition of post-traumatic stress symptoms and involve a three-point Likert scale. The CROPS has 26 items and includes for example the following: "I daydream"; "I have headaches" and "My future looks bad". The PROPS has 32 items, with some examples including: "Feels too guilty"; "Difficulty concentrating" and "Worries". Research on the psychometric properties shows that both questionnaires have very high internal consistency (CROPS: .91; PROPS: .93), high test-retest reliability (CROPS: .79; PROPS: .80), and favorable criterion validity as retrieved via comparison to the Lifetime Incidence of Traumatic Events Scales (LITE; CROPS: .56; PROPS: .60; Strand, Sarmiento, & Pasquale, 2005).

**Executive Functions.** Mentor-reported executive functions were measured using the Dutch version of the Behavioral Rating Inventory of Executive Functions (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). The parent version of the BRIEF consists of 75 items and uses a three-point Likert scale as a response format. It is composed of eight subdomains of executive functions, including 'Inhibit', 'Shift', 'Emotional Control', 'Initiate', 'Working Memory', 'Plan/Organize', 'Organization of Material', and 'Monitor'. A 'Metacognition Index' (MI) can be calculated using the subdomains 'Initiate', 'Working Memory', 'Plan/Organize', 'Organization of Material', and 'Monitor', while a 'Behavioral Regulation Index' (BRI) can be calculated using the subdomains 'Inhibit', 'Shift', and 'Emotional Control'. The MI and the BRI can be combined to retrieve an overall 'Global Executive Composite' (GEC) score. Higher scores on all scales and indices indicate more problems with executive functions. Studies on reliability and validity of the BRIEF show that it has high internal consistency (from .80 to .98) and test-retest reliability (from .76 to .85; Huizinga & Smidts, 2012). Examples include: "Work is sloppy"; "Does not take initiative" and "Becomes upset too easily".

### **Sample Size**

Before conducting the study, G\*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) was used to estimate the sample size required to detect an immediate (pre-post) intervention effect on the main outcome of post-traumatic stress symptoms. We based the analysis on a small-to-medium effect ( $d = .30$ ), an estimated correlation of repeated measures of .6, an alpha of .05, and a power of .80. A repeated measures (pre-post) ANOVA with two conditions requires a total sample size of 72 participants. To account for attrition our aim was to recruit 80 participants.

### **Participants**

We recruited participants at two residential care institutions from January 2018 to June 2018. Exclusion criteria consisted of current or recent (< 3 months) EMDR or TF-CBT, simultaneous participation in another clinical intervention study, psychotic symptoms, and

negative clinical advice. We selected 76 youths based on the pre-screening for post-traumatic stress symptoms, but 18 youths had to be excluded due to current or recent EMDR or TF-CBT, and 14 had to be excluded due to impending relocation. We invited 44 individuals to participate in our study. Of those, 36 agreed but seven had to be excluded due to negative clinical advice or a medical condition, and in one case the parents declined study participation.

At baseline, our sample consisted of 28 (17 males, 11 females) participants, none of which withdrew from the study during the intervention. The age of participants ranged from 10 to 17 years ( $M = 15.04$ ;  $SD = 0.37$ ), and the intelligent quotient (IQ) ranged from 54 to 99 ( $M = 71.56$ ;  $SD = 4.91$ ) for youths with intellectual disabilities and from 84 to 126 ( $M = 98.73$ ;  $SD = 4.18$ ) for youths without intellectual disabilities. Based on the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) we classified the mental disorders found in our sample into the following categories: neurodevelopmental disorders which we further divided into intellectual disabilities, attention-deficit disorders (including attention-deficit-hyperactivity disorder [ADHD], and attention-deficit disorder [ADD]), and autism-related disorders (including autism and Asperger); depressive disorders (depressive disorder, mood disorder, and dysthymia); anxiety disorders; disruptive, impulse, and conduct disorders (conduct disorder [CD], oppositional defiant disorder [ODD], and disorder in impulse control); and trauma- and stressor-related disorders (PTSD and reactive attachment disorder). In our sample, we found the following distribution: 35.7% were diagnosed with intellectual disabilities, 7.1% with an attention-deficit disorder, and 25% with an autism-related disorders, while 7.1% were diagnosed with a depressive disorder or an anxiety disorder, 39.3% were diagnosed with a disruptive, impulse, and conduct disorder, and 67.9% of youths were diagnosed with a trauma- and stressor-related disorder.

### **Statistical Analyses**

In an initial step we calculated the mean total scores for each participants' CROPS, PROPS, and BRIEF at both time points. Regarding the measurement of executive functions, we utilized the mean total GEC-score, as we were interested in the development of overall executive functions. We then examined descriptive statistics regarding participants' baseline characteristics, post-traumatic stress symptoms, and executive functions separately for both conditions. We checked for any baseline differences between the two conditions by conducting independent  $t$ -tests using the continuous dependent variables age, IQ, CROPS, PROPS, and BRIEF as well as chi square tests using the categorical dependent variables

gender, mental disorder, and other received treatments. Furthermore, we investigated the agreement between self- and mentor-reports on post-traumatic symptoms, and mentor-reported executive functions by examining Pearson correlations between the CROPS, the PROPS, and the BRIEF at both baseline and post-treatment. To examine the intervention-effect on the three main outcomes (self-reported post-traumatic stress symptoms, mentor-reported post-traumatic stress symptoms, and mentor-reported executive functions) we conducted repeated measures analysis of variance (ANOVA) with time (baseline; post-treatment) as the within-group factor and condition (Muse; TAU) as the between-group factor. All data were analyzed using the statistical program SPSS (version 24; IBM, 2016).

## Results

### Baseline Characteristics

Baseline characteristics for both conditions are presented in Table 1. Before conducting the independent *t*-tests and the chi square tests, we tested the statistical assumptions for all variables. For the continuous variables age and IQ, no statistical assumptions were violated (meaning there were no significant outliers, there was a normal distributions of all variables in both groups, and Levene's tests of homogeneity were insignificant (age:  $F = .51, p = .484$ ; IQ:  $F = .27, p = .613$ )). For the chi square tests, the assumption that no more than 20% of the cells should entail an expecting value less than 5 was violated for all variables. Therefore, we are reporting the *p*-value of Fisher's test.

We found no significant differences between the two conditions regarding the demographic variables age ( $t(26) = 0.77, p = .446$ ), gender ( $p = 1.00$ ), and IQ ( $t(18) = -0.27, p = .793$ ). In addition there were no significant differences found between the two conditions regarding any of the mental disorders (intellectual disabilities:  $p = 1.00$ ; attention-deficit disorder:  $p = 1.00$ ; autism-related disorder:  $p = .165$ ; depressive disorders:  $p = 1.00$ ; anxiety disorders:  $p = 1.00$ ; disruptive, impulse, and conduct disorder:  $p = 1.00$ ; trauma- and stressor-related disorder:  $p = .407$ ). Regarding the interventions youths received during the study, there was a significant difference found between the two conditions on animal-assisted therapy ( $p = .026$ ). Regarding all other therapies, there were no significant differences found between the two conditions (individual therapy:  $p = 1.00$ ; creative therapy:  $p = 1.00$ ; family therapy:  $p = 1.00$ ; medication:  $p = .290$ ).

**Table 1**

*Descriptive Statistics (Means and Standard Deviations or Number of Cases and Percentages) for Demographic Variables per Condition at Baseline.*

Characteristics	Muse Condition ( <i>n</i> = 19)	Control Condition ( <i>n</i> = 9)
Age	14.84 (1.82)	15.45 (2.22)
Gender		
Male	11 (57.9%)	6 (66.7%)
Female	8 (42.1%)	3 (33.3%)
IQ	87.29 (21.01)	84.67 (17.56)
Mental Disorders		
Intellectual Disability	7 (36.9%)	3 (33.3%)
Attention-Related Disorders	2 (10.5%)	0 (0.0%)
Autism-Related Disorders	3 (15.8%)	4 (44.4%)
Depressive Disorders	1 (5.3%)	1 (11.1%)
Anxiety Disorders	2 (10.5%)	0 (0.0%)
Disruptive, Impulse-Control, Conduct Disorder	7 (36.8%)	4 (44.4%)
Trauma- and Stressor Related Disorders	14 (73.7%)	5 (55.6%)
Other interventions		
Animal Assisted Therapy	9 (47.4%)	0 (0.0%)
Individual Therapy	5 (26.3)	2 (22.2%)
Creative Therapy	4 (21.1%)	1 (11.1%)
Family Therapy	1 (5.3%)	0 (0.0%)
Medication	17 (89.5%)	6 (66.7%)

*Note.* IQ = intelligent quotient.

## Main outcomes

Pearson correlations between self- and mentor-reported post-traumatic stress symptoms and mentor-reported executive functions at baseline and post-treatment are displayed in Table 2.

Table 3 shows baseline and post-treatment scores regarding self- and mentor-reported post-traumatic stress symptoms (CROPS, PROPS) as well as mentor-reported executive functions (BRIEF). We had no missing values for the self-reports, but the mentor-reports of two participant were missing at post-treatment. The main-effect analyses for self-reported post-traumatic stress symptoms are thus based on data the of 28 participants, whereas the main-effect analyses for mentor-reported post-traumatic stress symptoms and executive functions are based on the data of 26 participants.

Before conducting independent *t*-tests to test for baseline differences on the CROPS, PROPS, and BRIEF, we checked the statistical assumptions. The statistical assumptions were found to be not violated (meaning there were no significant outliers, there was a normal distributions of all variables in both groups, and Levene's tests of homogeneity were insignificant (CROPS:  $F = .03$ ,  $p = .862$ ; PROPS:  $F = .04$ ,  $p = .837$ ; BRIEF:  $F = .00$ ,  $p = .970$ )). At baseline we found no significant differences between the two conditions regarding self-reported post-traumatic stress symptoms ( $t(26) = -1.54$ ,  $p = .136$ ), mentor-reported post-traumatic stress symptoms ( $t(26) = -1.12$ ,  $p = .275$ ), or mentor-reported executive functions ( $t(26) = -0.58$ ,  $p = .571$ ). There was a significant interaction effect of time and condition on self-reported post-traumatic stress symptoms at post-treatment ( $F(1,26) = 6.60$ ,  $p = .016$ ). A greater decrease in self-reported post-traumatic stress symptoms was found for participants in the Muse condition as compared to the control condition, and the effect was large ( $\eta^2 = .20$ ; Richardson, 2011). We found no significant interaction effect of time and condition on mentor-reported post-traumatic stress symptoms ( $F(1,24) = 0.10$ ,  $p = .760$ ) and mentor-reported executive functions ( $F(1,24) = 0.57$ ,  $p = .456$ ).

**Table 2**

*Pearson Correlations among CROPS, PROPS and BRIEF at Baseline (T1) and Post-Treatment (T2)*

	CROPS T1	CROPS T2	PROPS T1	PROPS T2	BRIEF T1	BRIEF T2
CROPS T1	-					
CROPS T2	.79**	-				
PROPS T1	.36	.22	-			
PROPS T2	.33	.33	.61**	-		
BRIEF T1	.23	.10	.65**	.43*	-	
BRIEF T2	.12	.15	.49*	.72**	.68**	-

*Note.* CROPS, Child Report of Post-Traumatic Symptoms; PROPS, Parent Report of Post-Traumatic Symptoms; BRIEF, Behavioral Rating Inventory of Executive Functions. T1, Baseline; T2 Post-Treatment.

\*\*  $p < .01$  (2-tailed); \*  $p < .05$  (2-tailed).

**Table 3**

*Descriptive Statistics (Means and Standard Deviations) for CROPS, PROPS, and BRIEF per Condition at Baseline and Post-Treatment.*

Characteristics	Muse Condition ( $n = 19$ )	Control Condition ( $n = 9$ )
Baseline		
CROPS	27.47 (9.36)	21.58 (9.67)
PROPS	28.03 (11.22)	22.53 (11.28)
BRIEF	138.13 (30.89)	133.51 (35.79)
Post-treatment		
CROPS	22.00 (11.60)	22.82 (7.86)
PROPS	24.61 (11.29)	20.40 (10.70)
BRIEF	141.74 (46.79)	127.14 (36.04)

*Note.* CROPS, Child Report of Post-Traumatic Symptoms; PROPS, Parent Report of Post-Traumatic Symptoms; BRIEF, Behavioral Rating Inventory of Executive Functions.

## Discussion

The aim of the present study was to test the effectiveness of Muse, a gamified relaxation intervention, for institutionalized youths experiencing clinical levels of post-traumatic stress symptoms. We expected that twelve sessions of playing Muse would result in decreased post-traumatic stress symptoms as reported by both the youths themselves as well as the mentors. In addition, we expected executive functions to increase for individuals who played Muse. Our results partly support our hypotheses. At post-treatment, youths in the Muse condition showed greater reductions in self-reported post-traumatic stress symptoms compared to youths in the control conditions. In contrast to our hypotheses, we found no differences between the two conditions in mentor-reported post-traumatic stress symptoms and mentor-reported executive functions.

The reduction of self-reported post-traumatic stress symptoms from baseline to post-treatment was greater for youths in the Muse condition compared to youths in the control condition. Muse thus seems to serve as a promising intervention for high-risk traumatized youths in residential care. This result is aligned with our expectations and earlier research, which stated that mindfulness-based interventions improve mental, behavioral, and physical outcomes of traumatized youths (Ortiz & Sibinga, 2016). Importantly, our study was the first to test a mindfulness-based intervention on post-traumatic stress symptoms within residential care. Only a single previous pilot-study recruited a sample of high-risk youths in foster care, but they did not measure post-traumatic stress symptoms before or after the intervention (Jee et al., 2015). Furthermore, our study was the first to use a gamified intervention requiring relatively brief sessions of only 30 minutes. In contrast, the majority of earlier studies applied trainings that consisted of weekly 2-hour sessions and none utilized a gamified intervention. The present study thus advances the research field by showing that a gamified intervention entailing relatively brief relaxation sessions can be effective in mitigating the subjective experience of post-traumatic stress symptoms in a high-risk youth population.

We found no greater decrease on mentor-reported post-traumatic stress symptoms for youths in the Muse condition compared to youths in the control condition. This finding is neither aligned with our hypotheses nor with our results regarding the influence of Muse on self-reported post-traumatic stress symptoms. However, a comparable discrepancy between self-reported and caregiver-reported emotional and behavioral problems has been found in a substantial number of earlier studies (Gearing, Schwalbe, MacKenzie, Brewer, & Ibrahim, 2015; Ooi et al., 2017; Youngstrom, Loeber, & Stouthamer-Loeber, 2000). Interestingly,

whereas mentor-reported post-traumatic stress symptoms and mentor-reported executive functions were found to be significantly positively related, there was only a moderate, insignificant relationship found between self- and mentor-reported post-traumatic stress symptoms. These findings support earlier studies that showed different perceptions of youths and mentors regarding the amount and severity of externalizing as well as internalizing problems (Gearing et al., 2015). Generally, caregivers in clinical settings tend to rate youths higher regarding problematic behaviors compared to how children rate themselves. Thus, a possible explanation for the insignificant intervention effect on mentor-reported post-traumatic stress symptoms could be that mentors are more critical about youths' improvements. In addition, a post-hoc power analysis revealed that, with a total sample size of 26 mentor-reports, we achieved a power of .38 ( $d = .30$ ; correlation of repeated measures = .6,  $\alpha = .05$ ). It is accordingly possible that Muse has an effect on mentor-reported post-traumatic stress symptoms, but our sample size is not large enough to detect such an effect. Future research should aim to include a larger sample to either confirm that Muse is not effective in decreasing mentor-reported post-traumatic stress symptoms or to reveal that there is an intervention effect that we were not able to detect.

In contrast to our expectations, Muse was not found to be effective in decreasing problems with executive functions in our sample of traumatized youths. We based our hypothesis on existing literature which indicated that mindfulness-based interventions are effective in improving specific aspects of executive functions, including attention, emotional regulation, and cognitive control (Riggs et al., 2015; Tang et al., 2012). The importance of self-regulatory capacities in high-risk youths populations is widely acknowledged, but only a single study has previously applied a mindfulness-based interventions to increase self-regulatory capacities in that high-risk population (Spinazzola, Rhodes, Emerson, Earle, & Monroe, 2011). However, these researchers did not include a systematic measure of executive functions but instead based their conclusions on anecdotal data. The present study was thus the first to systematically measure executive functions both before and after applying a mindfulness-based relaxation intervention in residential care. One possible explanation for the absent effect in our sample could be that the highly structured environment within residential care concealed any changes in youths' executive functions and self-regulatory capacities (Whittaker et al., 2016). An important limitation of our study regards the inability of including a self-report measure of executive functions. It is therefore possible that, as with post-traumatic stress symptoms, youths themselves could have recognized an effect of Muse on their executive functioning skills even though their mentors reported no improvements.

Future research should replicate the present study and additionally include a self-report of executive functions. Further results that support our finding that there is no effect of mindfulness-based interventions on executive functions in institutionalized youth would indicate that executive functions are not an underlying mechanism of the intervention effect on self-reported post-traumatic stress symptoms.

As already mentioned, the most important limitation of the present study concerns its small sample size, as the resulting low power is problematic for several reasons. Firstly, this limitation probably prevented us from identifying a true effect of Muse on mentor-reported post-traumatic stress symptoms and executive functions. Secondly, low power results in low positive predictive values (PPV; Button et al., 2013), which means that there is a low probability, that the significant effect of Muse on self-reported post-traumatic stress symptoms actually reflects a true effect. Thirdly, we must be critical of the estimated magnitude for the intervention effect on self-reported post-traumatic stress symptoms, as studies with low statistical power tend to result in inflated effects. Future research should aim to replicate the present study while utilizing a larger sample size.

Another limitation of the present study regards the fact that we did not use an active control condition. Participants in our control condition received TAU alone, whereas participants in the experimental condition received Muse in addition to TAU. Participants were informed about the two distinct conditions, therefore it is possible that the knowledge of not receiving treatment affected outcomes in the control condition (Freedland, Mohr, Davidson, & Schwartz, 2011; Mohr et al., 2008). Furthermore, participants in the experimental condition received additional individual attention. An ideal control condition should therefore include the same amount of individual attention and contact with the researcher as well as provide a treatment rationale to elicit comparable outcome expectations in all participants. However, the aim of the present study was to test the general effectiveness of Muse as a beneficial addition to the typical care within residential care institutions. Traditional trauma-focused treatments are difficult to implement in residential care, and our aim was to address this problem by testing the effectiveness of Muse. From our study, we can conclude that Muse can be used as a beneficial addition to traditional care to address youths' subjective experiences of post-traumatic stress symptoms. Future research should aim to include an active control group that utilizes a comparable game with different working mechanisms, which would allow further examination of the working mechanisms of Muse.

The present study tested the effectiveness of Muse as an intervention for traumatized youths in residential care, thereby addressing the lack of suitable trauma-focused therapies

within this high-risk population. Although there was no effect of Muse found on mentor-reported post-traumatic stress symptoms and executive functions, self-reported post-traumatic stress symptoms decreased after playing Muse, providing initial evidence for the game's effectiveness. Future research should focus on further examining the effectiveness of Muse using a larger sample size and an active control group. The present findings further support the use of games as mental health interventions and present Muse as a promising beneficial addition to traditional trauma-focused treatment approaches.

## References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.
- Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, *14*(5), 365-376.  
doi:10.1038/nrn3475
- Cohen, J. A., Deblinger, E., & Mannarino, A. P. (2018). Trauma-focused cognitive behavioral therapy for children and families. *Psychotherapy Research*, *28*(1), 47-57.  
doi:10.1080/10503307.2016.1208375
- Collin-Vézina, D., Coleman, K., Milne, L., Sell, J., & Daigneault, I. (2011). Trauma experiences, maltreatment-related impairments, and resilience among child welfare youth in residential care. *International Journal of Mental Health and Addiction*, *9*(5), 577-589. doi:10.1007/s11469-011-9323-8
- Connor, D. F., Doerfler, L. A., Toscano, P. F., Volungis, A. M., & Steingard, R. J. (2004). Characteristics of children and adolescents admitted to a residential treatment center. *Journal of Child and Family Studies*, *13*(4), 497-510.  
doi:10.1023/B:JCFS.0000044730.66750.57
- Cook, A., Spinazzola, J., Ford, J., Lanktree, C., Blaustein, M., Cloitre, M., ... & Mallah, K. (2017). Complex trauma in children and adolescents. *Psychiatric Annals*, *35*(5), 390-398. doi:10.3928/00485713-20050501-05
- Didden, R. (2006). Gedragsanalyse en cognitieve gedragstherapie bij mensen met een verstandelijke beperking: Een tussenbalans. In R. Didden, (Ed.), *In Perspectief* (101-126). Houten: Bohn Stafleu van Lochem.
- Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G\* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. doi:10.3758/BF03193146
- Freedland, K. E., Mohr, D. C., Davidson, K. W., & Schwartz, J. E. (2011). Usual and unusual care: existing practice control groups in randomized controlled trials of behavioral interventions. *Psychosomatic Medicine*, *73*(4), 323-335.  
doi:10.1097/PSY.0b013e318218e1fb
- Gearing, R. E., Schwalbe, C. S., MacKenzie, M. J., Brewer, K. B., & Ibrahim, R. W. (2015). Assessment of adolescent mental health and behavioral problems in institutional care:

- discrepancies between staff-reported CBCL scores and adolescent-reported YSR scores. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(3), 279-287. doi:10.1007/s10488-014-0568-y
- Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Test review behavior rating inventory of executive function. *Child Neuropsychology*, 6(3), 235-238. Retrieved from <https://www.tandfonline.com/doi/abs/10.1076/chin.6.3.235.3152?journalCode=ncny20>
- Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American Psychologist*, 69(1), 66-78. doi:10.1037/a0034857
- Green, E. J., & Myrick, A. C. (2014). Treating complex trauma in adolescents: A phase-based, integrative approach for play therapists. *International Journal of Play Therapy*, 23(3), 131-145. doi:10.1037/s0036679
- Greenwald, R., Rubin, A., Jurkovic, G., Wiedemann, J., Russell, A., O'Connor, M., & Weishaar, D. (2002). Psychometrics of the CROPS & PROPS in multiple cultures/translation. Retrieved from <http://www.childtrauma.com/postrops.html>.
- Harder, A. T., Knorth, E. J., & Kalverboer, M. E. (2012). Securing the downside up: Client and care factors associated with outcomes of secure residential youth care. *Child Youth Care Forum*, 41(3), 259-276. doi:10.1007/s10566-011-9159-1
- Huizinga, M., & Smidts, D. P. (2012). BRIEF Vragenlijst executieve functies voor 5-tot 18-jarigen: handleiding.
- IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.
- Jee, S. H., Couderc, J. P., Swanson, D., Gallegos, A., Hilliard, C., Blumkin, A., ... & Heinert, S. (2015). A pilot randomized trial teaching mindfulness-based stress reduction to traumatized youth in foster care. *Complementary Therapies in Clinical Practice*, 21(3), 201-209. doi:10.1016/j.ctcp.2015.06.007
- Karver, M. S., Handelsman, J. B., Fields, S., & Bickman, L. (2006). Meta-analysis of therapeutic relationship variables in youth and family therapy: The evidence for different relationship variables in the child and adolescent treatment outcome literature. *Clinical Psychology Review*, 26(1), 50-65. doi:10.1016/j.cpr.2005.09.001
- Kearney, C. A., Wechsler, A., Kaur, H., & Lemos-Miller, A. (2010). Posttraumatic stress disorder in maltreated youth: A review of contemporary research and thought. *Clinical Child and Family Psychology Review*, 13(1), 46-76. doi:10.1007/s10567-009-0061-4

- Lau, H. M., Smit, J. H., Fleming, T. M., & Riper, H. (2017). Serious games for mental health: are they accessible, feasible, and effective? A systematic review and meta-analysis. *Frontiers in Psychiatry*, 7, 209. doi:10.3389/fpsyt.2016.00209
- Leenarts, L. E., Diehle, J., Doreleijers, T. A., Jansma, E. P., & Lindauer, R. J. (2013). Evidence-based treatments for children with trauma-related psychopathology as a result of childhood maltreatment: a systematic review. *European Child & Adolescent Psychiatry*, 22(5), 269-283. doi:10.1007/s00787-012-0367-5
- Mevissen-Renckens, E. H. M. (2017). Assessment and treatment of posttraumatic stress disorder in individuals with intellectual disabilities. In C. R. Martin, V. R. Preedy, & V. B. Patel, (Eds.), *Comprehensive Guide to Post-Traumatic Stress Disorder, Chapter: Assessment and Treatment of PTSD in People with Intellectual Disabilities* (281-299). Switzerland: Springer.
- Mohr, D. C., Spring, B., Freedland, K. E., Beckner, V., Arean, P., Hollon, S. D., ... & Kaplan, R. (2009). The selection and design of control conditions for randomized controlled trials of psychological interventions. *Psychotherapy and Psychosomatics*, 78(5), 275-284. doi:10.1159/000228248
- Mothes, L., Kristensen, C. H., Grassi-Oliveira, R., Fonseca, R. P., Lima Argimon, I. I., & Irigaray, T. Q. (2015). Childhood maltreatment and executive functions in adolescents. *Child and Adolescent Mental Health*, 20(1), 56-62. doi:10.1111/camh.12068
- Nadeau, M. E., & Nolin, P. (2013). Attentional and executive functions in neglected children. *Journal of Child & Adolescent Trauma*, 6(1), 1-10. doi:10.1080/19361521.2013.733794
- Ooi, Y. P., Glenn, A. L., Ang, R. P., Vanzetti, S., Falcone, T., Gaab, J., & Fung, D. S. (2017). Agreement between parent-and self-reports of psychopathic traits and externalizing behaviors in a clinical sample. *Child Psychiatry & Human Development*, 48(1), 151-165. doi:10.1007/s10578-016-0659-y
- op den Kelder, R., Ensink, J. B., Overbeek, G., Maric, M., & Lindauer, R. J. (2017). Executive function as a mediator in the link between single or complex trauma and posttraumatic stress in children and adolescents. *Quality of Life Research*, 26(7), 1687-1696. doi:10.1007/s11136-017-1535-3
- Ortiz, R., & Sibinga, E. M. (2017). The role of mindfulness in reducing the adverse effects of childhood stress and trauma. *Children*, 4(3), 16. doi:10.3390/children4030016.

- Perrin, S., Meiser-Stedman, R., & Smith, P. (2005). The Children's Revised Impact of Event Scale (CRIES): Validity as a screening instrument for PTSD. *Behavioural and Cognitive Psychotherapy*, 33(4), 487-498. doi:10.1017/S1352465805002419
- Richardson, J. T. (2011). Eta squared and partial eta squared as measures of effect size in educational research. *Educational Research Review*, 6(2), 135-147. doi: 10.1016/j.edurev.2010.12.001
- Riggs, N. R., Black, D. S., & Ritt-Olson, A. (2015). Associations between dispositional mindfulness and executive function in early adolescence. *Journal of Child and Family Studies*, 24(9), 2745-2751. doi:10.1007/s10826-014-0077-3
- Schuermans, A. A., Nijhof, K. S., Engels, R. C., & Granic, I. (2017). Using a Videogame Intervention to Reduce Anxiety and Externalizing Problems among Youths in Residential Care: an Initial Randomized Controlled Trial. *Journal of Psychopathology and Behavioral Assessment*, 1-11. doi:10.1007/s10862-017-9638-2
- Schuermans, A. A., Nijhof, K. S., Vermaes, I. P. R., Engels, R. C. M. E., & Granic, I. (2015). A pilot study evaluating “dojo,” a videogame intervention for youths with externalizing and anxiety problems. *Games for Health Journal*, 4, 401–408. doi:10.1089/g4h.2014.0138
- Shapiro, F., & Maxfield, L. (2002). Eye movement desensitization and reprocessing. In M. Hersen, & W. Sledge, (Eds.), *Encyclopedia of Psychotherapy* (777-785). Amsterdam; Boston: Academic Press.
- Spinazzola, J., Rhodes, A. M., Emerson, D., Earle, E., & Monroe, K. (2011). Application of yoga in residential treatment of traumatized youth. *Journal of the American Psychiatric Nurses Association*, 17(6), 431-444. doi:10.1177/10783903111418359
- Strand, V. C., Sarmiento, T. L., & Pasquale, L. E. (2005). Assessment and screening tools for trauma in children and adolescents: A review. *Trauma, Violence, & Abuse*, 6(1), 55-78. doi:10.1177/1524838004272559
- Sturmeijer, P., & Didden, R. (2014). *Evidence-based practice and intellectual disabilities*. Hoboken: Wiley-Blackwell.
- Tang, Y. Y., Yang, L., Leve, L. D., & Harold, G. T. (2012). Improving executive function and its neurobiological mechanisms through a mindfulness-based intervention: Advances within the field of developmental neuroscience. *Child Development Perspectives*, 6(4), 361-366. doi:10.1111/j.1750-8606.2012.00250.x
- van Binsbergen, M. (2003). *Motivatie voor behandeling: Ontwikkeling van behandelmotivatie in een justitiële instelling*. Garant.

- van der Kolk, B. A. (2010). *Developmental trauma disorder*. Retrieved from [http://www.traumacenter.org/products/pdf\\_files/preprint\\_dev\\_trauma\\_disorder.pdf](http://www.traumacenter.org/products/pdf_files/preprint_dev_trauma_disorder.pdf)
- van Nieuwenhuijzen, M. (2010). *De (h)erkenning van jongeren met een lichte verstandelijke beperking*. Amsterdam: SWP.
- Weisz, J. R., & Kazdin, A. E. (2010). *Evidence-Based Psychotherapies for Children and Adolescents (2nd ed.)*. New York, NY: Guilford Press.
- Whittaker, J. K., Holmes, L., del Valle, J. F., Ainsworth, F., Andreassen, T., Anglin, J., ... & Courtney, M. (2016). Therapeutic residential care for children and youth: A consensus statement of the international work group on therapeutic residential care. *Residential Treatment for Children & Youth, 33*(2), 89-106. doi:10.1080/0886571X.2016.1215755
- Youngstrom, E., Loeber, R., & Stouthamer-Loeber, M. (2000). Patterns and correlates of agreement between parent, teacher, and male adolescent ratings of externalizing and internalizing problems. *Journal of Consulting and Clinical Psychology, 68*(6), 1038-1050. doi:10.1037//0022-006X.68.6.1038